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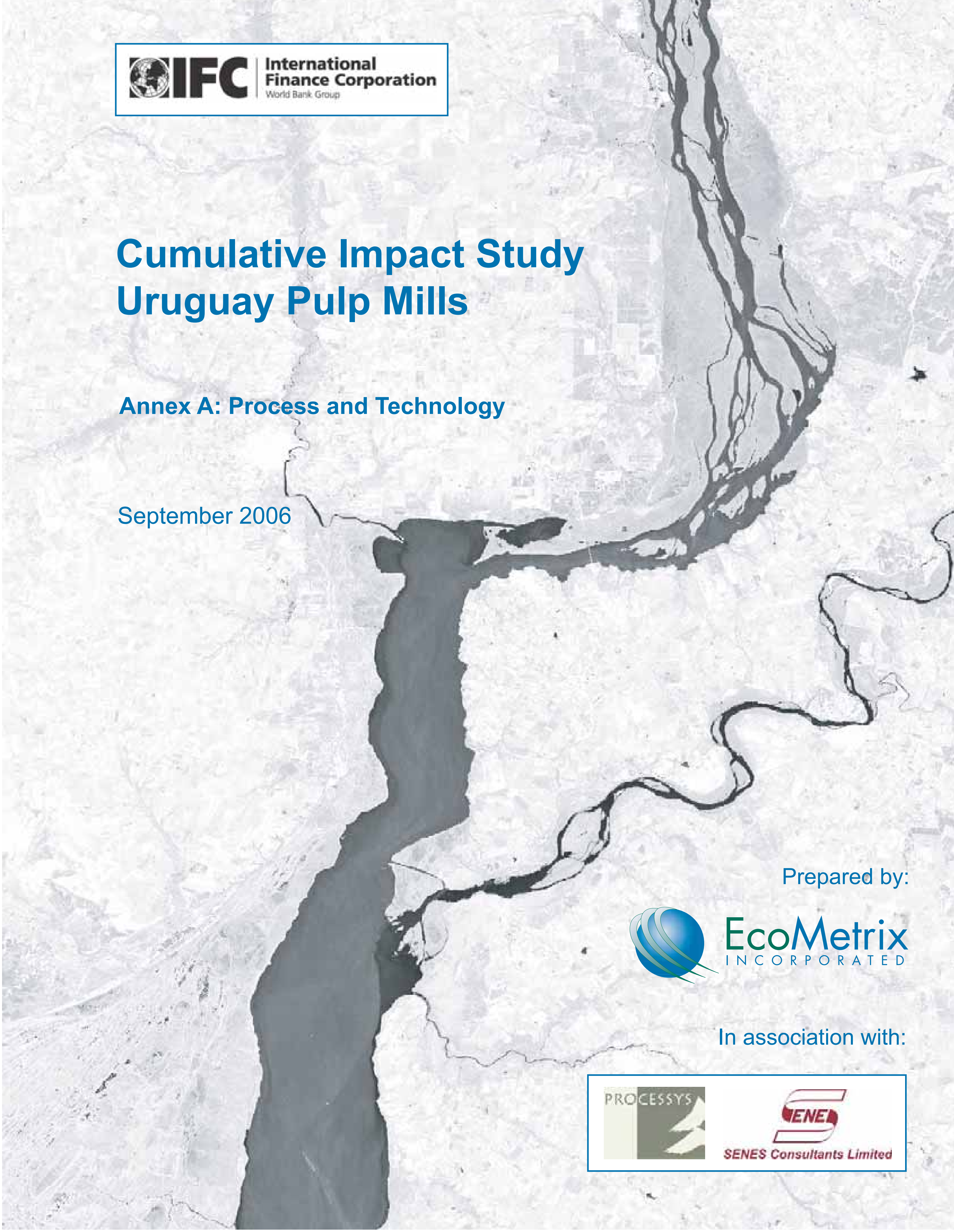

Cumulative Impact Study
Uruguay Pulp Mills

Annex A: Process and Technology

September 2006

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ANNEX A

Process and Technology

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A1.0 INTRODUCTION

The International Finance Corporation of the World Bank Group (IFC) is currently assessing two pulp mill projects in Uruguay for financing. The mills are located on the Rio Uruguay near the city of Fray Bentos near the border with Argentina. In addition, the Multilateral Investment Guarantee Agency (MIGA) is evaluating whether to provide political risk insurance to one of the mills.

To complete the assessment of the combined environmental and social effects of the two proposed mills, IFC commissioned a Cumulative Impact Study (CIS) of the construction and operations of the two pulp mills and their respective raw material sourcing. The draft CIS was prepared by Pacific Consultants International and Malcolm Pirnie Incorporated and issued by IFC in December 2005. Following a period of public review and professionally facilitated consultations in Argentina and Uruguay, the IFC commissioned a panel of independent experts to review existing project documentation and all comments provided by stakeholders. The results of this review are summarized in a report issued by the independent experts in April 2006. The report, referred to as the Hatfield Report, also identifies additional information and analysis required to complete the environmental assessment for the two mills. EcoMetrix Incorporated (EcoMetrix) and its consultants, SENES Consultants Limited (SENES) and Processys Incorporated (Processys), revised and finalized the draft CIS in response to the recommendations of the Hatfield Report, the published Terms of Reference, original research, stakeholder commentary and other project related documentation.

The purpose of Annex A of the CIS is to provide information concerning the analysis of the proposed pulp mill processes, in order to validate whether or not the mills are being designed using best available technology (BAT). The contributing members of the project team include:

- Paul Stuart, Ph.D., a Principal of Processys Incorporated and professor of Chemical Engineering at the Ecole Polytechnique, Montreal, Canada;
- Peter Gleadow, B.Eng., a process specialist with Processys Incorporated, Vancouver, Canada; and
- Jean-Martin Brault, M.Sc. (Ph.D. candidate), process engineer with Processys Incorporated, Montreal, Canada.

There are many references to the literature and other reports in this Annex. Some of the key references include the following:

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WORLD BANK GROUP-Pollution Prevention and Abatement Handbook-Pulp and Paper Mills, 1998. http://ifcln1.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_pulp_WB/$FILE/pulp_PPAH.pdf#search=%22world%20bank%20handbook%20pulp%20paper%22.

A1.1 Summary of BAT Evaluation Methodology

Modern kraft pulp mills, such as those being evaluated in this CIS, should have discharges which are significantly less than those of older smaller mills, due to the implementation of state-of-the-art process technology suitable for large production throughputs. Discharges from modern mills are lower not only in specific terms (on a "per tonne of production" basis), but sometimes also in absolute terms (on a "tonne per day" basis) despite the higher production, when compared with older mills. Implementation of state-of-the-art technology alone is insufficient to guarantee BAT; it is critical that the equipment is well-operated and maintained to ensure operating objectives are consistently met over the longer term. These aspects are discussed in this BAT analysis, as well as an assessment of whether the environmental regulating body in Uruguay, DINAMA, will ensure BAT operation through their permitting process and requirements.

What is best available technology? Best Available Techniques (BAT) are defined in the EC Directive 96/61 as "the most effective and advanced stage in the development of activities and their methods of operation which indicates the practicable suitability of particular techniques for providing the basis for emission limit values designed to prevent, and where that is not practicable, generally to reduce the emissions and the impact on the environment as a whole". BAT takes into account the following principles:

1. The use of low-waste technology, for example techniques which maximize pulp yield and minimize pulp rejects.

2. The use of less hazardous substances than in most non-BAT mills. For example the use of molecular chlorine or hypochlorite should not be considered in a modern pulp mill bleaching operations.

3. The furthering of recovery and recycling of substances generated and used in the process and waste, where appropriate, for example the return of grits and dregs to the forest which is being considered by both mills, as is engineering for the possibility of filtrate recycle from the bleach plant to the recovery system.

4. Comparable processes, facilities or methods of operation which have been tried with success on an industrial scale. For example, both companies have relied on their significant operating experience in defining the mill processes, in the context of how to implement BAT. This is seen for example in plans for operation of the odorous gas collection systems, which the CIS project team predicts will have extremely high levels of efficiency and availability. Both mills are also using major equipment vendors with knowledge of the latest developments in, for example, recovery boiler technology, with operation at high dissolved solids input (75% and higher) and high operating steam temperatures (485-488 ºC), while ensuring reliable operation with low emissions.

5. Technological advances and changes in scientific knowledge and understanding. For example, while the bleaching sequences are different for the two mills, they are both considered advanced ECF bleaching technologies which are particularly suitable for eucalyptus pulp, will require minimum chlorine dioxide charge (of under 10 kg ClO_2 per tonne), and will result in minimum discharge of chlorinated organic compounds.

6. The nature, effects and volume of the emissions concerned. For example special attention has been made in this study regarding the control and minimum discharge of nutrients, to levels below those being permitted, in order to minimize the likelihood of eutrophication in the Rio Uruguay due to mill effluents. Both mills are also using advanced odorous gas collection and combustion systems, with strong and dilute gas collection systems covering the brown fiberline, evaporation and recausticizing, with primary and secondary points of incineration for the complete strong and weak gas systems. It is unusual to see such extensive back-up in odour control systems. These mills

are among the best in the world with this degree of coverage, and have gone considerably beyond IPPC-BAT (2001).

7. The commissioning dates for the plant. IPPC-BAT (2001) (discussed below and next section) is the main standard used in this section for evaluating the Botnia and ENCE pulp mills, however emission rates from other BAT standards are used, as well as emissions from new pulp mills that have started-up since the publication of IPPC-BAT in 2001.

8. The consumption and nature of raw materials (including water) used in the process and the energy efficiency of the process. For example although water use is not normally regulated for pulp mills, the designed water use in the case of the pulp mills has been benchmarked to ensure it has been minimized. As well, the energy-efficient mills will export electricity, whereas most traditional mills consume electricity produced by burning fossil fuel at a remote power station.

9. The need to prevent accidental discharges and to minimize the consequences of these on the environment, for example a detailed assessment of the management of odorous gases has been made to ensure that the likelihood of odorous events is minimized.

Pulp and paper products and their manufacturing processes, even for an apparently similar product such as bleached eucalyptus kraft pulp (BEKP), vary greatly. Plant design and equipment selection are complex processes, and many factors must be taken into account to produce the target production and product quality, while ensuring a high level of environmental protection. For example, it is pertinent to recognize that the pulp mills use Uruguayan eucalyptus furnish, since this factor has played an important role in the process design. It is also important to place in context the experience of Botnia and ENCE at their own mills, for example both Botnia and ENCE have had extensive experience in the manufacture of TCF and are familiar with the TCF market; ENCE has been processing Uruguayan eucalyptus furnish at their Huelva mill for many years.

BAT is thus not defined by prescribing state-of-the-art process techniques, but rather, by the emissions estimated when a set of state-of-the-art techniques is implemented to produce pulp. BAT analysis is linked to the environmental performance of the pulp mills, and not to the selection of any single equipment item. For example, different fibre lines and bleach sequences have been defined for the two mills based on experience, market considerations and overall mill production rate (scale). Thus for example, a given charge of chlorine dioxide in the bleaching operations of each mill will result in different AOX emissions for apparently similar products. In the context of these subtle complexities, the equipment selection for both pulp mills has been evaluated in the CIS to ensure that a state-of-the-art selection has been made for the unique design context of each pulp mill.

It is pertinent to note that the pulp mill configurations, BAT assessment, and emission estimates have been made while the mills were at different stages of engineering design and construction. While most of the major equipment items had been selected for both mills while this CIS was being completed, it is normal that there remains some uncertainty concerning design details. For example in the case of both mills, the standard operating procedures (SOPs) and the environmental management systems (EMS) to be implemented were not defined. In these cases, the CIS project team has sought additional detail to the extent practical from each of the mill proponents.

It is the objective of this section to describe the BAT evaluation methodology employed for the CIS, whose results are presented in this Annex. A balance has been sought between exploring critical environmental issues relative to the mill process designs, and providing overly detailed and technical background.

The following methodology has been employed in evaluating BAT in this CIS, and the Annex sections link to the methodology in a consistent manner.

1. Definition of BAT Emission Rates

The CIS must evaluate whether the Botnia and ENCE BEKP mills are being built using BAT, however several bases might be used for defining the technology for the BAT emission rates. IPPC-BAT (2001) comprises the most widely accepted and practical definition of BAT, however other definitions of BAT are employed in this analysis in addition to that of IPPC-BAT (2001), to ensure that the mills are state-of-the-art.

For example in August 2004, a Tasmanian government study was issued which defines Accepted Modern Technology (AMT) as a “technology which has a demonstrated capacity to achieve the desired emission concentration in a cost-effective manner, takes account of cost-effective engineering and scientific developments, and pursues opportunities for waste minimisation.” In addition to being a BAT standard that includes a more recent survey of state-of-the-art process techniques than IPPC-BAT (2001), Tasmanian-AMT (2004) considers the particularities of kraft pulping of eucalyptus furnish, for example related to the difficulty in pulp bleaching due to hexenuronic acid groups. In July 2006, the Draft Integrated Impact Statements for a preliminary mill design by Gunns, in Australia, was submitted under these Tasmanian AMT guidelines.

In particular for aspects related to the control of dioxin and furan emissions, and for the case of liquor spills control through best management practices (BMP), the USEPA Cluster Rule (2000) has also been considered in this analysis.

Emission rates from state-of-the-art mills such as Brazil’s Veracel mill and other pulp mills, and also, the best-performing and most comparable Botnia and ENCE mills have been considered in the BAT analysis for this CIS.

2. BAT Considerations for IPPC-BAT (2001) and Tasmanian-AMT (2004)

These BAT standards are further described in Annex A, Sections A2 and A3.

3. Estimates of Pulp Mill Emission Rates

As part of the BAT methodology, Botnia and ENCE were required to estimate the proposed mill emission rates. This information was evaluated as part of the BAT analysis to understand the basis of the emission rates, and to ensure that concepts of process variability were considered. Through this evaluation, and by comparing technologies and emission rates between operating mills, Botnia and ENCE BEKP mill predicted emission rates were validated within the context of good engineering judgment (GEJ). This analysis is described in Annex A, Section A4.

4. Assessment of BAT Based on Pulp Mill Emission Rates

The validated pulp mill emission rates are systematically compared against emission rates from the various BAT sources considered, in order to determine whether the proposed mills are BAT. This analysis is presented in Annex A, Section A5.

5. Assessment Whether BAT will be Ensured Through the Mill Permitting Process and Permit Requirements

The Botnia and ENCE pulp mills are among the most significant projects in Uruguay's history. The Uruguayan government is analyzing the projects through a systematic permitting process intended to ensure minimum environmental impact. Certain of the permitting activities by the National Directorate for the Environment of the Uruguayan Government (hereinafter called "DINAMA", its Spanish acronym) are pertinent to the context of ensuring BAT.

In Annex A, Section A6, various aspects of the permitting process are discussed with respect to ensuring BAT:

- DINAMA's permit-setting process: The stepwise approach being taken by DINAMA to permit the mills is described, and evaluated to determine whether the permit process ensures that BEKP mill emissions that correspond to BAT are included in the mill permits.
- Permit Requirements and performance benchmarking: The basic limits proposed by DINAMA are discussed.
- Monitoring and reporting requirements: Once the permits have been finalized and issued, it will be essential for DINAMA to monitor end-of-pipe and end-of-stack emission rates, as well as their impact on the receiving environment. If well-designed and implemented, emission rate data will provide an important tool for DINAMA to ensure that the mills are well-operated and maintained over the longer term.

6. Description of Mill Processes

In Annex A, Section A7, each of the BEKP mill processes is presented, highlighting key environmental characteristics of the design.

7. Systematic Evaluation of Key BAT Issues

Annex A, Section A8 discusses each of the following key issues: overall water use in the mill, wastewater treatment, energy issues, auxiliary boilers, evaporation and recovery, liquor spills collection, and odorous gas management.

8. Issues Related to Pulp Bleaching

Annex A, Section A9 systematically evaluates key bleaching issues including a) oxygen delignification, b) the issue of ECF versus TCF including pulp properties and market for these two different products, c) the choice of ECF bleaching sequence and validation that the mills are implementing a process that may better be described as “ECF-light” for low AOX discharges, and d) an analysis of alkaline filtrate recycling, which will be examined by the pulp mills, but is considered to be an emerging technology (i.e. beyond BAT).

9. Assessment of BAT Operating Requirements

An analysis of the planning and design of key operating practices is evaluated, including the following:

- Management of residuals: Annex A, Section A10 reviews the planned residuals management strategy for each of the mills, including plans for establishing landfill sites and other environmentally-proactive strategies for certain wastes.
- Monitoring: Monitoring and reporting requirements are critical to provide data ensuring that BAT emissions are met through optimal process operation. While monitoring plans are being discussed between the mill proponents and DINAMA at the time this CIS was written, the status of these discussions is summarized in Annex A, Section A11.
- Due diligence plans: Annex A, Section A12 reviews key non-technology issues related to BAT including training, education and motivation of staff and operators, process control and process optimization, ensuring sufficient maintenance of mill assets, and the design of the environmental management system (EMS).

10. Summary of BAT Assessment

A summary of the BAT analysis is made, including a summary of process techniques employed at each mill.

This systematic and objective BAT evaluation of the mill technology and emissions permits a clear conclusion regarding the expected environmental performance of the two proposed pulp mills.

A2.0 CHARACTERIZATION OF IPPC-BAT (2001)

IPPC is the acronym for Integrated Pollution Prevention and Control. The European Union (EU) established a set of common rules for permitting and controlling industrial installations in their IPPC Directive of 1996. The IPPC Directive seeks to minimise pollution from various industrial sources throughout the EU including from the pulp and paper sector. About 50,000 industrial installations in the EU are covered by the IPPC Directive, and these installations must be brought into compliance with the standard by 30 October 2007.

The IPPC Directive is based on several principles including (1) an integrated approach, (2) best available techniques, (3) flexibility and (4) public involvement.

The integrated approach means that permits must take into account a broad perspective regarding the environmental performance of the plant, including emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, etc. This principle is being addressed by the CIS BAT methodology, including a review of DINAMA’s permitting process and likely permit requirements at the time of writing the CIS (treated in Annex A, Section A6).

The permit conditions including emission limit values must be based on Best Available Techniques (BAT). To assist licensing authorities and companies to determine BAT, the EU has published BAT Reference Documents (so-called BREFs). The pulp and paper BREF has been systematically considered in the context of this BAT assessment (Annex A, Sections A8 and A9). In Section A13 summarizing the BAT analysis, the BREF requirements for process technology are systematically summarized.

The IPPC Directive contains elements of flexibility by allowing the licensing authorities to determining permit conditions that take into account the specific technical characteristics of the installation, the geographical location of the plant, and the local environmental conditions. DINAMA’s autonomy and flexibility have been assumed throughout the development of this document.

The Directive ensures that public involvement occurs in the decision making process, by providing access to permit applications, permits, and the results of the monitoring of releases. This issue is discussed in Annex A, Section A11.

The accepted design norm for the Botnia and ENCE pulp mills until this time has been the so-called IPPC-BAT (2001) standard, which is the pulp and paper sector BREF referenced last section. The IPPC BAT (2001) is in effect the design standard for new mills or fibre lines in the European Union. It was also used by the Veracel mill in Brazil. Aracruz and Suzano in Brazil benchmark the environmental performance of their mills against the IPPC BAT (2001) standard.

The section provides a brief summary of IPPC-BAT (2001), and places it in context for this BAT review.

Specifically for the kraft pulp sector as well as for other pulp and paper sectors, the IPPC-BAT (2001) systematically a) reviews typical current processes and techniques implemented in the sector, b) summarizes the emissions from mills, and identifies environmental concerns, c) describes techniques for emission abatement, waste minimisation and energy savings that should be considered in the determination of BAT emission levels, d) defines the range of emissions to water and air that result from the implementation of BAT (see next paragraph), and e) discusses emerging techniques.

Instead of representing the environmental performance of pulp and paper mills as a single value, the emission performance in IPPC-BAT (2001) is expressed as a range. This reflects that apparently similar manufacturing techniques can employ a wide range of technologies in order to process different quantities and qualities of raw materials (e.g. softwood versus birch versus eucalyptus), in order to manufacture product for specific markets, with the consequence that emissions vary within a range. These emission ranges are summarized for the BAT assessment presented in Annex A, Section A5.

The basic techniques that are considered to be part of BAT are summarized in the paragraphs below and along with others, are addressed in this analysis as well as summarized in the summary of Annex A, Section A13.

IPPC-BAT (2001) Related to Emissions to Water

IPPC-BAT (2001) considers best available techniques (BAT) for kraft pulp mills to be the following:

- dry debarking of wood;
- increased delignification before the bleach plant by extended or modified cooking and additional oxygen stages;
- highly efficient brown stock washing and closed cycle brown stock screening;
- elemental chlorine free (ECF) bleaching with low AOX or Totally chlorine free (TCF) bleaching;
- recycling of some (mainly alkaline) process water from the bleach plant;
- effective spill monitoring, containment and recovery system;
- stripping and reuse of the condensates from the evaporation plant;
- sufficient capacity of the black liquor evaporation plant and the recovery boiler to cope with the additional liquor and dry solids load;
- collection and reuse of clean cooling waters;
- provision of sufficiently large buffer tanks for storage of spilled cooking and recovery liquors and dirty condensates to prevent sudden peaks of loading and occasional upsets in the external effluent treatment plant; and

- in addition to process-integrated measures, primary treatment and biological treatment is considered BAT for kraft pulp mills.

IPPC-BAT (2001) Related to Emissions to Atmosphere

Point source and fugitive emissions from kraft pulp mills to the atmosphere originate may from the recovery boiler, lime kiln, bark furnace, chip storage, digester, pulp washing, bleach plant, bleaching chemicals preparation, evaporation, screening, washing, white liquor preparation, and storage tanks including wastewater treatment. The main point sources from the process include the recovery boiler, the lime kiln and auxiliary biomass boiler (only in the case of the ENCE-CMB mill). Emissions to the atmosphere consist mainly of nitrogen oxides (NO_x), sulphur-containing compounds such as sulphur dioxide (SO_2), and malodorous reduced sulphur compounds (TRS). In addition, there are emissions of particulates (PM10). By systematically considering each of these potential impacts, IPPC-BAT (2001) considers best available techniques for kraft pulp mills to be the following:

- Collection and incineration of concentrated malodorous gases (concentrated NCGs or LVHCs), and control the resulting SO_2 emissions. The strong gases can be burnt in the recovery boiler, in the lime kiln, or in a separate low NO_x furnace. The flue gases of the latter have a high concentration of SO_2 that should be treated in a scrubber.
- Diluted malodorous gases (dilute NCGs or HVLCs) from various sources must be collected and incinerated, and the resulting SO_2 controlled.
- TRS emissions of the recovery boiler should be mitigated by efficient combustion control and CO measurement;
- TRS emissions of the lime kiln should be mitigated by controlling the excess oxygen, by using low-S fuel, and by controlling the residual soluble sodium in the lime mud fed to the kiln.
- The SO_2 emissions from the recovery boilers should be controlled by firing high dry solids concentration black liquor in the recovery boiler and/or by using a flue gas scrubber;
- NO_x emissions from the recovery boiler, lime kiln and from auxiliary boilers should be controlled through the firing conditions, and by appropriate design; in the recovery boiler, this can be through ensuring proper mixing and division of air in the boiler
- SO_2 emissions from auxiliary boilers should be reduced by using bark, gas, low sulphur oil and coal or controlling S emissions with a scrubber.
- Flue gases from recovery boilers, auxiliary boilers (in which wood waste and/or fossil fuels are incinerated) and lime kiln should be treated by efficient electrostatic precipitators.
- Application of cogeneration of heat and power

- Use of renewable sources of fuel, such as wood or wood waste in auxiliary boilers to reduce the emission of fossil CO_2.

IPPC-BAT (2001) Related to Emissions to Good Process Operation and Maintenance

The IPPC-BAT (2001) BREF recognizes that best available process and abatement technologies must be implemented in combination with the following operating and maintenance practices:

- training, education and motivation of staff and operators;
- process control optimisation;
- sufficient maintenance of the technical units and the associated abatement techniques; and
- environmental management system which optimises management, increases awareness and includes goals and measures, process and job instructions, etc.

A3.0 CHARACTERIZATION OF TASMANIAN–AMT (2004)

In addition to the accepted environmental standard for the Botnia and ENCE pulp mills called IPPC-BAT (2001), the Tasmanian-AMT (2004) emission rates have been considered in this BAT review. The section provides a brief summary of the Tasmanian-AMT (2004) standard.

Australian industry is based to a great extent on resource extraction. Australia is a net importer of wood pulp and an exporter of wood chips, so for a number of years there has been interest in developing a pulp mill in Tasmania, the Southern most State in Australia. In this context, the Tasmanian Government sought to develop environmental guidelines for any new bleached eucalypt kraft pulp (BEKP) mill, and the Tasmanian Resource Planning and Development Commission (RPDC) established and published these in August 2004 (see reference in Annex A, Section A1).

The Tasmanian guidelines are based on a review of state-of-the-art kraft pulp mill technologies and management practices, aimed at minimizing the environmental impact of pollutants released from BEKP mills. The RPDC report uses the term “accepted modern technology” or “AMT” to describe a “technology which has a demonstrated capacity to achieve the desired emission concentration in a cost-effective manner, takes account of cost-effective engineering and scientific developments and pursues opportunities for waste minimization.”

The development of these guidelines considered Australian legislation defining best practice environmental management (BPEM) and accepted modern technologies (AMT), as well as international definitions of best available techniques (BAT). The Tasmanian guidelines specifically consider IPPC-BAT (2001) to a great extent, and as well the United Nations Environment Program Stockholm convention on persistent organic pollutants, the US Environmental Protection Agency Cluster Rule, and environmental regulations in jurisdictions across Europe and North America.

In that the Tasmanian-AMT (2004) standard has been developed specifically for eucalyptus mills and are more recent than other BAT guidelines, they have been considered the BAT assessment for the Botnia-Orion and ENCE-CMB pulp mills.

The technology listings and definitions from this regulation are provided in the following four tables. These define general measures for the following:

- Best practice environmental management (BPEM);
- AMT for the reduction of impact to the aquatic environment;
- AMT for the reduction of emissions to the atmosphere; and
- AMT for the reduction and handling of solid waste.

The report presenting the Tasmanian-AMT (2004) standard includes a summary of emerging technology that might be considered beyond AMT. Emerging technologies that were considered beyond AMT in the Australian review included for example partial system closure (including bleach filtrate recycling to recovery), black liquor gasification, enzyme treatment of pulp, and hexenuronic acid removal. Two of these technologies are particularly relevant to the Botnia-Orion and ENCE-CMB mills (bleach filtrate recycling to recovery and hexenuronic acid removal), and will be discussed in more detail in Section A9.

Table A3-1: Tasmanian-AMT (2004) Measures for Best Practice Environmental Management

High standards of maintenance	• To maintain the efficiency of the unit operations of pulp mills and the associated pollution abatement technologies at a high level
Emissions monitoring	• Development and implementation of protocols for monitoring the performance of pollution abatement facilities and compliance with environmental permits
Environmental Management System (EMS)	• A system which clearly defines the responsibilities for environmentally relevant aspects of a mill. It raises awareness of issues and includes goals and measures, process and job instructions, check lists and other relevant documentation • The EMS needs to be independently audited to an international standard and include environmental monitoring and a response mechanism • The reporting framework of the EMS needs to be open and transparent • Community consultation is recommended to ensure interested communities are informed and involved in any new kraft mill development and its impact on them
Planning	• Investment planning/cycles, co-ordination of process improvements to reduce technical bottlenecks and to introduce AMT
Process control monitoring and optimisation	• To be able to reduce different pollutants simultaneously and to maintain low emissions • Raw materials specification and monitoring of raw materials for precursor materials
Substitution	• Identification and substitution of potentially harmful compounds with less harmful alternatives • Use of a detailed inventory of raw materials used, chemical composition, quantities, fate and environmental impact
Training, education and motivation of personnel	• Pulp and paper mills are operated by people. Training of staff can be a very cost-effective way to reduce environmental impact and use of resources

Table A3-2: Tasmanian-AMT (2004) for Emissions to the Aquatic Environment

Topic or Mill Area	Description of AMT
Avoidance of synthetic dioxin precursors	• Exclusion of wood chips produced from wood treated with polychlorinated phenols • Exclusion of defoamers containing more than 10 ppb dibenzo-p-dioxin and 40 ppb dibenzofuran by weight • Exclusion of polychlorinated phenols in paint, cutting oils and other inadvertent inputs to the process
Optimised wood Handling	• Optimisation of raw material storage, seasoning period, chipping process, chip storage and chip dimensions • Dry debarking
Pulping and brown stock processing	• Modified batch cooking or modified continuous cooking Closed brown stock screening and washing (i.e. return of all filtrates to chemical recovery) • Oxygen delignification followed by efficient washing (99% overall recovery of dissolved wood solids and pulping chemicals from the pulp)
Chemical recovery and handling of accidental discharges	• Effective control, containment, recovery and storage of all spills, leakages and releases of process liquids and solids and avoidance of any loss of these materials prior to their re-introduction to the process or their disposal in an approved manner • Adequate size of black liquor evaporation plant and recovery boiler to handle additional liquor and dry solids loads due to collection of spills and possible recycle of selected bleach plant effluents • Stripping and appropriate reuse of foul condensates • Collection and reuse of clean cooling and sealing waters, including those from cooling towers • Efficient washing of lime mud
Bleaching chemical preparation	• On-site generation of chlorine dioxide with low contamination of elemental chlorine (methanol or hydrogen peroxide processes)
Effluent treatment	• Primary and secondary (biological) treatment of all process effluent, excluding uncontaminated cooling water • Anoxic selector for chlorate reduction • Provision of containment basin(s) to temporarily store, for subsequent treatment, untreated process effluent that has sufficiently high levels of contamination to adversely affect the operation of the effluent treatment plant
Cooling water	• Recirculation to a cooling tower and reuse of indirect cooling water

Table A3-3: Tasmanian-AMT (2004) for Emissions to the Atmosphere

Pollutant	Description of AMT
Chlorine dioxide and related compound	• Collection and scrubbing in the bleach plant scrubber, which uses alkaline scrubbing media • Collection and scrubbing in the chlorine dioxide plant environmental scrubber, which uses alkaline scrubbing media
Inorganic chlorinated compounds	• Collection and scrubbing in the bleach plant scrubber, which uses alkaline scrubbing media • Collection and scrubbing in the chlorine dioxide plant environmental scrubber, which uses alkaline scrubbing media
Total reduced sulfur (TRS)	• Collection and incineration of concentrated non condensable gases (CNCG) in either the recovery boiler or a stand-alone low-NO_x incinerator • Backup system for the CNCG – which is activated during upsets, maintenance or other downtimes of the main system – consisting of: a flare/incinerator and secondary incineration unit (e.g. the lime kiln), or a pre-purged alternative disposal point immediately available with interlocks permitted to allow switching without venting (bump less transfer) to a power boiler • Methanol recovery from the foul condensate stripper off-gases • Collection and incineration of dilute NCG (DNCG) in the recovery boiler after their addition to its secondary or tertiary combustion air • For the recovery boiler: computerised combustion control and carbon monoxide (CO) measurement • For the lime kiln: control of the excess oxygen, use of low-sulfur fuel, and control of the residual soluble sodium in the lime mud fed to the kiln • Spot monitoring program carried out by measuring odour with a mobile gas chromatograph/mass spectrometer (GC-MS). Testing will be more frequent initially and less frequent later in the program
Dioxins and furans	• Inhibiting the formation of dioxins and furans within power and recovery boilers by appropriate design to achieve the most suitable time/temperature profile, and by appropriate operation including control of oxygen content, instituting systematic sootblowing, and the firing of fuels having minimum contamination with dioxins, furans and their precursors to minimise dioxins and furans in the flue gases

Table A3-3: Tasmanian-AMT (2004) for Emissions to the Atmosphere (cont'd)

Pollutant	Description of AMT
Sulfur dioxide (SO_2)	• For the recovery boiler: firing of black liquor with high dissolved solid concentration to mitigate SO_2 formation or flue gas scrubbing, or both • For a standalone CNCG incinerator: flue gas cooling with either steam boiler or quench coolers and flue gas scrubbing • For the power boiler: use of bark, gas, low-sulfur oil, low-sulfur coal or flue gas scrubbing
Nitrogen oxides (NO_x)	• For the recovery boiler: control of combustion temperature profile; air distribution and excess air; and black liquor nitrogen content; and also appropriate design (low NO_x) For the lime kiln: control of firing conditions and also appropriate design (low NO_x) • For the power boiler: control of firing conditions and also appropriate design (low NO_x)
Particulate matter (PM) or dust	• Cleaning of the flue gases from the recovery boiler, the power boiler (in which other biofuels or fossil fuels, or both are burned) and the lime kiln with efficient electrostatic precipitators

Table A3-4: Tasmanian-AMT (2004) for the Reduction and Handling of Solid Waste

- Minimised generation of solid waste and recovery, recycle and reuse of these materials as far as possible
- Separate collection of waste fractions at the source and, if necessary, intermediate storage of residuals/ waste to make possible an appropriate handling of the remaining waste products
- Incineration of all non-hazardous organic material (e.g. bark, wood waste, effluent sludge) in a power boiler, specially designed for burning of moist, low calorific value fuels (e.g. a fluidised bed boiler). Biosludge may be burned in the recovery boiler. All material to be burned after pressing to the maximum possible consistency
- Disposal of hazardous waste should be carried out by authorised firms only
- Material that cannot be reused, recovered or has to be handled differently should be taken to a secure landfill facility. Only inert, primarily inorganic waste should be landfilled. All material to be landfilled after pressing to the maximum possible consistency. Organic waste should not be landfilled
- Generation of dioxins and furans can occur in the convection back passes (the cooler sections) of power and recovery boilers. Depending on concentrations, dusts from these sections should be managed in the same way as other special wastes and not spread on land
- Efficient washing of green liquor dregs prior to disposal to landfill, to minimise leaching of caustic
- Efficient washing of lime mud prior to reuse in the lime kiln to minimise the formation of hydrogen sulfide (H_2S) during the mud drying process
- External utilisation of residuals/waste as substitutes in forestry, agriculture or other industries, if possible and subject to approval under the Waste Management Regulations 2000

A4.0 ESTIMATE OF MILL EMISSION RATES

The predominant kraft pulp process effluent contaminants include oxygen-consuming organic substances that are measured as Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD). Effluent from the bleach plant, where chlorine-containing bleaching chemicals are used, can contain organically bound chlorine compounds, measured as Absorbable Organic Halides (AOX). Kraft pulp mill emissions to the atmosphere consist mainly of products of combustion, including particulate matter, NO_x and SO_2, as well as malodorous reduced sulphur compounds, commonly referred to as total reduced sulphur (TRS) compounds. From the bleach plants and preparation of bleaching chemicals chlorine compounds may escape to the atmosphere.

A number of other contaminants are emitted in very small quantities, as discussed below.

A careful assessment of average and maximum discharge emission rates was completed by the mill proponents, and reviewed by the CIS project team. Experience of mill staff, mass and energy balances, vendor performance guarantees, operating experience of mills with similar design and other design considerations are the bases for the estimation of emission factors for the pulp mills presented in Tables A4-1, A4-2 and A4-3. Basic emission criteria were used to estimate the long term average, monthly max and daily max estimates presented in Table A4-1. Metals and their salts are generally referred to as non-process elements (NPEs) in kraft pulping processes, because they serve no useful purpose in the process. They enter the process primarily with the wood, in which they may be present as nutrients. They have been estimated as concentrations, as shown in Table A4-2, however there is some uncertainty over these values due to uncertainty over the variable metals content of the local eucalyptus wood furnish, which can vary more than for other furnish types depending primarily on soils. The water and air emission rate estimates in the tables are for mill-wide emissions, and their values consider mill experience and the process technology used at the respective pulp mills.

Botnia-Orion's effluent metals estimates expressed in Table A4-2 are higher than ENCE-CMB's, although both mill proponents' estimates for these clearly comply with DINAMA's limits. Botnia has performed several laboratory tests to assess the metals content of eucalyptus but has not had conclusive results because of the significant variability resulting from different soils and eucalyptus species. ENCE has operating experience with eucalyptus, from where the effluent metals derive. ENCE has manufactured pulp from Uruguayan eucalyptus species and thus has reliable information in this respect. Because of the technological and raw material similarities between the two mills, Botnia's metal concentrations in the effluent are likely to match ENCE's estimates, however they do not have a scientific basis to lower their estimates from those presented. Given the normal range of variation in metals data, one can expect differences in estimates between experts.

The emission data provided by the two mills are reasonably consistent, and can be considered to be nearly identical within the context of normal process variability and design uncertainty. Based on the technology to be employed at the proposed pulp mills, it is likely that both the Botnia-Orion and ENCE-CMB plants can perform at the levels indicated in these tables or better. In the case of nutrients, while the mill estimates for N and P discharge can be considered as good relative to most mills, they are not amongst the best in the world.

Operationally, these results will depend on the mills implementing best practices for the integrated operation of different process areas. Plant management and associated monitoring and reporting will provide the data for confirmation that the plants are being operated optimally. Monitoring and due diligence plans related to training, control, maintenance and operation are discussed further in this Annex, in Sections A11 and A12.

Table A4-1: Estimates of Effluent Emission Rates for the Two Pulp Mills

Parameter	Botnia-Orion			ENCE-CMB		
	Long term average (annual) (kg/ADt)	Monthly max (kg/ADt)	Daily max (kg/ADt)	Long term average (annual) (kg/ADt)	Monthly max (kg/ADt)	Daily max (kg/ADt)
Ammonia (free)	0,016	0,026	0,048	0,020	0,030	0,060
AOX	0,08	0,15	0,20	0,10	0,22	0,32
BOD$_5$	0,30	0,70	1,50	0,60[1]	1,30	1,74
COD	8,0	15	30	8,7	19	29
Colour	9,0	10,0	25,0	6,4	11,0	23,0
Conductivity	<5000 µS/cm	5000 µS/cm	8000 µS/cm	<4000 µS/cm	4000 µS/cm	6500 µS/cm
Cyanide[2]	~0	<0,00625	<0,0125	0,0003	<0,006	<0,01
Detergents	~0	<0,025	<0,05	~0	<0,09	<0,12
Dioxins/furans	<2,5x10^{-10}	-	-	<2,9x10^{-10}	-	-
Fecal coliforms	~0	-	-	~0	-	-
Floating material	~0	-	-	~0	-	-
N total	0,15	0,26	0,52	0,17	0,30	0,60
Nitrates (NO$_3$)	0,08	0,13	0,24	0,09	0,14	0,30
Resin and fatty acids	Practically no RA	Practically no RA	Practically no RA	<0,0006	<0,0006	<0,0006
Oil and grease	~0	<0,31	<0,63	~0	<0,35	<0,70
P total	0,012	0,030	0,060	0,017	0,035	0,070
pH	7,5	6,0-9,0	6,0-9,0	6,0-9,0	6,0-9,0	6,0-9,0
Phenolic compounds	<5,5x10^{-5}	<5,5x10^{-5}	<1x10^{-5}	<2,9x10^{-5}	<4,6x10^{-5}	<8,7x10^{-5}
Sulphides	0,006	0,006	0,013	0,005	0,005	0,012
Temperature	28 ºC	30 ºC	30 ºC	< 30 ºC	< 30 ºC	< 30 ºC
TSS	0,7	1,3	2,6	0,9	1,6	2,4

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[1] This value has been guaranteed by system suppliers, with whom ENCE is still in negotiation.

[2] The presence of cyanide in mill effluents is variable, and extremely difficult to predict.

Table A4-2: Estimates of Metal Concentrations in the Effluent for the Two Pulp Mills

Metal	Botnia-Orion			ENCE-CMB		
	Long term average (annual) (mg/L)	Monthly max (mg/L)	Daily max (mg/L)	Long term average (annual) (mg/L)	Monthly max (mg/L)	Daily max (mg/L)
Cadmium (Cd)	<0,008	<0,012	<0,012	<0,003	<0,05	<0,05
Lead (Pb)	<0,05	<0,076	<0,076	<0,01	<0,3	<0,3
Copper (Cu)	<0,16	<0,24	<0,24	<0,0001	<1,0	<1,0
Nickel (Ni)	<0,32	<0,20	<0,20	<0,07	<0,2	<0,2
Zinc (Zn)	<0,044	<0,068	<0,068	<0,003	<0,3	<0,3
Arsenic (As)	<0,08	<0,12	<0,12	<0,01	<0,5	<0,5
Chromium (Cr)	<0,16	<0,24	<0,24	<0,03	<0,5	<0,5
Mercury (Hg)	<0,0025	-	-	0,002	-	-

Table A4-3: Estimates of Atmosphere Emission Rates for the Two Pulp Mills

Parameter	Botnia-Orion			ENCE-CMB		
	Annual average (kg/ADt)	Monthly max (kg/ADt)	24-h max (kg/ADt)	Annual average (kg/ADt)	Monthly max (kg/ADt)	24-h max (kg/ADt)
Carbon Monoxide (CO)	1,70	2,00	-	1,70	2,40	3,00
Sulphur Dioxide (SO_2) (as S)	0,30	0,60	2,50	0,23	0,33	1,4
Nitrogen Oxides (NO_x) (as NO_2)	1,35	1,50	1,60	1,30	1,84	1,97
Total Suspended Particulate Matter (TSP)	0,30	0,50	0,80	0,34	0,60	0,90
Inhalable Particulate Matter (PM_{10})	0,26	0,45	0,75	0,31	0,55	0,82
Total Reduced Sulphur (TRS) (as S)	0,050	0,100	0,300	0,030	0,060	0,20
Volatile Organic Compounds	0,10	-	-	0,33	-	-

A5.0 MILL EMISSION RATES COMPARISON WITH BAT EMISSION RATES

In Section A4, the effluent and air emission rates estimated by the mill proponents were examined, and it was concluded that the estimates are reasonable for the pulp mill technology bases being proposed for the Botnia-Orion and ENCE-CMB pulp mills. This section compares the mill emission rates expressed in Section A4 with achievable BAT emission levels defined by the IPPC-BAT (2001) standard. The Tasmanian-AMT (2004) standard was also considered, to account for emission rates from a more current definition of appropriate environmental protection measures which are specific to the eucalyptus pulp industry. The proposed pulp mills are also benchmarked with certain state-of-the-art operating bleached eucalyptus kraft pulp (BEKP) mills in Brazil, as well as with emissions from other comparable Botnia and ENCE mills (upon which certain design features of the proposed mills were based).

The emission values provided in IPPC-BAT (2001) and Tasmanian-AMT (2004) are expressed as loads, i.e. in units of kg per tonne of product, for long term average (LTA) values. IPPC-BAT (2001) specifies that “where a level is described as achievable using a particular technique or combination of techniques, this should be understood to mean that the level may be expected to be achieved over a substantial period of time in a well maintained and operated installation or process using those techniques”.

The long-term average (LTA) effluent emission data presented in BAT standards have been used in this CIS as the basis for the estimation of corresponding annual, monthly and daily maximum values for emission rates. The LTA values apply to biologically treated effluents that are measured at the point of discharge. For discharges to the atmosphere, in order to consider a consistent set of comparable data, only Total S and NO_x could be considered. The emission levels for particulate matter (or TSP) for emissions out of biomass boilers could also be compared with ENCE-CMB’s biomass boiler.

Finally, the USEPA New Source Performance Standards (NSPS) were considered particularly with respect to the control of dioxins and furans from the bleach plant. Compared to recent permit requirements in Europe, the NSPS standard for BOD_5, AOX and COD discharges in the US Cluster Rules are comparable but generally not as strict.

The LTA emission rates were used for the comparison of the proposed mills with BAT standards and existing modern eucalyptus mills, as well as with company comparable mills. Data presented for emission rates from mills in Brazil, Finland and Spain have been averaged, and reflect the average performance for a particular year.

Table A5-1 compares effluent discharges for the proposed new pulp mills with the IPPC-BAT (2001), Tasmanian-AMT (2004) and USEPA NSPS levels of 1997. Note that in the case of effluent, recommendations from the Tasmanian-AMT (2004) standard were based on the IPPC-BAT (2001) guidelines, and so are the same.

In terms of emissions to water, both the Botnia-Orion and the ENCE-CMB pulp mill emission estimates fall within the recommended ranges for long term operation developed in the BAT standards, and in the case of flow, the mills will perform better than the suggested lower limit. All estimated emission rates fall in the lower half of the BAT ranges and in some cases, especially in the case of the Botnia-Orion mill, the achievable lower limit is met.

Based on this analysis it is concluded that for overall effluent discharges, both mills meet the BAT standards contained in IPPC-BAT (2001) and Tasmanian-AMT (2004). Both the Botnia-Orion and ENCE-CMB pulp mills also comply with USEPA NSPS standards for dioxins and furans.

Table A5-2 presents atmospheric emission estimates from the Botnia-Orion and ENCE-CMB pulp mills, as well as the standard for IPPC-BAT (2001) and Tasmanian-AMT (2004). Both mill emission estimates fall within the recommended IPPC-BAT ranges for all parameters. Quite critically, the technology employed in both mills with regards to odorous gases will lead to very low TRS discharge levels significantly below those recommended by IPPC-BAT (2001), and as well will minimize or virtually eliminate emissions during certain process upset conditions.

To compare ENCE-CMB's emissions from the biomass boiler, the TSP from biomass boilers was considered. Modern biomass boilers such as the one that will be installed at the ENCE-CMB facility are equipped with electrostatic precipitators (ESP's) with cleaning efficiencies well in excess of 95%.

With regards to NOx, Botnia will possibly exceed the Tasmanian-AMT level. Botnia is concerned that a higher content of N in the incoming wood will lead to a higher generation of NOx in the recovery boiler. Botnia will install a vertical air system in its recovery boiler to minimize the formation of NOx and may operate at a lower level of NOx emissions than that which is indicated. The draft integrated impact statement for the bleached eucalypt kraft pulp mill proposed by GUNNS in Tasmania also indicates similarly that they do not expect to be able to meet the Tasmanian AMT guideline for NOx.

Table A5-1: Comparison of Botnia-Orion and ENCE-CMB Effluent Discharge Estimates with IPPC-BAT (2001) Tasmanian-AMT (2004) and USEPA NSPS Levels of 1997

Parameter	Units	Botnia-Orion Long term average (annual)	ENCE-CMB Long term average (annual)	IPPC-BAT (2001) Long term average[1]	Tasmanian-AMT (2004) Long term average[2]	USEPA NSPS[3] Annual average
AOX	kg/ADt	0,08	0,10	0 – 0,25	0 – 0,25	0,208
BOD_5	kg/ADt	0,30	0,60	0,3 – 1,5	0,3 – 1,5	1,73
COD	kg/ADt	8,0	8,7	8 – 23	8 – 23	28
Flow	m^3/ADt	25	29	30 – 50[4]	30 – 50[5]	-
N total	kg/ADt	0,15	0,17	0,10 – 0,25[6]	0,10 – 0,25	-
P total	kg/ADt	0,012	0,017	0,010 – 0,030[7]	0,010 – 0,030	-
TSS	kg/ADt	0,7	0,9	0,6 – 1,5	0,6 – 1,5	2,72
Dioxins/furans	pg/L	<10	<10	-	<10/31,9[8]	<10/31,9[6]

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[1] These emission levels are associated with the use of a suitable combination of best available techniques after biological treatment for bleached Kraft non-integrated and integrated pulp mills.

[2] Recommended long term average emission levels to the aquatic environment generally achieved by new bleached kraft pulp mills employing Achievable Modern Technology/Best Management Environment Practices (AMT/BPEM). These values have been based on the IPPC-BAT (2001) document.

[3] Discharges that result from use of EPA's NSPS technology basis, as described in *Supplemental Technical Development Document for Effluent Guidelines and Standards (Subparts B and E),* EPA Document No. EPA-821-R-97-011, October 1997.

[4] Cooling water and other clean water are discharged separately and are not included.

[5] Cooling water and other clean water are discharged separately and are not included.

[6] Any nitrogen discharge associated with the use of complexing agents should be added to the figure of total N. This comment is also valid for the Tasmanian-AMT values.

[7] Eucalyptus has a higher content of phosphorus in wood than other wood furnish types, and the mills may not achieve these values if P is in excess of the need of the biological treatment plant. In this case, emissions will be determined by P-content of the wood. This comment is also valid for the Tasmanian-AMT values.

[8] The first value of 10 pg/L is for dioxins. The 31,9 pg/L value for furans is a daily maximum value.

Table A5-2: Comparison of Botnia-Orion and ENCE-CMB Air Emission Estimates with IPPC-BAT (2001) and Tasmanian-AMT (2004)

Parameter	Units	Botnia-Orion Long term average (annual)	ENCE-CMB Long term average (annual)	IPPC-BAT (2001) Long term emission levels[9]	Tasmanian-AMT (2004) Annual average[10]
TSP	kg/ADt	0,30	0,34	0,2 – 0,5	-
TSP from biomass boiler	mg/Nm^3	-	30	-	10 – 30[11] @ 6% O_2
Total S	kg/ADt	0,35	0,26	0,3 – 0,6	0,4
SO_2 as S	kg/ADt	0,30	0,23	0,2 – 0,4	-
NO_x as NO_2	kg/ADt	1,35	1,30	1,0 – 1,5	1,30
TRS as S	kg/ADt	0,05	0,03	0,1 – 0,2	-

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[9] Emission levels from the pulping process associated with the use of a suitable combination of best available techniques (emissions from any auxiliary boiler are not included). Process related emissions include recovery boiler(s), lime kiln(s), fugitive emissions and separate furnaces (e.g. for TRS incineration) linked to the process, if any. Values for bleached and unbleached Kraft pulp mills are not distinguished because there is no significant technical difference to consider.

[10] Total reduced sulphur (TRS), sulphur dioxide (SO_2), sulphur trioxide (SO_3) and sulphuric acid mist are included in millwide sulphur emissions from all sources excluding power boiler because the emission of SO_2 from the power boiler depends on fuel sulphur content. Nitrogen oxides are similarly included in millwide NO_x from all sources excluding power boiler.

[11] When electrostatic precipitators (ESP) are employed.

In Tables A5-3 and A5-4, the Botnia-Orion and ENCE-CMB estimated mill emission rates are compared with targeted best practice mills in Brazil[12], namely:

- Veracel and Suzano-Mucuri, in the State of Bahia,
- Aracruz – Barra do Riacho, in the State of Espírito Santo and
- Aracruz – Guaiba, in the State of Rio Grande do Sul.

Table A5-3 compares the pulp mill effluent discharge estimates with the average discharges with the above-referenced mills shows that the proposed pulp mills will achieve comparable levels of environmental performance, and will likely have better performance in some cases. Of particular interest, the proposed pulp mills compare favourably with Veracel, which is the newest BEKP mill in Brazil.

Table A5-4 compares the expected long term performance from Botnia-Orion and ENCE-CMB with regards to emission of sulphur dioxide, nitrogen dioxide and total suspended particulate matter with three Brazilian BEKP mills. Comparable data are available only for a limited number of parameters; however, the proposed mills compare favourably with the other BEKP mills, and expect to perform better with respect to NO_x and TSP.

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[12] Data on the emission rates from these BEKP mills was taken from their 2005 sustainability and annual reports available on their respective Websites, except where specified otherwise.

Table A5-3: Comparison of Estimated Botnia-Orion and ENCE-CMB Effluent Discharges with Selected Modern Pulp Mills

Parameter	Units	Botnia-Orion Long term average (annual)	ENCE-CMB Long term average (annual)	Veracel Annual average[13]	Aracruz-Barra do Riacho Annual average[14]	Aracruz-Guaiba Annual average[15]	Suzano-Mucuri Annual average[16]
AOX	kg/ADt	0,08	0,10	0,1	0,09	0,08	0,08
BOD	kg/ADt	0,30	0,60[17]	0,7	1,3[18]	0,18	0,2
COD	kg/ADt	8,0	8,7	11,0	15,5	3,19	4,5
Flow	m^3/ADt	25	29	24	35,3[19]	27,9	33,9
N total	kg/ADt	0,15	0,17	0,2	N/A	0,27	N/A
P total	kg/ADt	0,012	0,017	0,01	N/A	0,028	N/A
TSS	kg/ADt	0,7	0,9	N/A	1,22	0,64	N/A
Colour	kg/ADt	9,0	6,4	N/A	30,4[20]	8,8	8,0[21]

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[13] Information on all parameters taken from the 2005 Veracel Sustainability Report.

[14] Information on all parameters taken from the 2005 Aracruz Sustainability Report.

[15] Information on all parameters taken from the 2005 Aracruz Sustainability Report, except for Total N and Total P values which were taken from the “Recommended environmental emission limit guidelines for any new bleached eucalypt Kraft pulp mill in Tasmania” document (August 2004).

[16] Information on all parameters taken from the 2005 Suzano Papel e Celulose Annual Report, except for colour. The effluent treatment plant at Suzano-Mucuri uses an aerated lagoon.

[17] This value was provided by the suppliers with whom ENCE is in the final stage of negotiation.

[18] The higher BOD value for this mill can be due to the use of an aerated stabilization basin for secondary treatment.

[19] Production went up from 2 093 002 t/y in 2004 to 2 134 530 t/y in 2005 and this caused the effluent flow to go up compared with 2004.

[20] It is common for effluent colour to remain stable or even increase across the aerated stabilization basin (ASB) process. This could explain this higher value.

[21] This value is dated 2003 and is taken from “Independent Advice On The Development Of Environmental Guidelines For Any New Bleached Eucalypt Kraft Pulp Mill In Tasmania – Reported Emissions From Secondary Effluent Treatment Of Bleached Kraft Pulp Mills Annual Averages”, 2004.

Table A5-4: Comparison of Estimated Botnia-Orion and ENCE-CMB Atmospheric Discharges with Selected Modern Pulp Mills

Parameter	Units	Botnia-Orion Long term average (annual)	ENCE-CMB Long term average (annual)	Veracel Annual average[22]	Aracruz-Barra do Riacho Annual average[23]	Aracruz-Guaiba Annual average[24]
Sulphur Dioxide (SO_2) (as S)	kg/ADt	0,30	0,23	0,022[25]	N/A	N/A
Nitrogen Oxides (NO_x) (as NO_2)	kg/ADt	1,35	1,30	2,11	N/A	N/A
Total Suspended Particulate Matter (TSP)	kg/ADt	0,30	0,34	N/A	0,64	2,24

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[22] Information on all parameters taken from the 2005 Veracel Sustainability Report.

[23] Information on all parameters taken from the 2005 Aracruz Sustainability Report.

[24] Information on all parameters taken from the 2005 Aracruz Sustainability Report.

[25] The emission rates have been corrected to 8% oxygen for the recovery and auxiliary boilers and to 10% oxygen for the lime kiln.

In the following tables, the Botnia-Orion and ENCE-CMB are compared with company mills in Finland and Spain. While these company mills do not operate with the same technology, wood species or under the same regulatory requirements as the proposed mills, their analysis is useful to add the perspective of the design and operation experience of the mill proponents for their projects in Uruguay.

Table A5-5 first compares the Botnia-Orion proposed pulp mill with two pulp mills from Botnia, namely their Joutseno and Kaskinen mills. Botnia's wastewater treatment plant (WWTP) in Kaskinen, was the main model on which Botnia relied for the design of the Botnia-Orion WWTP, even though results and experience from all of the company's effluent treatment plants were also considered. The Joutseno WWTP treats the wastewater generated by a softwood pulp mill which uses more or less the same technology that the Botnia-Orion mill will use, however which is integrated with a BCTMP plant. In the case of emissions to water, the proposed Botnia-Orion mill is expected to achieve a similar level of performance as the Joutseno and Kaskinen mills. Joutseno achieves higher performance levels for TSS removal because of a 2-day polishing lagoon following the secondary clarifiers.

Table A5-5: Comparison of Botnia-Orion Effluent Discharge Estimates with Comparable Company Mills

Parameter	Units	Botnia-Orion Long term average (annual)	Botnia-Joutseno Annual average[26]	Botnia-Kaskinen Annual average
AOX	kg/ADt	0,08	0,13	0,06[27]
BOD	kg/ADt	0,30	0,21	0,21
COD	kg/ADt	8,0	9,2	10,1
Flow	m^3/ADt	25	38,7	48,7
N total	kg/ADt	0,15	0,13	0,11
P total	kg/ADt	0,012	0,011	0,015
TSS	kg/ADt	0,7	0,2	0,6

From the perspective of air emissions, Joutseno is included in this comparison because it uses similar process technology that will be used at the Orion mill, namely continuous cooking, recovery boiler, evaporators and lime kiln. Some differences exist, for example

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[26] The Joutseno facility uses a polishing lagoon of a 2 day residence time between the secondary clarifiers and the lake in which it discharges. All measurements shown in this table are taken from the effluent flowing from the lagoon to the lake. Lower numbers can be explained by the presence of this lagoon, especially with regards to TSS and nutrients.

[27] At the Kaskinen mill, ozone is used together with ClO_2, and certain grades are bleached without ClO_2 altogether, in the bleaching sequence which results in a low AOX value.

Joutseno uses natural gas instead of heavy fuel oil, and does not have a reserve burner for HVLC odorous gases. The pulping sulphidity level is significantly higher at Joutseno compared to the Orion mill.

Table A5-6 shows that the Orion facility should perform well compared to the other mills. Particularly in the case of TRS, lower emissions of odorous gases are expected.

Table A5-6: Comparison of Botnia-Orion Air Emissions Estimates with Comparable Company Mills

Parameter	Units	Botnia-Orion Annual average	Botnia-Joutseno Annual average[28]	Botnia-Kaskinen Annual average[29]
Carbon Monoxide (CO)	kg/ADt	1,70	N/A	N/A
Sulphur Dioxide (SO_2) (as S)	kg/ADt	0,30	0,08	0,82
Nitrogen Oxides (NO_x) (as NO_2)	kg/ADt	1,35	1,69	1,82
Total Suspended Particulate Matter (TSP)	kg/ADt	0,30	0,22[30]	0,57
Inhalable Particulate Matter (PM_{10})	kg/ADt	0,26	N/A	N/A
Total Reduced Sulphur (TRS) (as S)	kg/ADt	0,050	0,065	0,11

ENCE has used a combination of equipment vendor experience and their experience with the Huelva and Pontevedra eucalyptus pulp mill in Spain to design the CMB BEKP mill. The emissions from these mills are presented in Tables A5-7 and A5-8. While both mills are processing eucalyptus pulp, the Huelva pulp mill uses an ECF bleaching process whereas the TCF bleaching process is implemented at the Pontevedra facility.

In the case of ENCE-CMB, both effluent and air emissions levels compare favourably with data from the Huelva and Pontevedra pulp mills. With respect to effluent emissions, the CMB mill will operate at lower long term discharge rates than other ENCE mills for all parameters except for AOX (see footnote on the Pontevedra AOX value).

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[28] From 2004. Provided by Botnia by e-mail communication. The Joutseno mill uses natural gas instead of heavy fuel oil which results in low SO_2 emissions.

[29] From 2004. Provided by Botnia by e-mail communication.

[30] It is to be noted that the PM10 measurements are derived from the flue gases opacity measurements at the mill which can lead to large errors. This number should be carefully taken into consideration.

Table A5-7: Comparison of ENCE-CMB Effluent Discharge Estimates with Comparable Company Mills

Parameter	Units	ENCE-CMB Long term average (annual)	ENCE-Huelva Annual average	ENCE-Pontevedra Annual average
AOX	kg/ADt	0,10	0,20	0,004[31]
BOD	kg/ADt	0,60	-	2,64
COD	kg/ADt	8,7	14,2	7,64
Flow	m^3/ADt	29	31,2	31,7
N total	kg/ADt	0,17	0,19	0,19
P total	kg/ADt	0,017	0,04	0,025
TSS	kg/ADt	0,9	3,1	1,16

Table A5-8: Comparison of ENCE-CMB Air Emission Estimates with Comparable Company Mills

Parameter	Units	ENCE-CMB Long term average (annual)	ENCE-Huelva Annual average[32]	ENCE-Pontevedra Annual average[33]
Carbon Monoxide (CO)	kg/ADt	1,70	1,05	N/A
Sulphur Dioxide (SO_2) (as S)	kg/ADt	0,23	0,90	0,45
Nitrogen Oxides (NO_x) (as NO_2)	kg/ADt	1,30	1,29	0,99
Total Suspended Particulate Matter (TSP)	kg/ADt	0,34	0,74	0,45
Inhalable Particulate Matter (PM_{10})	kg/ADt	0,31	N/A	0,44
Total Reduced Sulphur (TRS) (as S)	kg/ADt	0,030	0,044	0,060
Volatile Organic Compounds (VOCs)	kg/ADt	0,33	0,93	1,10

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[31] A very low level of AOX is achieved at the Pontevedra mill because it uses the TCF bleaching process.

[32] Data from the Huelva mill does not include the biomass boiler emissions.

[33] Data from the Pontevedra mill does not include the biomass boiler emissions.

Based on this comparative review and the experience of the CIS project team, the emission rate estimates appear to be reasonable and are consistent with BAT. Both mills have been designed to perform at or even better levels, in most cases, than the IPPC-BAT (2001) and Tasmanian-AMT (2004) standards.

Compared with best existing BEKP mills in Brazil, both proposed mills compare favourably as well based on their estimates for effluent and air emissions.

Finally, by comparing with Botnia’s and ENCE’s respective comparable company mills, it has been shown that the companies’ design experience was incorporated favourably into the design process of the Orion and CMB BEKP mills, and that the companies’ operating experience at European mills can be expected to be reflected as well in their operation of the proposed mills in Uruguay.

A6.0 MILL PERMITTING AND REQUIREMENTS

This section reviews the permit-setting process and requirements that the mill proponents are subjected to in Uruguay, as controlled by the *Dirección Nacional de Medio Ambiente* (DINAMA). The basis of this information comes from several meetings with DINAMA made by the CIS Project Team, and follow-up information sent by DINAMA.

Extensive monitoring and reporting are critical in order to ensure that the mills are operated well, and meet the targeted BAT emission rates. Section A11 of Annex A is dedicated to compliance monitoring, as understood at the time the CIS was written. In addition to good monitoring, other key non-technology related items are also important to comply with BAT requirements, such as maintenance, training and control. For further discussion on these required due diligence plans, see Section A12.

A6.1 DINAMA Permit-Setting Process

DINAMA is part of the Ministry of Housing, Land Use Planning, and Environment (MVOTMA), and is the agency of the Government of Uruguay with the most direct control over the environmental impacts of the pulp mills proposed by Botnia and ENCE. The Environmental Impact Evaluation Division of DINAMA (DEIA) evaluates the admissibility of potential environmental impacts.

To determine if they are environmentally viable, the projects are submitted to the following authorization process before they are allowed to operate:

1. **Project communication:** The project proponent communicates with the DEIA, and presents preliminary project information containing, amongst other information, project location, an identification of the key technical personnel responsible for project elaboration and execution, details of the possible environmental impacts and the planned prevention, mitigation and correction measures.

2. **Project classification:** With the information provided in the project communication documents, the MVOTMA issues the Project Classification Certificate which determines the category in which the project will fall, depending on the significance of the environmental impacts it can generate. The proposed pulp mills fall into category “C”, which includes projects that can generate significant negative environmental impacts. These projects are required to deliver a detailed EIA. Only once the EIA has been completed can the project proponent ask for the Initial Environmental Authorization (*Autorización Ambiental Previa* or AAP).

3. **Application for the AAP:** The project proponent’s application must contain a copy of the Project Classification Certificate, the EIA and a summary of the environmental report (*Informe Ambiental Resumen*, IAR). Should DINAMA find the EIA insufficient in some regard, it can require the project proponent to provide additional information or

modifications. Significant interaction and iteration with the project proponent occurs at this point in time.

4. **Statement of Environmental Location Viability (VAL):** As of February 2nd 2006, by decree 349/005, the project proponent is required to obtain the *Declaración de Viabilidad Ambiental de Localización* (VAL) that allows for the solicitation of an environmental authorization for one or more alternative project locations considered to be environmentally viable. Interventions of the local government and public participation are addressed in this declaration.

5. **Initial Environmental Authorization (AAP):** At this point, the project is open for public consultation. The MVOTMA renders the IAR available to the public which has 20 days to comment. If the project implies serious cultural, social or environmental repercussions, the MVOTMA can have public hearings organized. Once the EIA is considered to contain sufficient information and has been thoroughly reviewed, DINAMA issues a recommendation to the MVOTMA whether to issue or not the AAP to the project proponent. The AAP obligates the project proponent to build its plant in compliance with the commitments made in the EIA but it does not yet authorize the project proponent to start construction or operate.

6. **Authorization for Industrial Wastewater Discharge (ADI)**: The *Autorización de Desagüe Industrial* or ADI is required by any industrial facility so that discharges of liquid effluents to a water course or a sewer system do not modify the quality of the receiving environment. It is awarded to the project proponent after it is established that the proposed wastewater treatment plant design and engineering comply with the effluent standards.

7. **Approval of the Environmental Management Plan (PGA)**: This step requires the project proponent to submit detailed management plans (*Plan de Gestión Ambiental* or PGA) prior to undertaking any activity with respect to the project, including construction. These plans contain detailed specifications identifying the means by which pollution and other environmental impacts will be avoided during both construction and operation of the plants. They may contain the following:

    - implementation plan for mitigation and compensation measures;
    - monitoring and reporting plan;
    - plan for the prevention of accidents;
    - emergency response plan; and
    - abandonment plan.

8. **Environmental Authorization to Operate (AAO)**: Even after a plant has received its initial authorization and has been authorized to commence construction activities, the project proponent must receive a separate authorization to operate before operations can begin. The MVOTMA is authorized to include additional requirements and safeguards in the *Autorización Ambiental de Operación* or AAO (modification to this

requirement recently made in September 2005). An AAO will only be issued after construction is complete and a compliance monitoring plan has been submitted. To ensure that operating standards and procedures continue to be state-of-the-art, industrial plants must request a renewal of their authorizations to operate every three years. Furthermore, at each renewal, Decree 349/005 empowers DINAMA to impose additional protective conditions onto the project proponent, if necessary. If the plants are planning on increasing production or making major process modifications, permit renewal is also required.

The decision to award the authorizations listed above is taken by the MVOTMA, after being reviewed by DINAMA, except for the approval of the PGA and AAO renewals which are directly handled by DINAMA.

The permitting process leading to operation was ongoing at the time the CIS was written and that both mill proponents were at different stages in the process.

A6.2 Status of Mill Proponents Relative to the Permitting Process

The ENCE-CMB and Botnia-Orion projects were awarded AAPs on October 9th 2003 and February 14th 2005, respectively, and both processes were conducted in strict compliance with the Environmental Impact Assessment Rules[1]. DINAMA reviewed the EIAs submitted by the project proponents prior to making its recommendation to the MVOTMA to award the AAP for the Botnia and ENCE pulp mills, and DINAMA officials engaged in discussions with representatives from both Botnia and ENCE regarding the environmental impacts of the projects, operational requirements of the plants, and the proposed mitigation measures. DINAMA required both Botnia and ENCE to submit supplemental information to their initial submissions and to submit multiple revisions of their EIAs. The processes of both approvals were accompanied by interaction with the public, in the form of notifications and public hearings.

One of the purposes of the PGAs is to ensure that appropriate environmental protection measures will be taken to comply with all applicable regulations and standards, including the IPPC-BAT (2001) standard. DINAMA can require additional protective measures as a requirement for approval of the PGAs, if necessary. At the time of this CIS, ENCE had only received approval for construction activities involving land movement while Botnia had received approval for removal of vegetation cover, fencing and land movement, construction of a port, construction of the chimney, concrete plant, and foundations and for construction of the bleached pulp plant including the chemical plant.

Botnia provided an updated EIA to DINAMA in June 2006, and ENCE still must provide an updated EIA, as specified in the AAP. These updated EIAs are required prior to obtaining

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[1] Decree 435/994 (September 21st 1994), now replaced by Decree 349/005 (September 21st 2005).

the AAO and before the plants are allowed to operate. As of this date, an application for approval to operate has neither been submitted by nor approved for either plant.

A6.3 Botnia and ENCE Permit Requirements for Effluent and Air Emissions

As specified in their respective AAPs, Botnia and ENCE must comply with Decree 253/79 and amendments with respect to effluent and with limits incorporated into the AAPs with respect to effluent and air. Decree 253/79 and amendments regulations establish water quality standards for water bodies in Uruguay and set maximum discharge limits and detailed discharge limitations for sources that discharge to those water bodies. Both mills will have to comply with Class 1 regulations for water used or which could be used as drinking water supplies for human consumption with conventional treatment as well as with regulations for waste pipes directly discharging to water courses. Additional limits on an annual average basis for AOX, total nitrogen and nitrates were included in Botnia's AAP. While these were not included in ENCE's AAP, ENCE's commitment to control nitrogen and AOX is found in its EIA, which is enforceable through the AAP. It is most likely that both mill proponents' ADIs and AAOs will be aligned and, to a great extent, there will be similar requirements for both companies.

The additional requirements to be included in the companies' ADIs and AAOs are not yet determined, but will consider the requirements listed in Table A6.3-1. With each of these additional requirements, the general methodology used by DINAMA is also mentioned. This information is based on a draft prepared by DINAMA for Botnia's ADI. To award this authorization, DINAMA will look at the requirements established in the AAP, at the parameters included in Decree 253/79 and amendments, at BAT guidelines for emissions to water, at international regulations and standards and at parameters that according to DINAMA's judgement need to be considered in these types if authorizations.

In addition to the applicable Uruguayan environmental laws, a second safeguard exists to ensure that industrial sources discharging to the Rio Uruguay are operating in an environmentally responsible manner: the water quality standards developed by the Rio Uruguay Administrative Commission (CARU). Pursuant to the CARU regulations, Argentina and Uruguay have primary authority to develop effluent limitations with which industrial sources in their jurisdictions must comply. Each country's effluent limitations, however, are subject to certain CARU guidelines and must take into account the requirements of complying with CARU water quality standards. DINAMA has stated that the effluent limitations set forth in Decree 253/79 and amendments are adequately protective to ensure that CARU water quality standards are not exceeded.

Table A6.3-1: Additional Requirements to be Considered in the Mill Proponents Authorization for Industrial Wastewater Discharge (information provided by DINAMA)

Parameter	Methodology
BOD_5	*Monthly average requirement, loading-based (t/d)*: it will be established with the concentration limit in Decree 253/79 and amendments, the effluent daily maximum flow presented by the company and an appropriate factor that takes into account variability between the monthly and annual averages. *Annual average requirement, loading-based (kg/ADt)*: it will be established with the concentration limit in Decree 253/79 and amendments, the maximum daily production and the effluent daily maximum flow presented by the company. Verification as to whether this limit falls into the BAT recommended range will be done.
COD	*Monthly average requirement, loading-based (t/d)*: it will be established with the average concentration and the effluent daily maximum flow presented by the company as well as an appropriate factor that takes into account variability between the monthly and annual averages. *Annual average requirement, loading-based (kg/ADt)*: it will be established with the average concentration, effluent daily maximum flow and the maximum daily production presented by the company. Verification as to whether this limit falls into the BAT recommended range will be done.
TSS	*Monthly average requirement, loading-based (t/d)*: it will be established with the concentration limit in Decree 253/79 and amendments, the effluent daily maximum flow presented by the company and an appropriate factor that takes into account variability between the monthly and annual averages. *Annual average requirement, loading-based (kg/ADt)*: it will be established with the concentration limit in Decree 253/79 and amendments, the maximum daily production and the effluent daily maximum flow presented by the company. Verification as to whether this limit falls into the BAT recommended range will be done.
AOX	*Monthly average requirement, loading-based (t/d)*: it will be established with the concentration limit specified in the AAP (on an annual average basis) and the effluent daily maximum flow presented by the company as well as an appropriate factor that takes into account variability between the monthly and annual averages. *Annual average requirement, loading-based (kg/ADt)*: it will be established with the concentration limit specified in the AAP (on an annual average basis) and the maximum daily production and effluent daily maximum flow presented by the company. Verification as to whether this limit falls into the BAT recommended range will be done.
Nutrients (N and P)	*Monthly average requirement, loading-based (t/d)*: it will be established by using the average of the BAT recommended loads for N and P, the maximum daily production presented by the company and an appropriate factor that takes into account variability between the monthly and annual averages. *Annual average requirement, loading-based (kg/ADt)*: it will be established by using the average of the BAT recommended loads for N and P, the AAP and Decree 253/79 concentrations as well as the maximum daily production and the effluent daily maximum flow presented by the company.
Dioxins and furans	*Limit, concentration-based*: it will be based on international regulations such Canada's and the USA's.

Limits for air emissions in the AAP were determined with the help of the Technical Environmental Standardization Group on Air (GESTA/Aire), a technical group within the MVOTMA Environmental Protection Technical Evaluation Commission (COTAMA) whose mandate is to elaborate proposals for air quality standards as well as for mobile and fixed sources. In 2005, the latest proposal for air quality and the mobile sources standards was presented while the proposal for fixed source emissions is still under study. Technical documents by GESTA/AIRE, although not legally binding, are used as reference by DINAMA, especially during the development of projects and EIAs.

A6.4 DINAMA Regulations and Performance Benchmarking

The benchmarking of DINAMA permit requirements against other permit requirements and the performance of existing mills is difficult due to the form of the Decree 253/79 concentration requirements and the uncertainty of the requirements to be contained in the AAOs issued to the mills prior to their start-up. An overall assessment involving assumptions on time-averaged effluent variability leads to the following general conclusions[2]:

- The estimated monthly average BOD limit corresponds to the most stringent requirement in the world, that only a limited number of mills would be able to comply with.
- The same can be said with TSS where only a small number of North American mills and about half of Scandinavian mills could comply with.
- For AOX, the expected permit limit of 6 mg/L as an annual average is also among the most stringent in the world, that about half of North American mills and most Scandinavian mills could comply with.
- As for nutrients permit limits, the phosphorus limit is higher than many Scandinavian and South American mills. A few Canadian mills and most Scandinavian mills could comply with the concentration limit.
- Finally, for nitrogen, with a permit limit of 8 mg/L of total nitrogen on an annual average basis, about half of the mills in Canada and Scandinavia could comply with this requirement.

Regarding effluent requirements, it can be concluded that DINAMA’s standards are amongst the best in the world when benchmarked against other jurisdictions. In particular, the extremely stringent TSS and BOD requirements will require that the effluent treatment plants are both and operated to be amongst the world's best.

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[2] The benchmarking of permits and mill performances indicated below is based on data provided in: Ekono Inc., Environmental Performance, Regulations and Technologies in the Pulp and Paper Industry (2005), August 2006

Limited benchmarking data was available for air emissions, but it can be seen that for recovery boiler SO_2 emissions, DINAMA situates itself amongst the best permit limits in North America. In the cases where the permit value is not among the most stringent in the world, the predicted mill emission rates are significantly lower than the permit requirements.

In summary, the permit-setting process used by DINAMA is practical and rigorous, and through DINAMA's receiving environment monitoring program and permit renewal process it is expected that the proposed pulp mills will be required to operate to BAT emission rates. The process used in Uruguay allows DINAMA to require additional protective measures at successive stages throughout the process to ensure compliance with applicable environmental standards.

A7.0 PULP MILL PROCESS DESCRIPTIONS

This section presents a general process description of the Botnia-Orion and ENCE-CMB pulp mills. More detailed information on the mill processes is available in the EIA prepared by each of the project proponents. Botnia-Orion's revised Chapter 4 of the EIA is dated May 2006 and is considered by the company to be an up-to-date reference document with regards to process description. The information provided in Chapter 1 of ENCE-CMB's 2003 EIA is still generally current, and a memorandum provided by the company summarizes recent changes and improvements made to the process design since the 2003 EIA (see ENCE-CMB memo in the Appendices of this Annex). It is pertinent to note that at the time this CIS was written, Botnia-Orion was in advance of ENCE-CMB in the engineering and construction processes, and it is normal that there is a greater level of definition including more certainty in the Botnia-Orion mill process description. Data was collected on mill designs by examining company documents, and reviewing the design with company engineers in Spain and Uruguay. A comparison of the proposed designs was also made with modern industry practice to validate the information obtained by the mill proponents.

Both projects use the kraft process for pulp production and an ECF bleaching process. In this section, the kraft process and its emissions are first described in general. The following sub-sections describe the specific process features implemented at each of the two mills, highlighting features that are pertinent to their environmental performance.

A7.1 The Kraft Pulping Process

The kraft or sulphate process is the dominant pulping process worldwide, due to the superior pulp strength properties, its application to most wood species, the ability to recover and reuse the main process chemicals used and its energy efficiency. The main environmental concerns with kraft pulping include wastewater effluent, emissions to atmosphere including malodorous gases, the management of solid waste residuals, and energy consumption. The modern kraft process is one of the few industrial processes which can produce more energy than is needed in the facility by renewable biofuel.

The main raw materials for the process include wood fibre, water, energy, and chemicals for cooking and bleaching. Figure A7.1-1 presents an overview of the processes of a kraft pulp mill. The raw material and energy inputs as well as the output of products, by-products and the major releases (emissions, waste etc.) in the production of kraft pulp are summarized in Figure A7.1-2. A brief introduction to the fiberline process is given below.

Wood is mainly comprised of 3 parts, cellulose, hemicellulose and lignin. For eucalyptus, the cellulose content is 50 – 55% and lignin content about 15 – 20%. The fiberline of a kraft mill aims to remove lignin, and to preserve cellulose. Bleached kraft pulp mainly consists of cellulose fibers. Generally, hemicellulose is lost with lignin. The wood derived organic material recovered and burnt in the recovery boiler primarily is lignin and hemicellulose.

The fiberline comprises pulping, oxygen delignification and bleaching, and each step of the process is designed to remove lignin, while preserving the cellulose fibers. Each stage is optimized to do this as well as the stage chemistry and equipment allow. The ability to remove lignin and preserve cellulose is called “selectivity”.

The initial delignification occurs in alkaline stages using caustic soda (NaOH) and sodium sulphide (Na_2S) in the digester. In a modern digester, the concentration of these chemicals is controlled in different parts of the digester, and this is called modified cooking. This is followed by uses of oxygen and caustic soda in one or two stages (oxygen delignification). Bleaching generally uses alternate acid and caustic stages with chlorine dioxide, hydrogen peroxide and oxygen. The digester and oxygen delignification stages are in the “closed-cycle” part of the fiberline, and chemicals used and wood material released are recovered by washing. The bleaching section is “open” in that chemicals and wood material released are discharged through effluent treatment.

Bleaching that uses a combination of acid, chlorine dioxide, peroxide and oxygen can be described as ECF bleaching. ECF bleaching is accepted by the World Bank, European Union, UNEP POPS, USEPA and all major permitting technologies as appropriate technology for new bleached kraft mills. In discussion of bleaching, plants which use chlorine dioxide as the only chlorine chemical are called ECF. Chlorine chemicals used in older mills bleaching may include chlorine, hypochlorite and hypochlorous acid. These are shown by the symbols C and H when describing bleaching sequences. Mills which do not use any form of chlorine-based chemicals are called TCF mills.

The Kappa number is a universally accepted measurement of the amount of residual lignin in pulp. Although not exact, one may consider that eucalyptus may start with a “Kappa number” of about 200, is cooked (delignified) in the digester to about 18, treated in an oxygen stage to kappa 11, and finally bleached to a final kappa number of less than 1. In general terms, a kappa number of 11 to bleaching, combined with the low wash losses would indicate that about 94% of the total wood based material removed in the fiberline, is sent to the recovery boiler, and about 6% is contained in the bleaching effluent.

In very general terms, you may consider that the wood based material (lignins and hemicelluloses) removed in the fiberline requires about 1 500 kg of oxygen per tonne of pulp to reduce it to water (H_2O) and carbon dioxide (CO_2) If this material was released to the environment, it could be measured as COD (chemical oxygen requirement). A low kappa number to bleaching, efficient brown stock washing and modern effluent treatment are essential elements to reduce organic discharge with effluent.

A new wood component, which is part of the hemicelluloses, but behaves in bleaching in a similar manner to lignin, was discovered in the mid 1990’s. This surprised many wood chemists, who felt that most wood components had been well defined since the 1930’s. This component is called hexenuronic acid (HexA). This component is particularly important generally in hardwoods, and more specifically in eucalyptus. About 30% of the “kappa number” entering bleaching may actually be HexA rather than lignin. Modern eucalyptus bleaching systems may include stages specific to remove HexA. This is a key difference between hardwood (particularly eucalyptus) and softwood bleached kraft pulp mills.

For Botnia-Orion and ENCE-CMB, about 1 400 kg of this COD load is eliminated in the recovery boiler and 25 – 30 kg are directed to effluent treatment plant, from bleaching. The final discharge from effluent treatment contains about 8 kg/ADt of COD (less than 0,3% of the material dissolved in the fiberline, or 0,15% of the wood material entering the mill). This may contrast with neighbouring kraft pulp mills in Mercedes (Uruguay) or Puerto Piray (Argentina) which do not have a chemical recovery furnace or efficient effluent treatment and so discharge all of the wood material dissolved in the fiberline, or about half of the wood material entering the mill.

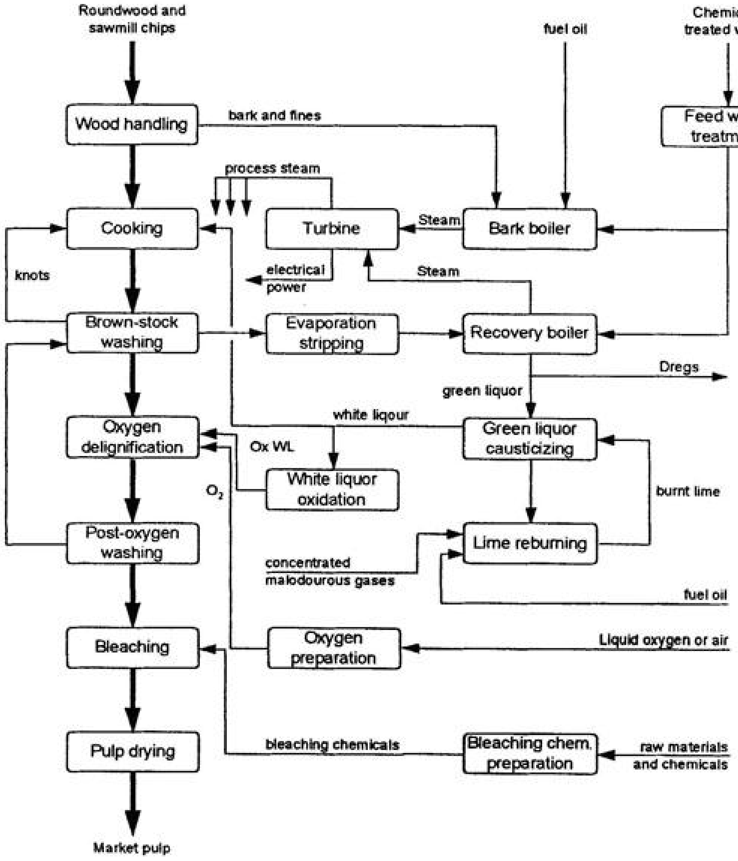

Figure A7.1-1: Overview of the Kraft Pulping Process (IPPC-BAT (2001))

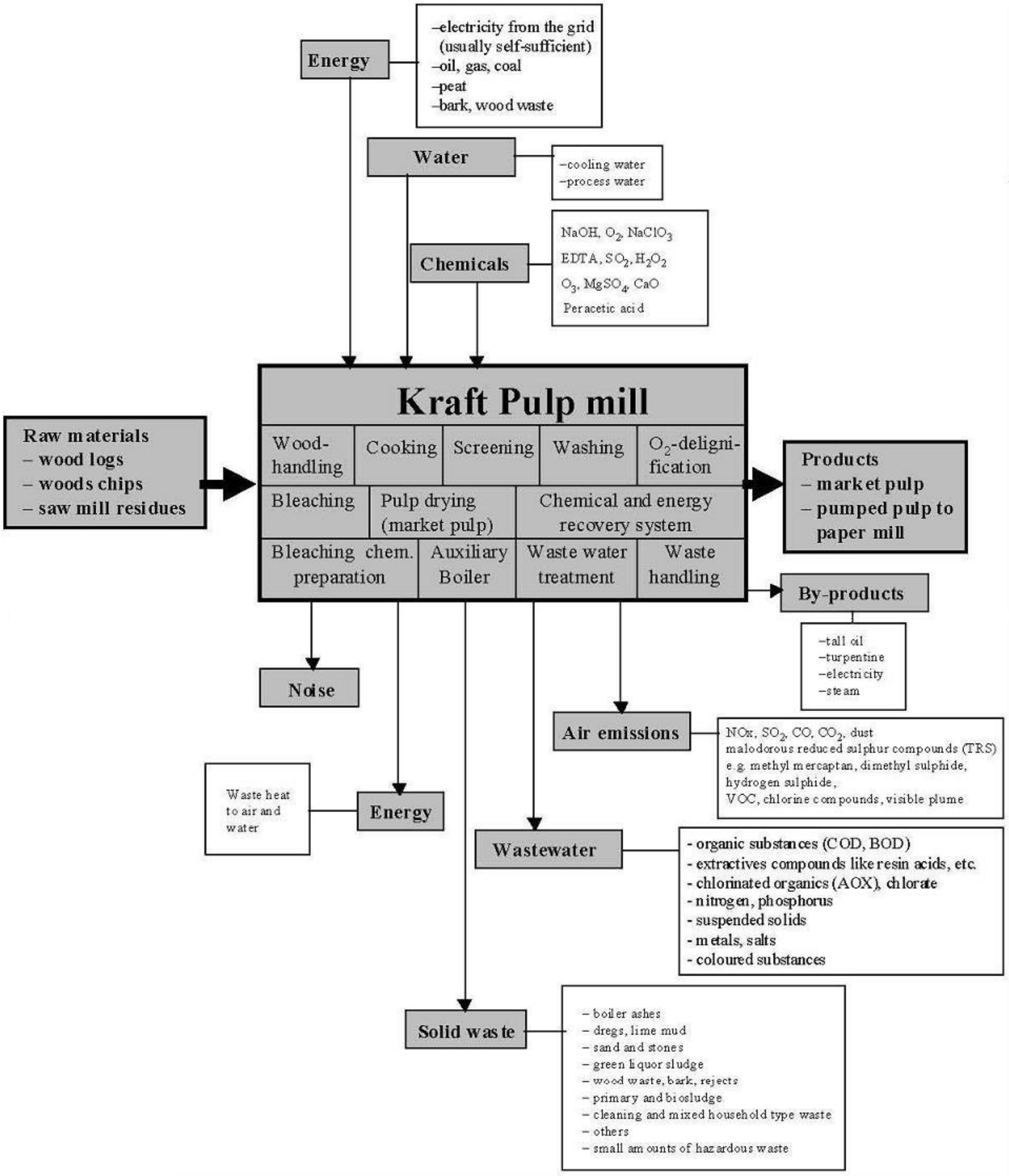

Figure A7.1-2: Mass Stream Summary for the Kraft Pulping Process (IPPC-BAT (2001))

A7.2 Emissions from the Kraft Pulping Process

Figure A7.2-1 summarizes the main emissions to water from the different process stages in a kraft pulp mill including the bleaching processes and accidental or temporary spills. Emissions to water are dominated by oxygen-consuming organic substances, which can be measured as COD or BOD. Effluent from the bleach plant, where chlorine-containing bleach chemicals are used, can contain organically bound chlorine compounds measured as AOX. If untreated, or inadequately treated, liquid effluents from kraft mills have toxic effects on aquatic organisms. Emissions of coloured substances may affect the living species in the recipient waters negatively, since water transparency is decreased, but the principal environmental impact of color discharges is aesthetic. Emissions of nutrients (nitrogen and phosphorous) can have a negative impact due to eutrophication. Individual metals extracted from the wood can also be found in low concentrations in the effluents.

Figures A7.1-1 and A7.1-2 are general diagrams. While both Botnia-Orion and ENCE-CMB will generally be using the same process technology generally as shown in these figures, it is to be noted that in both cases, pulp will not be pumped to a paper mill and electricity will be most likely be exported, not imported. Some by-products and emissions will also not be present at the Botnia-Orion and ENCE-CMB facilities. For example, tall oil and turpentine are produced in softwood (pine) mills, and are not present in hardwood (eucalyptus) mills, and Botnia-Orion does not have a bark boiler.

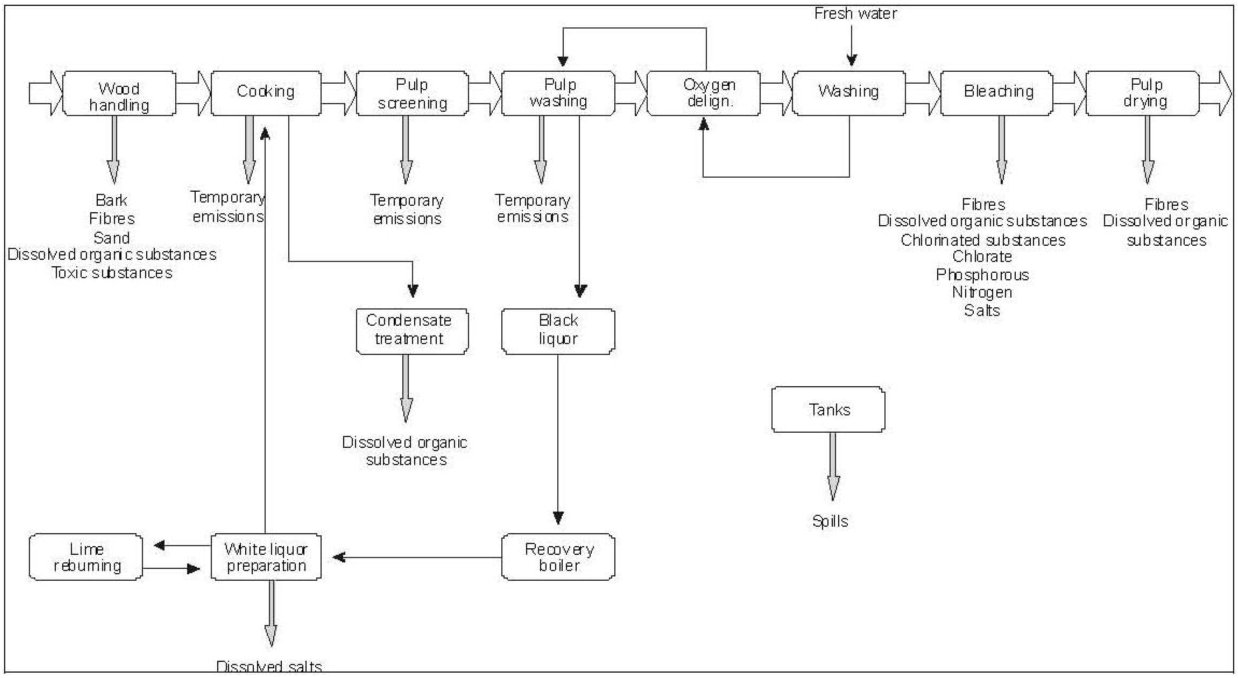

Figure A7.2-1: Emissions to Water from a Kraft Pulp Mill (IPPC-BAT (2001))

An overview of the emissions to the atmosphere from a kraft pulp mill is presented in Figure A7.2-2. Emissions to the atmosphere from a kraft pulp mill may originate from chip storage, pulp digester, pulp washing, bleach plant, bleaching chemicals preparation, black liquor evaporation, recovery boiler, white liquor preparation, lime kiln, storage tanks, pulp drying, and the bark furnace. Fugitive emissions of odorous gases can also come from effluent and sludge management operations. Atmospheric emissions consist mainly of sulphur-containing compounds such as sulphur dioxide and malodorous reduced sulphur compounds. The latter compounds are commonly referred to as total reduced sulphur (TRS). From furnaces, nitrogen oxides are also emitted as well as small amounts of dust (solid particulates) such as fly ash. From bleach plants and from bleaching chemical preparation, chlorine compounds are present and may leak to the atmosphere. Volatile Organic Compounds (VOCs) and particulates can be emitted to the atmosphere from wood chip piles.

A significant reduction of emissions from pulp mills is achieved in modern kraft pulp mills by in-process measures and end-of-pipe treatment. Botnia-Orion and ENCE-CMB have generally selected technology to minimize the possibility of emission generation, and have comprehensive effluent and odorous gas collection and treatment systems.

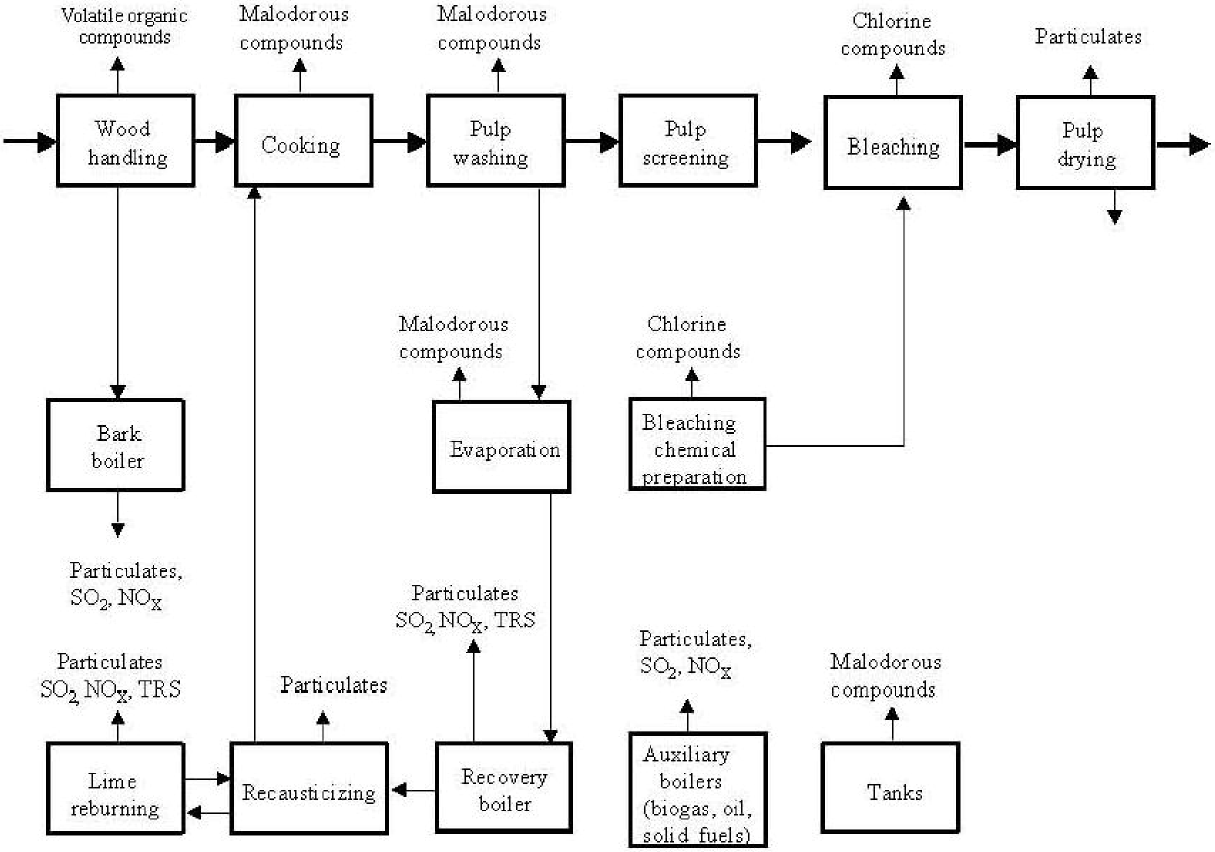

Figure A7.2-2: Emissions to the Atmosphere from Kraft Pulp Mills (IPPC-BAT (2001))

A7.3 Botnia-Orion Pulp Mill Process Description

The proposed project is a kraft pulp mill producing 1 000 000 air-dry tonne per year (ADt/y) of bleached eucalyptus pulp destined mainly for Europe and Asia. A general flowsheet of the Botnia-Orion mill process is given in Figure A7.3-1.

A7.3.1 Wood Handling

Logs will be dry-debarked at the plantations so that the residuals can be returned to the soil, and thus the debarking drums at the mill must remove only the remaining bark and impurities such as remnant soil and sand. Water used in washing of the logs will be recycled, with a minimum purge going to the effluent treatment plant. The water consumption from wood handling are expected to be between 0,5 and 2,5 m^3/ADt.

Because the mill will use different eucalyptus species, there will be two separate chipping lines and storage. This will allow certain chip mixtures of desired fiber properties to be produced, and process conditions will be optimized based on raw material. Bark residues and fines from screening will be returned to the plantations. The chips will be stored in outdoor storage piles, equipped with an automatic loading and unloading systems designed to minimize fugitive chip dust emissions. After chipping, the wood will be screened and transported by belt conveyors to the cooking process.

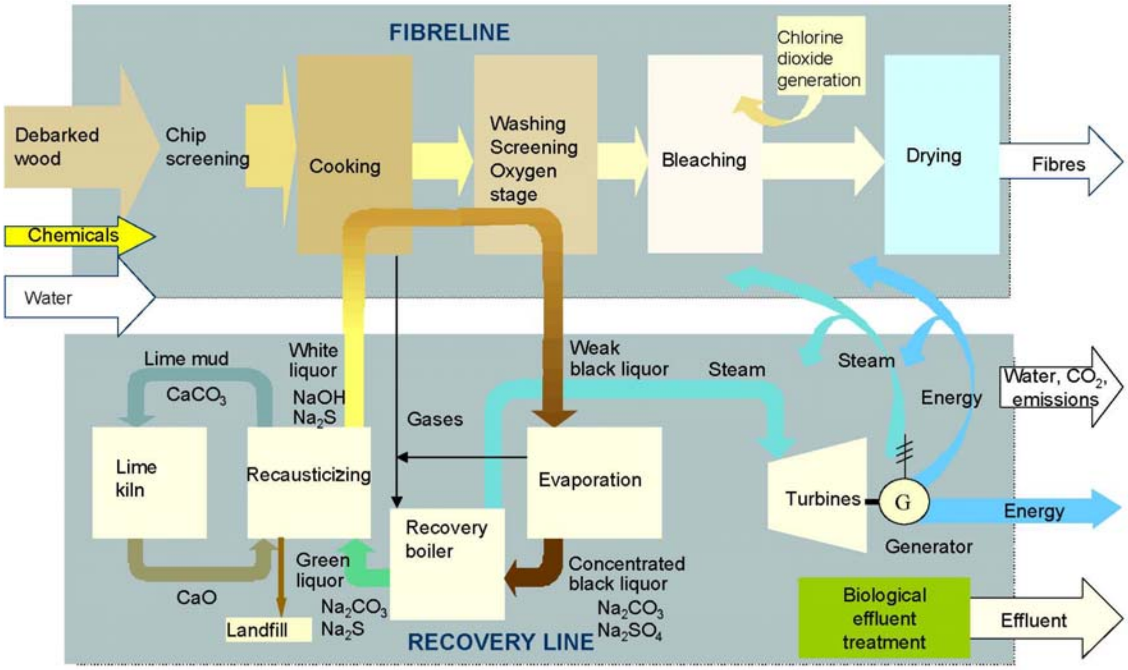

Figure A7.3-1: Botnia-Orion Pulp Mill Processes

A7.3.2 Cooking, Washing, Screening and Oxygen Delignification

Cooking will be done in a Downflow Lo-Solids® continuous digester, and brown stock washing is designed so that the pulp going to oxygen delignification contains less than 60 kg COD per tonne of pulp. Brown stock pulp will be washed first in the digester, then in 3 high-efficiency drum displacement washers in parallel before oxygen delignification, and there will be two more washers in parallel after oxygen delignification and before bleaching. The design washing loss to bleaching is 6 kg COD per tonne of pulp. This indicates that brown stock washing removes about 99,5% of the washable material from the digester and oxygen delignification stages.

Brown stock screening will be done in a three-stage closed cycle, with slotted pressure screens. The design strategy is to reject the impurities and shives at an early stage in the process, so that the purity of the end product is enhanced and the consumption of bleaching chemicals is minimized.

Before bleaching, pulp will be delignified in a two-stage oxygen delignification, after which the kappa number will be under 11.

A7.3.3 Bleaching

The 4-stage Botnia-Orion ECF bleaching sequence will be AD-PO-D-P, with DD-washers used in the intermediate washing stages. The AD stage removes hexenuronic acids and furthers delignification. The PO stage is the extraction stage while the D stage is used for removal and bleaching of residual lignin. The P stage is a polishing stage, and helps preventing brightness reversion. Botnia-Orion recycles acid and alkaline filtrates within the bleach plant, to reduce chemical use and effluent flow, with a design bleach effluent flow of 12 m^3/ADt. Botnia-Orion has also designed for and will consider recycling part of the alkaline filtrate from the bleach plant back to recovery once the mill has reached and maintained full production for some time.

Bleaching at Botnia-Orion uses a combination of acid, chlorine dioxide, peroxide and oxygen and so can be described as ECF bleaching. Figure A7.3-2 shows the ECF bleaching sequence at Botnia-Orion’s pulp mill.

Botnia-Orion has a low kappa number to the bleach plant, and uses peroxide and oxygen to reinforce bleaching. This results in a comparatively low predicted consumption of chlorine dioxide (less than 10 kg/ADt) compared with most ECF mills. For this reason, the mill may be more accurately described as an “ECF-Light” mill. It should be noted that the term “ECF-Light”, is not well defined in the technical community.

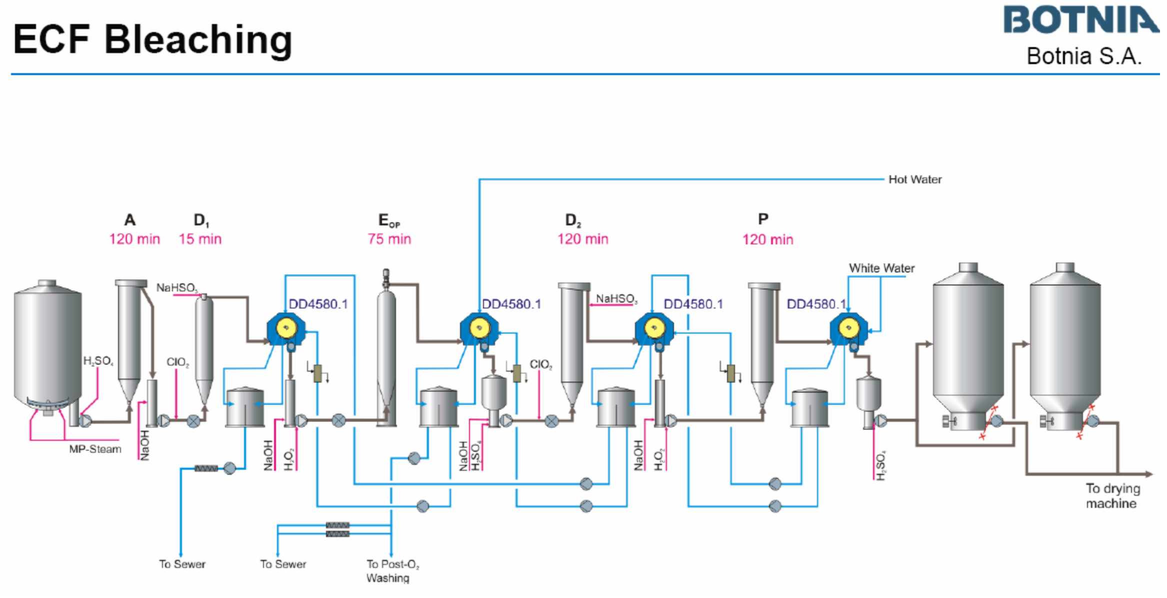

Figure A7.3-2: ECF Bleaching Sequence at the Botnia-Orion Pulp Mill

A7.3.4 Pulp Drying, Baling and Bale Storage

Two drying machines will be used at the Botnia-Orion mill with each a capacity of 60% of the fiber line capacity. The fact that the mill will be working with two parallel drying machines will help with controlling the mill water and steam balance.

Pulp baling consists of four baling lines, which can produce 250 kg bales wrapped bales unitized into 2 000 kg units, as well as 1 000 kg unwrapped bales unitized into 2 000 kg units. The units are loaded inside the bale storage area onto a terminal truck, which in turn transports the units to the barge harbour located on the mill site. The units are lifted straight onto the barge. The bale storage capacity on site will be only 1 – 3 days for special cases. The pulp will be transported by barge to a large storage facility in Nueva Palmira.

A7.3.5 Black Liquor Evaporation

The seven-effect evaporator train has a design capacity of 1 100 t/h of evaporated water. In addition to evaporating weak back liquor from brown stock washing, it will treat biosolids from the effluent treatment plant and salt cake from the ClO_2 plant. The evaporation plant was designed with an additional capacity of 20% above normal operation (as defined for a production of 1 000 000 ADt of pulp/y). This additional capacity allows sufficient margin to recover intermittent discharges and possible future bleach filtrate recycle. The weak black liquor will be evaporated to a minimum level of 75% dry solids. High levels of dry solids help ensure higher lower furnace temperatures and low sulphur dioxide emissions from the recovery boiler.

The clean primary condensates will be returned to the feed water tank of the recovery boiler while secondary condensates will be used in the fiberline and the white liquor plant. The foul condensates, with high content of volatile compounds, are purified in a stripping column to be reused in the process. Non-condensable gases from stripping enter the methanol separation system, where methanol is separated and purified, and the remaining gases enter the collection system of concentrated odorous gases. The stripping column was designed for a foul condensate treatment capacity (MCR) of 55 kg/s and TRS and methanol reduction efficiencies of 98%.

The stripper gas containing methanol will be fed first to the methanol distillation and further to the LVHC gas system and burned either in the recovery boiler or the dedicated odorous gas boiler. The vacuum system hot well gas and the foul condensate tank vent are also collected into the LVHC gas system.

A7.3.6 Recovery Boiler and Turbine Generator

The recovery boiler treats heavy black liquor (about 4 800 tonnes of dry solids per day with ash), which is sprayed into the furnace at a high solids content. The boiler, which will require fuel oil only for start-up and as support fuel, is a state-of-the-art low odour design with low emissions of TRS, sulphur dioxide and nitrous oxides. Dust in the flue gas is separated by an electrostatic precipitator. The recovery boiler will be equipped with a burner for low volume high concentration (LVHC) gases. Gases from the smelt dissolving tank will be fed directly to the recovery boiler, thus eliminating one air pollution source relative to most pulp mills.

The recovery boiler was designed according to the following criteria:

- additional capacity of 27% above design for peaks (9% for continuous operation);
- steam produced at 93 bars (absolute) and 488°C;
- low sulphur emissions through high dry solids black liquor firing;
- low NO_x emissions through a fourth level of air entry;
- low particle emissions through removal with an electrostatic precipitator with three chambers/four fields per chamber; and
- incineration of both high volume low concentration (HVLC) and LVHC gases under normal operation.

The plant will use two Siemens turbogenerators. One is an extraction-back-pressure turbo generator while the other is an extraction-back-pressure turbogenerator with condensing tail. The rated capacity of both machines is 70 MW. Two turbogenerators are needed because of power supply from the national grid is limited. There are two possibilities to connect the mill to the national 150 kV grid:

1. Connection to the Fray Bentos sub-station (3 – 4 km away):
    - investment estimate: USD 1,4 millions
    - maximum available power: 55 MW
    - estimated construction time: < 1 year
2. Connection to the Palmar 500/150 kV sub-station (85 km away):
    - investment estimate: USD 6,8 millions
    - no power limitation for the pulp/chemical mills
    - estimated construction time: 2 to 3 years

The first option requires investing in two generators, in order to enable the running of the mill during the turbine maintenance. Including all costs, this is economically the most feasible solution; it has the additional benefit of lowering the dependency on external electricity suppliers. In addition, it can easily be completed before the start-up.

At design capacity, the power generation will be 119 MW. The power demand of the pulp mill is estimated to be 71,5 MW. The additional 47,5 MW would be used for the chemical plant to be operated on-site by a third party, and/or sold to the national grid. Depending on market conditions, it is anticipated that 0 – 30 MW would be sold to the national grid with a likely amount of 15 MW.

The plant will also employ two heavy fuel oil tube boilers for back-up. Both will be used as back-up odorous gas incinerators. The capacity of the boilers is 50 t/h of steam at a pressure of 16 bars.

A7.3.7 Lime Kiln and Recausticizing

A single lime kiln will be installed. The lime mud will be washed efficiently and dried, and the lime kiln will be equipped with an electrostatic precipitator to control particulate emissions. The kiln capacity will be about 800 tonnes per day of lime, and will be fired with fuel oil. Limestone will be used as make-up. Because of anticipated difficulties of purchasing make-up lime (CaO), a large silo of a capacity of 6 000 tonnes will be used.

White liquor will be prepared by adding lime to green liquor in a system comprising a slaker-classifier and causticizing tanks. A portion of the white liquor will be oxidised by air or oxygen in order to oxidise sulphides, and be used in the oxygen delignification system and subsequent bleaching stages. Botnia-Orion is exploring the possibility to take the dregs and the grits from the recausticizing plant back to the forest plantations. These streams contain many of the trace elements and nutrients that enter the mill with wood. Initially dregs and grits will go to landfill. Figure A7.3-3 the lime kiln and recausticizing process at the Botnia-Orion pulp mill.

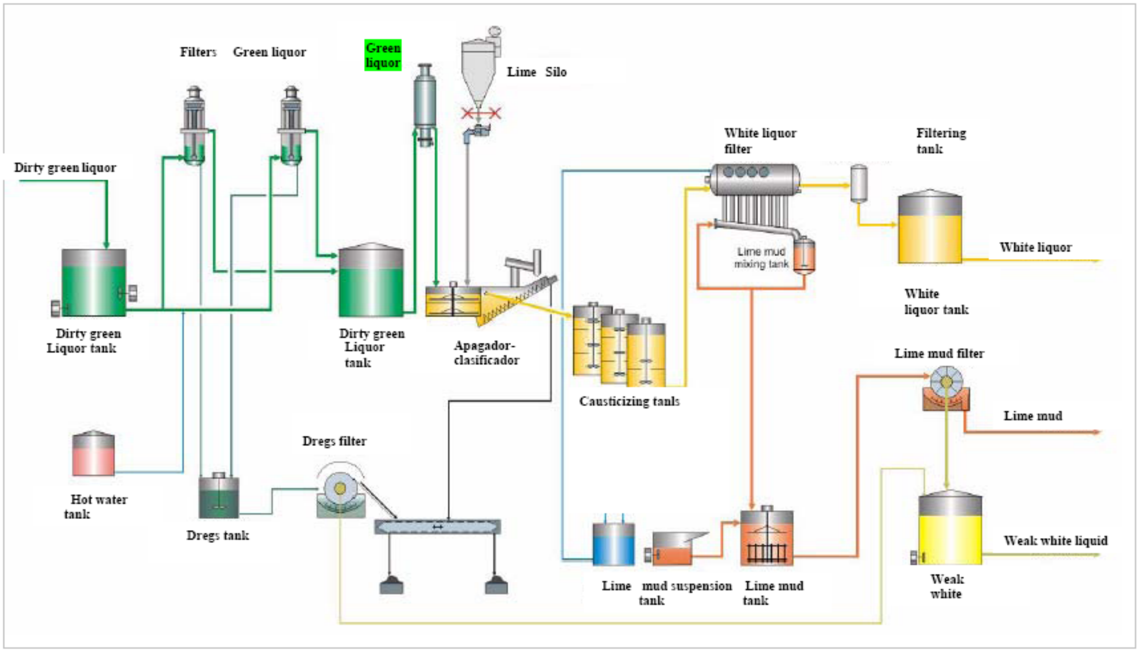

Figure A7.3-3: Lime Kiln and Recausticizing at the Botnia-Orion Pulp Mill

A7.3.8 Chemical Island

The bleaching chemicals preparation system includes on-site production units for chlorine dioxide, hydrogen peroxide, oxygen and sodium chlorate. All other chemicals will be purchased. The storing and handling systems for purchased sodium hydroxide, sulphuric acid, magnesium sulphate and talc are included in the chemicals preparation plant. The chemical island will be owned and operated by a third party chemical supplier (Kemira). Botnia-Orion will be responsible for the emissions regarding air, water and residuals from the chemical preparation plant except for the Alox waste from the hydrogen peroxide plant that will be returned by Kemira for recycling.

The chlorine dioxide plant consists of a chlorine dioxide generator, absorption tower and storage tanks for chlorine dioxide water and chilled water plant. From the chlorine dioxide production, salt cake solution is obtained as a by-product which will be used as chemical make-up. Oxygen production is based on a cryogenic process, where oxygen is separated from the air by nitrogen liquefaction. A liquid oxygen storage tank and oxygen evaporator system is also included for back-up.

A7.3.9 Water Treatment

Raw water will be pumped from the Rio Uruguay at an average rate of 87 000 m^3/d and subsequently treated in a large feed tank where chemicals (including sodium hydroxide and polymers) will be added prior to passing through clarifiers and sand filters. The filtered water will be stored in a tank prior to consumption in the various process areas.

Water to be used for steam production will be further demineralized in one of two lines using cation and anion exchange technology, followed by mixed bed ion exchange.

In order to reduce both the volume of river water required by the mill, and simultaneously the volume of the effluent, cooling towers will be used to recycle water. The cooling load for the main turbogenerator and the cooling load for the evaporator surface condensers will be provided by these cooling towers.

A7.3.10 Effluent Treatment Plant

The effluent treatment plant will use the activated sludge treatment (AST) process which will consist of two parallel lines of one aeration basin and one secondary clarifier each, treating an average discharge flow of approximately 73 000 m^3/d (25 m^3/ADt). The total volume of the aerated basins is 150 000 m^3. An analysis of the WWTP design and estimated removal efficiencies is done in section A8.2 of this Annex.

Two different sewer flows will be collected at the pulp mill and sent for treatment to the WWTP:

- Low solids effluent: the low solids effluent will be adjusted for pH by quick lime in a pre-neutralization tank before being directed to the equalization basins.
- High solids effluent: the high solids effluent will first be directed to a mechanical screen chamber for coarse solids removal and then to a primary clarifier. The primary clarifier supernatant is then sent to the equalization basins.

The effluent treatment system will be equipped with a system of three equalization and safety basins. Three basins, with a capacity of 25 000 m^3 each, are operated so that during normal operation one of the basins is empty, one is being filled with process effluent, and the third one is being emptied to the biological treatment system. The temperature of the effluent out of the equalization and safety basins, about 50 to 60°C, will be reduced in a series of cooling towers to between 30 and 37°C. Urea and phosphoric acid nutrients will be added to the wastewater and its pH adjusted prior to treatment in the AST basins. Sanitary wastewater from the mill will be added directly to the aeration basins without pre-treatment. The activated sludge system employs two aeration basins each of 75 000 m^3 which contain an anoxic zone and a selector stage. A degassing tank ends each basin before the effluent from the AST process is directed to the secondary clarifiers. The treated effluent (after sampling for permit requirements) will be mixed with river water prior to discharge, in order to lower the effluent temperature and minimize any color differences between the effluent and river.

The primary sludge is sent to the dewatering system consisting of a sludge mixing tank and belt presses. Polyelectrolyte solution may be added to the primary sludge to enhance the performance of the belt presses. The primary sludge will either be mixed with wood waste and bark and landspread on plantations, or sent to composting. Most of the secondary sludge is recirculated back to the activated sludge basins as return activated sludge (RAS) while the waste activated sludge (WAS) will be sent to the biosludge pits and then to the centrifuge dewatering unit. The secondary sludge will be mixed with weak black liquor prior to being treated in the evaporators and fired into the recovery boiler.

Process water runoff, including water from debarking and woodhandling and stormwater collected within a safety area around the plant are collected and sent to ponds prior to the WWTP. Stormwater from outside the safety area is collected and sent to three stormwater ponds. At these three ponds, conductivity is measured and TV surveillance and a skimmer to collect oil and foams are installed.

A7.3.11 Non-Condensable Gases (NCGs)

The concentrated NCGs or LVHC gases will either be burnt directly in the recovery boiler or in the dedicated odorous gas burner. Either light fuel oil or liquid methanol will be used as a support fuel in the burner. This separate burner is equipped with a small boiler and a scrubber and the resulting sodium bisulphite from the scrubber could be used in the bleach plant instead of sulphur dioxide. The exhaust gases will be discharged in the main stack.

The dilute NCGs or HVLC odorous gases from tanks and equipment vents will be collected and mixed with feed air into the recovery boiler. A separate small boiler, fired on oil will be used to burn the HVLC gases should the recovery boiler not be available. The back-up boiler exhaust gases will be fed to the main stack. This system will eliminate one of the major causes of odour from traditionally designed mills.

A7.4 ENCE-CMB Pulp Mill Process Description

The proposed project is a kraft pulp mill producing about 500 000 air-dry tonnes per year (ADt/y) of bleached eucalyptus pulp destined for the European market. A perspective on the ENCE-CMB mill is presented in Figure A7.4-1 while a general flowsheet is given in Figure A7.4-2.

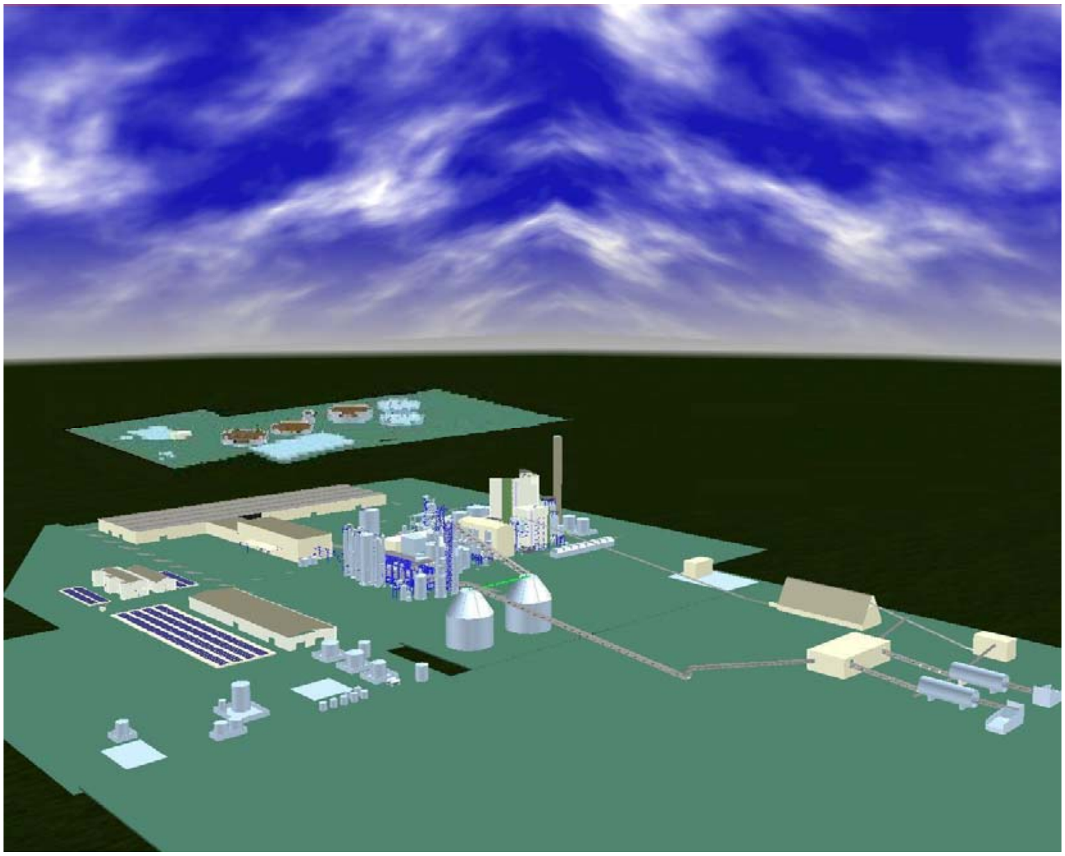

Figure A7.4-1: ENCE-CMB Mill Perspective

A7.4.1 Wood Handling

Two parallel wood preparation lines will be used, each with a capacity of 250 m^3/h wood. The eucalyptus logs arrive by truck at the wood yard and are fed by crane to the reception deck. Different wood species will be processed separately. Logs with bark are fed to a dry debarker and washed to remove sand, dirt and other sources of contamination, prior to the chipper. Expected water usage will be in the order of 0,5 to 2,5 m^3/ADt.

Accepted chips will be sent to two storage silos (one for each species of eucalyptus processed), while oversized chips will be reprocessed. Fines will be mixed with bark and burned in the woodwaste boiler. Water is required for washing the wood, and a water handling system will be installed including stone traps, a screen to separate bark and

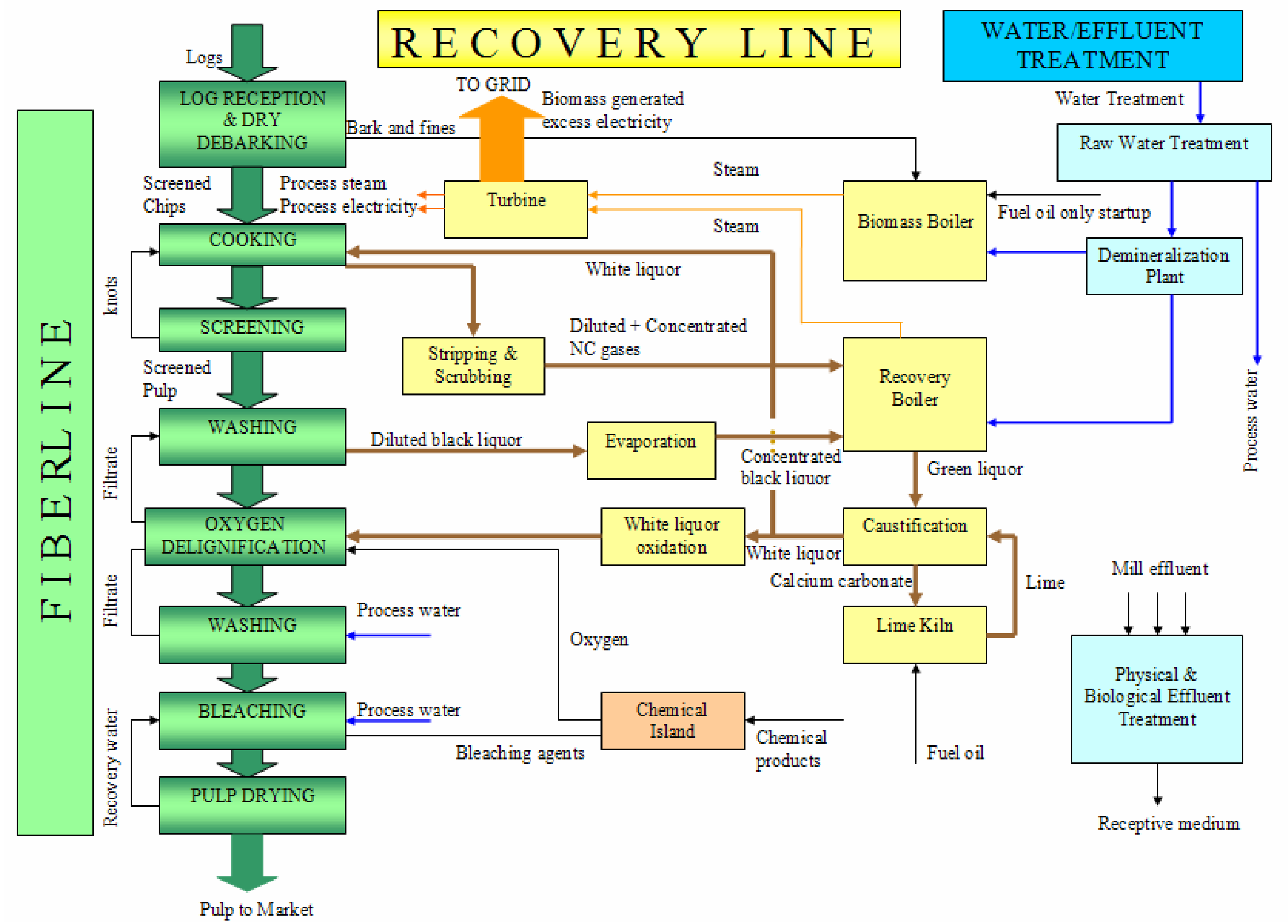

Figure A7.4-2: ENCE-CMB Pulp Mill General Flowsheet gravel particles, a settling basin and a grit collector. The bark will be sent to the bark shredders and stored in a covered biomass silo of a capacity of 7 days. The bark is dried through presses and conveyed to the woodwaste boiler.

A7.4.2 Cooking, Washing, Screening and Oxygen Delignification

The mixture of chips coming from different wood species is cooked at the cooking plant to a kappa level of approximately 16. The cooking plant (COMPACT COOKING™ process) consists of a chip bin, a pre-impregnation vessel, a high pressure feeder, a continuous digester and a blow tank of 1 000 m^3. The digester is of a compact design and comprises a bottom counter-current washing section.

Knots are diluted in wash liquor and separated from the fibers in a pressurised closed vessel before washing, thus saving chemicals. The knots are then pumped back to the digester for recooking. The screened pulp is dewatered and washed in two displacement presses in series in the brown stock washing system.

The oxygen delignification takes place in a two-stage oxygen reactor where oxidized white liquor will be used as the alkaline agent. This is produced by air oxidation of white liquor in a separate unit. A washing press follows the oxygen delignification reactor, and the washed pulp is stored in a high-density pulp storage tank before the final post-oxygen wash press stage. The final pulp kappa number to the bleach plant will be lower than 10. Finally, an additional post-oxygen delignification displacement press is used before the pulp is sent to bleaching. All brown stock and post-oxygen washing filtrates including the final wash press are recycled counter-currently to the evaporators. The brown stock washing is designed so that the pulp going to oxygen delignification contains less than 50 kg COD per tonne of pulp. The fiberline is designed to have a final washing stage carryover from the brown fiberline of 6 kg COD per tonne of pulp. This indicates the closed-cycle portion of the fiberline has a recovery efficiency of about 99,5%. ENCE-CMB intends to recycle part (20 – 25%) of the alkaline bleaching filtrate to the recovery system. With this recycle in place, the expected wash loss (which includes some carry forward of bleaching filtrate) is 8 kg COD/ADt, a fraction of the wash loss in most pre 2000 mills.

Figure A7.4-3 shows the fiberline implemented at the ENCE-CMB pulp mill.

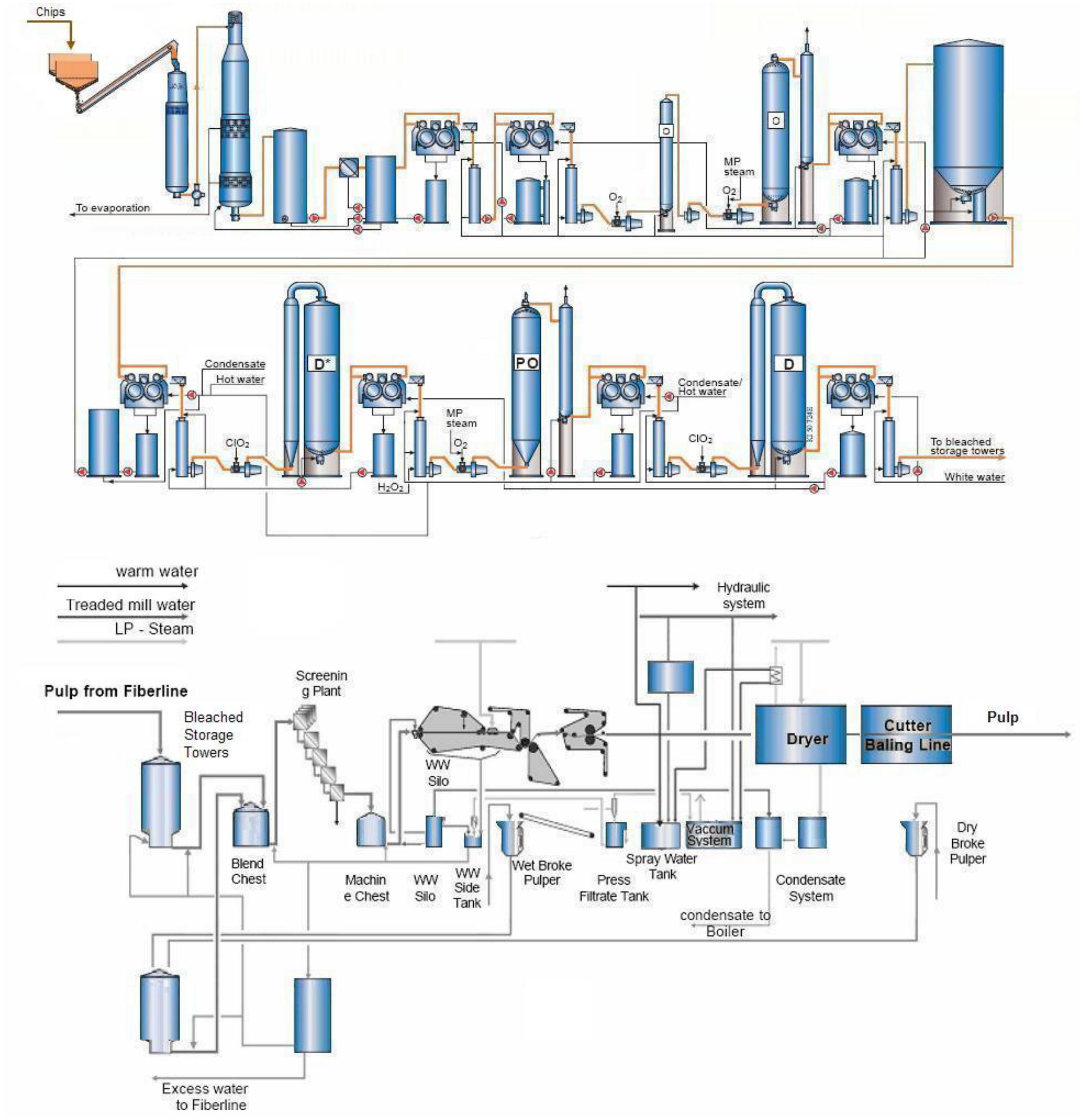

Figure A7.4-3: ENCE-CMB Pulp Mill Fibreline

A7.4.3 Bleaching

The ENCE-CMB 3-stage ECF bleaching sequence will be D_{Hot} – PO – D1. The bleaching sequence starts with a 2h retention time in a hot and acidic chlorine dioxide bleaching stage operating at about 85 – 90ºC. The D stage bleaching is used for delignification and to remove hexenuronic acids from the pulp. The PO is a pressurized peroxide bleaching stage which operates at a pressure of more than 4 bars. It has a 1h retention time and operates at about 100ºC. The final D1 stage has a 2h retention time, operates at a temperature of about 75ºC, and is used for removal and bleaching of the residual lignin. The bleaching process will use less than 10 kg ClO_2/ADt.

Displacement presses are used for washing the pulp after each bleaching stage. A certain amount of PO filtrate will be used as washing liquor. It is expected that once the plant has started up and is in stable operation mode, that about 20 – 25% of the alkaline filtrate will be recycled. Through this practice some of the alkaline PO filtrate will be recycled to the brown stock line and the recovery boiler.

The bleach plant is designed to operate with low effluent flow (10 m^3/ADt).

ENCE-CMB has a low kappa number to the bleach plant, and use peroxide and oxygen to reinforce bleaching. This results in a low predicted consumption of chlorine dioxide (less than 10 kg/ADt) compared with most ECF mills. For this reason the mill may be more accurately described as an “ECF-Light” mill.

A7.4.4 Pulp Drying, Baling and Bale Storage

The ENCE-CMB mill will use a single pulp drying machine with slot depuration, double wire, combipress and shoepress design using air. The baling will consist of two parallel baling lines and the baling storage area is sized for 20 minutes storage time for each line before the bale press. From the baling line, clamp trucks will lift the 2 tonne units into the pulp warehouse. The units are loaded onto a terminal truck and then onto boats that will take the final product to Europe.

Most of the water required in the pulp drying process is introduced to the process via vacuum pumps. The white water from the pulp machine is recirculated as dilution water for the high density tower, blend chest, machine chest, wet-end and dry-end broke pulpers, and for the screening system. The excess water is directed back to the fiberline. Effluents from the drying machine are collected and cooled down before they are sewered. The effluent flow from the pulp machine is estimated at 2,3 m^3/ADt.

A7.4.5 Black Liquor Evaporation

The design capacity of the evaporation plant is 600 t/h of evaporated water and comprises a 6-effect free flow falling film evaporation train. It was designed to treat biosludge and salt cake from the ClO_2 plant. The evaporation plant capacity is 15% above normal continuous operation. This capacity is sufficient for recovery of intermittent discharges and for recovery of some bleaching filtrates. The weak black liquor will be evaporated to a minimum level of 75% dry solids.

The clean primary condensates from the first effect will be collected and returned to the main condensate tank. Secondary condensates will be extracted from the fourth evaporation stage and reused mainly for pulp washing after the oxygen delignification stage. Intermediate secondary condensates will be taken out of the sixth effect and the surface condenser, and introduced into the causticizing plant for lime mud washing and dilution. The foul condensates will be collected from the segregated surface condenser and the vacuum system. They will subsequently be treated in the integrated steam stripper, returned to the intermediate secondary condensate tank and reused in process. Secondary condensates can also be used as wash water at the bleach plant in the PO stage, if necessary. As some bleaching filtrate is reused for brown stock washing, some excess condensate may be sent to the effluent treatment plant. The design flows for this are 0 to 5,5 m^3/ADt. The low effluent flow number is based on complete evaporator condensate reuse in the bleach plant, and the higher flow number with reduced bleach plant reuse. Reuse will depend on condensate quality and operating experience. It can be noted that only a few bleach kraft mills worldwide use evaporator condensates for bleach plant washing.

Gases from the steam stripper, which is integrated to the evaporation plant on the vapour side, are taken to a methanol column where the methanol content is concentrated up to 80%. Concentrated methanol vapour is condensed and stored as liquid in a methanol tank before it is burned in the recovery boiler. LVHC gases collected from the evaporation train and the methanol plant are incinerated in the recovery boiler.

A7.4.6 Recovery Boiler, Biomass Boiler and Turbine Generator

The design capacity of the recovery boiler is 2 700 tonnes of dry solids per day. The recovery boiler has been designed for an additional 20% capacity over normal continuous operation of the mill. Concentrated black liquor produced at the evaporation plant is fed to the recovery boiler at a dry solids content of approximately 75% and will be mixed with biosolids from the effluent treatment plant.

Oil is used only for boiler start-up and shutdown. The heat released during black liquor burning is recovered as superheated steam at a pressure of 85 bars and a temperature of 485ºC. Vent gases from dissolving tank are also introduced into the recovery boiler thus decreasing the total emissions from the recovery boiler area. Particulate matter in the flue gases is collected in two electrostatic precipitators and returned to the boiler. In order to control the potassium and chloride content of the mill liquor systems, most of the dust collected in the electrostatic precipitators is treated in an ash leaching system in order to remove chlorine and potassium from the process. This leaching system helps ensure that the recovery cycle can manage greater amounts of bleaching filtrate recycle than it would otherwise.

The biomass boiler is designed to burn bark from debarking operations, as well as waste produced during subsequent wood processing. A bubbling fluidized bed (BFB) combustion technology will be employed. The primary sludge from the wastewater treatment plant as well as biosolids from wastewater treatment (when it cannot be burned in the recovery boiler), can also be burned in the biomass boiler. Under normal operation, diluted non condensable gases (HVLCs) are burned in the recovery boiler as mentioned above, but they can also be burned in the biomass boiler. Heavy fuel oil is used to start-up and shutdown the boiler as well as for unbalanced conditions. The heat released by the biomass boiler is recovered as superheated steam of at bars and 485ºC. The steam is then delivered to a steam turbine.

Ammonia injection will be used in order to minimize the discharge of NO_x from the biomass boiler. Flue gases leaving the boiler are cleaned in an electrostatic precipitator before the gases are released to the atmosphere. Fly ash separated from the flue gases, as well as the bottom ash from the furnace, are taken to the landfill.

Superheated steam from the recovery boiler as well as from the biomass boiler is introduced in the turbogenerator that will have a capacity of 94,4 MW. The steam turbine used is a multi-extraction condensing turbine that first extracts steam for boiler sootblowing as well as medium and low pressure steam for process requirements.

The excess amount of steam not needed in the pulp mill processes is introduced into the condensing tail in order to maximize electricity production. Steam leaving the condensing tail is condensed and the water is recirculated back to the boilers. In the generator, the turbines' mechanical energy is converted to electricity, which is used at the mill and/or delivered to the national electricity grid. Power generation will be in the order of 72 MW, of which 41 MW will be consumed by the mill. Excess electricity generated by biomass (31 MW) will be dispatched to the national grid.

Figure A7.4-4 shows the recovery line implemented at the ENCE-CMB pulp mill.

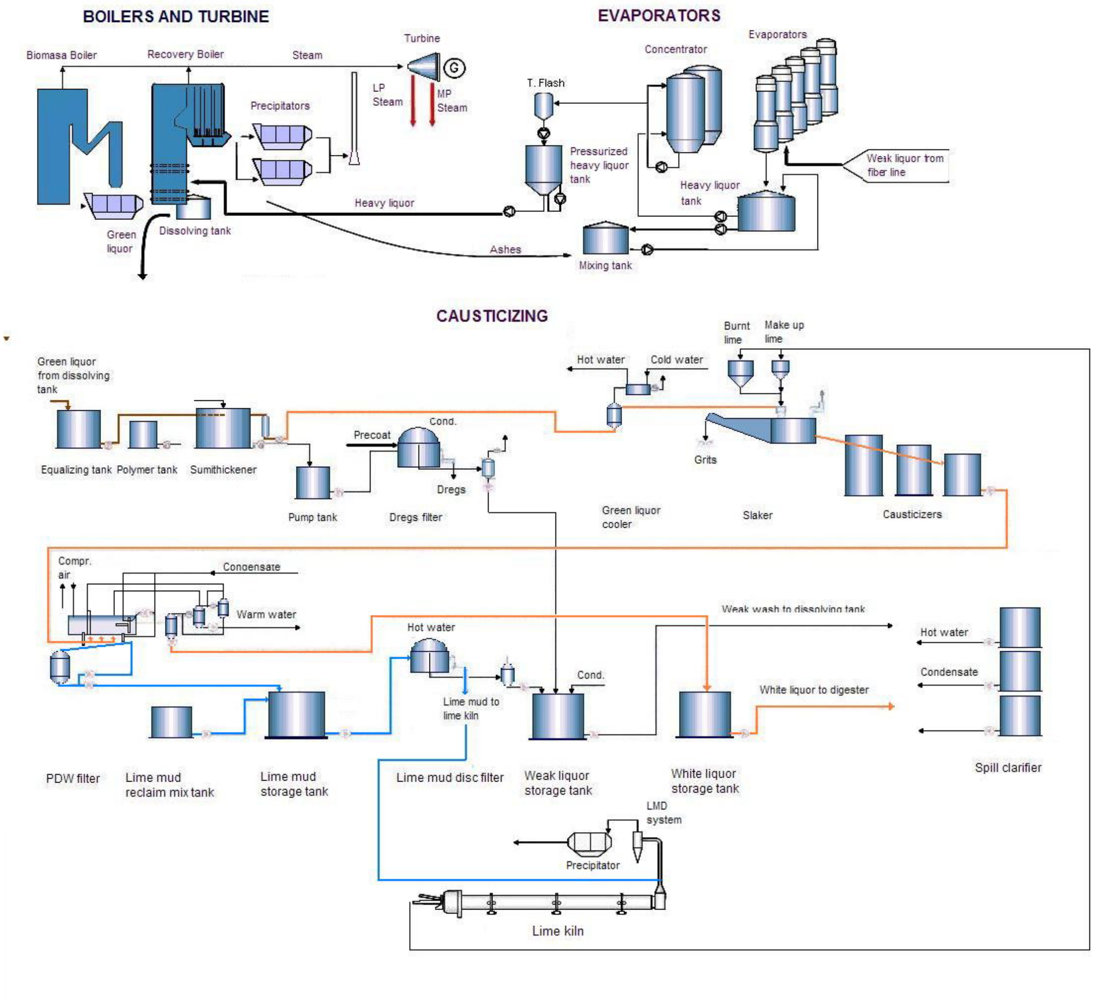

Figure A7.4-4: ENCE-CMB Pulp Mill Recovery Line

A7.4.7 Lime Kiln and Recausticizing

Smelt from the recovery boiler is dissolved into weak wash in the smelt dissolving tank. The green liquor from the dissolving tank is then taken to an equalization tank before entering the clarification unit. In the clarification process, dregs are separated and sent to a vacuum drum precoat filter to be washed and dewatered.

Clarified green liquor is mixed with reburned lime in the slaker. The causticizing reaction takes place in the slaker and continues into three recausticizing tanks. The slurry from the third tank is pumped to the white liquor pressurized disc filter, where white liquor is separated from lime mud and sent to the digesters to be used as cooking liquor. The design capacity of the causticizing line is 5 800 m^3/d of white liquor. At the pressurized disc filter, lime mud is washed with secondary condensate and sent to the lime mud storage area.

From the storage tank, lime mud is pumped to the vacuum filter to be further washed with hot water.

Filtrate is returned back to the process and lime mud is fed to the lime kiln which is equipped with a flash dryer. During the lime kiln process, lime mud is dried, preheated and finally calcined to lime. The sensible heat in the kiln product, i.e. lime, is recuperated by a heat exchanger/cooler, which brings the lime temperature to a level suitable for further handling but which also results in efficient operation and low energy consumption. Heavy fuel oil is used as fuel in the lime kiln.

Flue gases leaving the kiln are firstly introduced to the electrostatic precipitator in order to separate lime dust. Dust is returned to the process. The electrostatic precipitator is followed by a flue gas scrubber in which gases are further cleaned before they are introduced to the atmosphere. Diluted non condensable gases are collected from the causticizing area and taken to the recovery boiler to be burned.

Most of the process water used at the recausticizing plant is secondary condensate from the evaporation plant. A minor amount of pure water, hot and cold, is also needed. Cooling water, required at the jet condensers and vacuum pumps of the dregs and lime mud filters, is returned back to the cooling towers.

A7.4.8 Chemical Island

Chemicals are mainly consumed in the bleach plant. The main chemicals required are chlorine dioxide, hydrogen peroxide, sodium hydroxide and sulphuric acid. The required chemicals are delivered to the mill except for chlorine dioxide which will be generated on site. The production of chlorine dioxide is based on the R10 or SVP-SCW process. This process produces a neutral saltcake by-product and chlorine dioxide with very low levels of chlorine.

A7.4.9 Water Treatment

Raw water is pumped from the Uruguay River and clarified. Water for wood treatment is taken from the treated water basin and sent directly to process. Water required as process and cooling water in the pulp mill is directed to a cooling tower basin from where it is delivered to cooling applications. Cooling water is returned back to the cooling towers after use. Warm water is produced at the surface condenser of the evaporator train and delivered to process consumers. Hot water is produced mainly at the bleach plant by cooling the bleach plant filtrates. The hot water is used at the bleach plant, drying machine and recausticizing and the excess is sent to the cooling towers.

A certain quantity of makeup is required for condensate losses in the water/steam circuits. To ensure makeup water quality, the mill water is further treated in the demineralized water treatment plant before being introduced into the boiler feed water tank.

A7.4.10 Effluent Treatment Plant

The wastewater treatment plant (WWTP) treating the ENCE-CMB pulp mill effluent will employ the activated sludge treatment (AST) process and will treat approximately 46 000 m^3/d (29 m^3/ADt). An analysis of the WWTP design and estimated removal efficiencies is done in section A8.2 of this Annex.

Two different sewer flows will be collected at the pulp mill and sent for treatment to the WWTP:

- High solids effluent: the high solids effluent will first be directed to automatic bar screens for coarse solids removal and then to a primary clarifier. The primary clarifier supernatant is sent to the post-neutralization tank where it is mixed with the pre-neutralized low solids effluent.
- Low solids effluent: the low solids effluent will be adjusted for pH by lime in a pre-neutralization tank before being directed to the post-neutralization tank for fine adjustment of the pH level with sulphuric acid and caustic soda.

The outflow of the post-neutralization tank is sent to the equalization basin where urea and phosphoric acid nutrients are added, as well as antifoam, if necessary. The outflow can be sent to the emergency basin in the event of abnormal operating pH, temperature, organic content or influent flow. The contents of the emergency basin are metered back into the treatment system before the post-neutralization tank. The temperature of the effluent out of the equalization basin, about 35°C, can be reduced if necessary by indirect contact heat exchangers and a forced draft cooling tower before entering the aeration basin. The activated sludge system consists of a single aeration basin of 24 000 m^3 preceded by an anoxic chlorate removal unit and a selector stage of 5 000 and 8 000 m^3 respectively. A degassing tank follows the basin before the effluent from the AST process is settled in the secondary clarifiers. A final cooling tower can be used to cool the flow of treated effluent, if necessary, below 30ºC, before it can be discharged to the river. Alternatively, the effluent may be cooled by mixing with river water prior to discharge.

The primary sludge will be sent to the sludge mixing tank and subsequent flocculation tanks, followed by gravity tables and screw presses for dewatering. Polyelectrolyte solution may be added to the primary sludge to enhance the performance of the presses. The primary sludge will be incinerated in the biomass boiler. Most of the secondary sludge is recirculated back to the activated sludge basins as return activated sludge (RAS) while the waste activated sludge (WAS) will be thickened and taken to the mill evaporation system for incineration in the recovery boiler.

A7.4.11 Non-Condensable Gases (NCGs)

The concentrated NCGs or LVHC gases are collected from the methanol and evaporation plant and are burned in the recovery boiler in a dedicated gas burner, which is located at the secondary air level. The collection system is equipped with flame arrestors for safety reasons. In the event that the LVHC gases cannot be burned in the recovery boiler, they can be directed to a permanently ignited flare.

The dilute NCGs or HVLC gases are collected from the digester, the brown stock screening and washing units, the evaporation plant and from recausticizing, and are sent to a cooling scrubber located in the recovery boiler area. In the scrubber, gases are cooled to remove extra moisture and to reduce the volume of the gases. The cooling scrubber is equipped with two stages, one for washing and another for cooling. From the scrubber, these gases are taken via the droplet separator and pre-heater to the high secondary air duct and mixed with feed air. The mixture is introduced via a preheater into the recovery boiler through high secondary air nozzles. In the event that the gases cannot be burned in the recovery boiler, they can be fed to the biomass boiler.

A8.0 MILL TECHNOLOGY COMPARISON WITH BAT

A8.1 Overall Mill Water Use and Effluent Flow

In this section, the overall levels of water use and effluent flow for the Botnia-Orion and ENCE-CMB pulp mills will be assessed with respect to Best Available Technology.

A8.1.1 Water Use in Bleached Kraft Mills

Water is used in a bleached kraft pulp mill primarily for the following:

- cooling and heating (as steam and water);
- for transport (pumping) of pulp and chemicals;
- for lubrication of equipment (flushing and sealing); and
- for washing and cleaning pulp and equipment.

Water primarily enters from the river, through water treatment. Smaller amounts enter the mill processes via the wood furnish, with chemicals, and can be formed in pulping reactions and from combustion. Water primarily leaves the mill with the effluent, but also as water vapour from cooling towers, combustion devices, the pulp dryer vent, the oxygen delignification and peroxide bleaching vents, and in the final product. For a modern bleach eucalypt kraft mill, about 4 m^3/ADt of water is evaporated and about 0.1 m^3/t leaves with the product.

Water is needed to wash pulp, to ensure that the final product is free of COD, odour, and chemicals. If pulp contains high COD, this may cause operating problems for the papermaker or converter. In bleaching, washing is used to clean pulp between stages with incompatible chemistry, i.e. between acid and alkaline bleaching stages. Wash waters in the mill are from both fresh water, and recycled hot water sources.

The lowest water use and effluent flow for a bleached kraft pulp mill known to the CIS project team was achieved by Botnia at the Rauma mill. Rauma found that low water usage in bleaching was accompanied by detrimental effects such as bleach plant scaling, increased chemical consumptions, and specific effluent loadings of COD increased. The evaporators also had difficulty with scaling (as some bleach filtrates were recycled) and production was stopped (for evaporator cleaning) more often than normal. This also resulted in additional black liquor losses. The water use was subsequently increased, to provide better washing and purging of inorganic chemicals (such as calcium and oxalate), and effluent flow is now about 18 m^3/ADt. This has resulted in lower chemical usage and lower mill effluent organic loadings (COD) at Rauma.

In practical terms the minimum optimum water usage will be determined somewhat through operations and experience and needs to consider product, resources and equipment.

The current operating effluent flow for bleached market kraft pulp mills located in Canada, USA and Europe is shown in the Figure below. In this graph, annual average effluent flow for mills with a total of 21.5 million tonnes of pulp production is represented out of a world total of 41 million tonnes. 10% of the production is made with an effluent flow of less than 24.5m^3/ADt, whereas the median 50.3 m^3/t, and the upper decile is 102 m^3/ADt. The figure also shows that effluent flow has decreased over time (2000 versus 2004), as the higher water use mills shut down or renovate, and the lower water use mills increase production, while not increasing water supply.

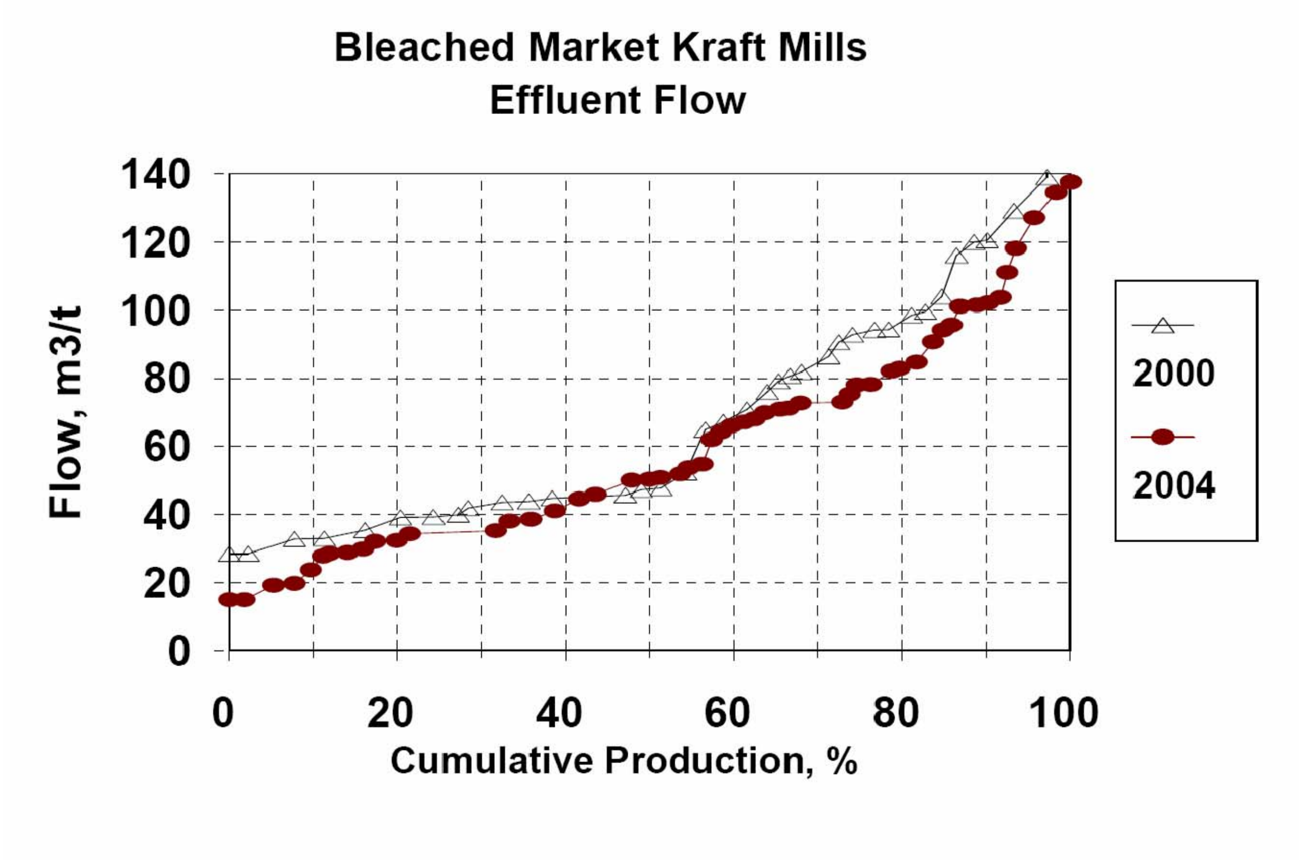

Figure A8.1-1: Average Effluent Flows from Bleached Market Kraft Mills in the USA, Canada and Europe in 2000 and 2004 (Ekono 2006)

A8.1.2 Botnia-Orion Water Use and Effluent Flow

Botnia-Orion has estimated that their long-term average (LTA) effluent flow will be just under 25 m^3/ADt, which would place this mill amongst the lowest 10% in the world. The Botnia Orion bleach effluent flow is close to 60% of total mill effluent. A summary of Botnia's water balance (for 3000 ADT/d production) and effluent sources are shown in the table below.

Table A8.1-1: Estimated Water Use and Effluent Flow for the Botnia-Orion Mill

Water from Rio Uruguay	26,0 m^3/ADt
Effluent Flow	m^3/ADt
Wood handling	0,7
Cooking and brown stock	0,5
Bleaching	13,2
Drying	2,3
Evaporation	1,3
Boilers	0,5
Causticizing and lime kilns	2,1
Demineralisation plant	1,0
Chemical plant	0,2
Water treatment	0,6
Flush waters, etc miscellaneous	0,4
Rainwater etc.	0,4
Total effluent from the mill	23,3

Botnia-Orion will recycle warm and hot waters for process use. Excess warm water will be cooled in a central cooling tower system, which is integrated in with the overall mill water supply. This arrangement avoids the need for cooling tower blow down (effluent) and chemical management of the cooling water circuit.

A8.1.3 ENCE-CMB Water Use and Effluent flow

ENCE-CMB has estimated that their long-term average (LTA) effluent flow will be approximately 29 m^3/ADt, which would place this mill amongst the lowest 15% in the world.

CMB's bleach effluent flow is about 35% of total mill effluent flow. A summary of ENCE-CMB's water balance (using a basis of 1587 ADT/d production) and effluent sources are shown in the table below. ENCE-CMB will also recycle warm and hot waters for process use. Excess warm water is cooled in a cooling tower system.

Table A8.1-2: Estimated Water Use and Effluent Flow for the ENCE-CMB Mill

Water In	m^3/ADt
From river	30.7
In wood and chemicals	2.1
Total water in	32.8
Water Out	
To atmosphere (evaporation)	5.2
In product	0.1
To effluent	27.5
Total water out	32.8

Effluent Flow	m^3/ADt
Woodhandling	1.0
Cooking and brown stock	0.0
Bleaching	9.8
Drying	2.3
Evaporation	5.5
Boilers	0.9
Causticizing and lime kilns	0.1
Demineralisation plant	1,0
Water treatment	0.9
Sealing, Flush, Cooling, Hoses, Miscellaneous	5.1
Domestic	0.3
Rainwater and Leachate	0.5
Total from the mill	27.5

A8.1.4 Summary of BAT Analysis for Water Use and Effluent Flow

The IPPC-BAT(2001) and Tasmanian-AMT(2004) standards indicate a process effluent flow of 30-50 m^3/ADt for mills using BAT technology, and call for collection and reuse of clean cooling waters.

The Botnia-Orion mill effluent flow of 25 m^3/ADt and collection and reuse of clean cooling water (150 m^3/ADt) meet BAT requirements. Botnia-Orion mill has a water use design which is fairly tight, and offers limited room for reductions in specific effluent flow over time, as the mill established production and is tuned to the Uruguayan wood and conditions.

The ENCE-CMB mill design effluent flow of 29 m^3/ADt and collection and reuse of clean cooling water (190 m^3/ADt) meet BAT requirements. ENCE CMB mill has a preliminary water use design, and has developed scenarios, within the performance guarantees of its vendors, which suggest that effluent flows of less than this target may be achievable in the long term. For example ENCE has selected technologies (a press-based bleach plant for washing) which after start up and initial operation, provide the potential for lower effluent flows. Should condensates be more completely reused, and/or partial PO filtrate recycle is successful, then specific flows in the same order as the Botnia-Orion mill should be achievable.

Each mill will develop its unique optimal water use given pulp quality and selected equipment requirements, and considering the impact on other environmental parameters. Generally, reducing water use significantly below the current design numbers may result in increases in other (possibly more important) parameters. The environmental benefit due to water reduction from these already low values on the receiving environment is not expected to be significant. Furthermore, since the permit limits for the mills will be based on concentration as well as loading-based values, effluent flow reduction may be limited in order to respect the mill operating permits.

A8.2 Wastewater Treatment Plant

Section A8.2 reviews the wastewater treatment technology to be implemented in the Botnia-Orion and ENCE-CMB pulp mills, and compares it with the IPPC-BAT (2001) and Tasmanian-AMT (2004) guidelines for kraft pulp and paper mills. A discussion on tertiary treatment at pulp and paper facilities is also provided.

A8.2.1 BAT Wastewater Treatment Plant Guidelines

This section summarizes the techniques pertinent in the determination of BAT for wastewater treatment plants. Both plants will use a form of the activated sludge treatment (AST) process for the removal of organic matter. AST is used when high or very high treatment efficiencies are required, as opposed to aerated stabilization basins (ASBs) that are generally considered to be less efficient [IPPC-BAT (2001)]. ASBs were widely installed in mills built before 1995, but have not been since then. Discharge limits defined by IPPC-BAT (2001) and Tasmanian-AMT (2004) are presented in Section A5.

The following describes the IPPC-BAT (2001) for the treatment of kraft pulp mill wastewater by the activated sludge process:

- *Primary treatment stages* including solids removal, neutralization, cooling and equalization. These primary stages aim at protecting the secondary treatment from excessive loads and shocks and overall at providing more cost-efficient purification of effluents.

- Low loaded activated sludge plants with a BOD load below 0,15 kg BOD/(kg MLSS*d) and a typical retention time in the aeration basin of about one day (and up to 2 days) are regarded as BAT. With these characteristics, mills can achieve high removal efficiencies and a stable treatment system. It should be noted that other treatment configurations with comparable emission levels and comparable costs can also be regarded as BAT.

- Oxygen and mixing are provided to the aeration basin by mechanical aeration equipment. Various types of aerators are in use, such as surface aerators, submerged turbine aerators, fine bubble aerators and jet aerators. The three last mentioned types require compressed air from blowers or compressors.

- *Typical reduction* values in the activated sludge process are:

    - 85 to 98% BOD_5 removal. LTA BOD concentrations in treated effluents between 10 and 25 mg/L are associated with BAT,
    - 60 to 85% COD removal. To be regarded as a well performing plant, the COD reduction rates in treatment should exceed 55%,
    - The overall efficiency of TSS removal across primary and secondary treatment is about 85 to 90%. Under normal operation conditions, the water from the secondary clarifier is fairly clear and the LTA suspended solids concentration is in the range of 20 to 30 mg/L,
    - 40 to 65% AOX reduction. ECF mills achieve emission levels of <0,25 kg/ADt.

- *Nutrients (N and P) control strategy* and fine tuning of the nutrient feed. It is critical to find and keep a balance between incoming N- and P-compounds that are available to the biomass, and the amount of nutrients added.

- *Emergency basin* is required to protect the biomass from toxic or hot concentrated liquors.

- *Equalization* is preferred, to equalise BOD and hydraulic loads.

The following features describe Tasmanian-AMT (2004) for the treatment of BEKP mill wastewater by the activated sludge treatment process:

- *Pre-treatment* includes normally sedimentation, cooling, neutralisation and equalization stages. The solids removal stage also aims to protect the subsequent treatment stage from disturbances due to accumulation of inert matter.

- *Primary and secondary (biological) treatment* of all process effluent, excluding uncontaminated cooling water.

- The *retention time* in kraft pulp mill ASTs should be between 15–50 hours. Aeration and mixing are provided by mechanical aeration equipment such as surface aerators, submerged turbine aerators, fine bubble aerators and jet aerators.

- Low-loaded activated sludge plants with an F/M ratio below 0,15 kg BOD/d/kg MLSS and typical hydraulic retention time in the aeration basin of about one day (up to 2 days) are regarded as AMT. Any other treatment system with comparable emission levels and cost is also regarded as AMT.

- *Selector* technique is commonly used in modern activated sludge plants. This technique has resulted in better sludge characteristics, which in turn gives more stable operation and less solids carry-over. Selectors in AST plants can have one or more of the following functions:

  - Minimization of the growth of filamentous (bulking or non-settling) bacteria and promotion of the growth of floc-forming (settling) bacteria,
  - Reduction of the final discharge of nutrients, achieved by a combination of lowering the discharge of suspended particles (biomass containing nutrients) and more stable operation at low levels of dissolved nutrients,
  - Prevention of foaming.

- *Chlorate* can, if required, be reduced biologically in an anoxic stage. A 90 – 100% reduction of chlorate (ClO_3^-) to chloride (Cl^-) can be achieved. The chlorate reduction process was developed at some Swedish bleached kraft mills operating aerated lagoons in the mid 1980's. The anoxic stage to achieve chlorate reduction is usually a separate tank ahead of the selector, having a retention time of the order of 5 – 10 hours. The design is dependent on chlorate load, the load of easily degradable organic matter (i.e. BOD), the amount of biomass, and temperature. It is usually equipped with agitators and a certain fraction of the biosludge is recirculated from the secondary clarifier to achieve a concentration of mixed liquor in the selector about 1 g/L.

- *Typical reduction* values in the activated sludge process are:
    - 85 to 98% BOD_5 removal
    - 60 to 80% COD removal
    - 40 to 65% AOX reduction
- The overall efficiency of *TSS removal* of primary and secondary treatment is about 85 to 90%.
- Provision of containment basin(s) to temporarily store untreated process effluent that has sufficiently high levels of contamination to adversely affect the operation of the effluent treatment plant.

A8.2.2 Botnia-Orion Wastewater Treatment Plant

Botnia's wastewater treatment plant (WWTP) in Kaskinen, Finland, was the reference on which Botnia relied most for the design of the Botnia-Orion WWTP in Fray Bentos, even though results and experience from all of the company's effluent treatment plants were considered. In 2002, Botnia completed an effluent treatment benchmarking study, comparing in detail the design and operation of various WWTP's. Kaskinen was ranked first in Botnia's fleet and was chosen as the basis for the design of Orion's WWTP. For more detail on the comparison between Kaskinen and Botnia, with respect to effluent treatment, refer to the Botnia memorandum in the appendices of this Annex.

The wastewater treatment plant for the Botnia Orion pulp mill effluent will employ the AST process, and will treat an average discharge flow of approximately 73 000 m^3/d (25 m^3/ADt). For a complete description of the WWTP, refer to Section A7.3.10. Table A8.2-1 summarizes the characteristics of the Botnia-Orion WWTP process units. Table A8.2-2 summarizes the influent characteristics to the WWTP as well as the removal efficiency with regards to various key parameters according to the IPPC-BREF document.

Table A8.2-1: Characteristics of the Botnia-Orion WWTP Process Units

Equipment item	Characteristics
Influent flow	Average: 75 000 m^3/d Maximum: 110 000 m^3/d
Primary clarifier	Diameter: 46 m Volume: 7 500 m^3
Pre-neutralization tank for low solids sewer	Volume: 285 m^3
Quicklime silo	Volume: 50 m^3
Sludge mixing tank	Volume : 250 m^3
Equalization basins (3)	Volume: 25 000 m^3 each
Neutralization tank	Volume: 360 m^3
Aeration basins (2)	Volume: 75 000 m^3 each Hydraulic retention time: 48 h Sludge retention time: 22 d Aeration type: 1 400 fine-bubble diffusers per basin Installed aeration blower capacity: 3,2 MW (0,8 MW as reserve)
Anoxic zone	Yes. For chlorate removal
Selector stage	Yes.
Degassing tanks (2)	Volume: 700 m^3 each
Secondary clarifiers (2)	Diameter: 65 m each Volume: 16 500 m^3 each
Biosludge pits (2)	Volume: 110 m^3 each

Table A8.2-2: Influent Characteristics into the Botnia-Orion Treatment Plant and Removal Performance

Parameter	Units	Influent LTA	Effluent LTA	% removal	IPPC-BAT % removal
Flow	m^3/ADt	25	25	-	-
COD	kg/ADt	55	8,0	85	60 – 85
BOD	kg/ADt	17	0,3	98	85 – 98
AOX	kg/ADt	0,3	0,08	73	40 – 65
Suspended Solids	kg/ADt	10	0,7	93	85 – 90
ClO_3^-	kg/ADt	5	0,075	99	90 – 100[1]

The WWTP designed for the Botnia-Orion mill clearly fulfills all BAT recommendations, including the following specific features:

- The design incorporates generous equalization and emergency basins, and in particular has an innovative design to avoid high organic loads to be charged into the AST. This design includes three 8-h retention time basins (equalization/emergency) that operate in a semi-continuous manner, i.e. they are filled continuously, and then the effluent quality in the basin is checked prior to discharge into the AST. In the event that a spill has occurred in the mill, the basin contents would have a high COD and would be discharged into the AST in a manner that does not overload the system.
- The design incorporates an anoxic zone for chlorate removal and a selector stage.
- The hydraulic retention time in the aeration basin is 48 hours.
- All BAT removal efficiencies are met and exceeded.

Botnia has not yet specified a nutrient control strategy for its Orion WWTP, however has demonstrated a high level of competence in its mills in Finland where discharge limits on nutrients are particularly stringent.

A8.2.3 ENCE-CMB Wastewater Treatment Plant

At the time that the CIS was written, ENCE was still negotiating with suppliers with regards to the wastewater treatment plant, each proposing somewhat different solutions. While most of the technology choices and dimensional questions have been settled and are reflected in this summary, the following description is not final.

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[1] This removal percentage range is taken from the RDPC-AMT recommendations

The wastewater treatment plant (WWTP) at the ENCE-CMB pulp mill will employ the extended aeration activated sludge treatment process, and will treat approximately 46 000 m^3/d (29 m^3/ADt). For a complete description of the WWTP, refer to Section A7.4.10. Table A8.2-3 summarizes the characteristics of the ENCE-CMB WWTP process units. Table A8.2-4 summarizes the long-term average (LTA) effluent loads into the treatment plant as well as the removal efficiency with regards to various key parameters according to the IPPC-BREF document.

With the BAT features highlighted at the beginning of this section and the technology described in Section A7.3.10, ENCE-CMB will implement all of IPPC recommended BAT features for biological treatment. The general design features for the ENCE-CMB WWTP include the following:

- The design will employ extended aeration AST technology, and include an anoxic zone for chlorate removal and a selector stage.
- The design will incorporate appropriate equalization and emergency basins.

ENCE shows lower removal efficiencies than Botnia with the proposed wastewater treatment plant. After analysis, the CIS project team attributes this to be related to the earlier stage of design for the ENCE plant, and ENCE stating guaranteed values that they have discussed with potential treatment plant suppliers.

ENCE has not yet specified a nutrients control strategy for its CMB WWTP. ENCE has had successful experiences with nutrient control at its Spanish mills, and its strategy with regards to nutrient minimization will most likely be inspired from this experience. Finally, based on the technology that the mills will be using and because ENCE is committed to close process monitoring and proactivity, the CMB mill's WWTP should achieve low nutrient discharge values.

Table A8.2-3: Characteristics of the ENCE-CMB WWTP Process Units

Equipment Item	Characteristics
Flow	Average: 46 000 m^3/d
Primary clarifier	Diameter: 40 m Depth: 4 m
Pre-neutralization tank for low solids sewer	Volume: 150 m^3
Emergency basin	Volume: 50 000 m^3 (2 x 25 000 m^3)
Equalization basin	Volume: 5 000 m^3
Post-neutralization tank	Volume: 120 m^3
Chlorate reduction stage	Volume: 5 000 m^3
Selector stage	Volume: 8 000 m^3
Aeration basin	Volume: 24 000 m^3 Hydraulic retention time: 21,5 h Sludge retention time: 25 d Aeration type: fine-bubble diffusers with membrane tubes Installed aeration blower capacity: 6 units (and 1 on standby) of 250 kW each
Secondary clarifiers (2)	Diameter: 50 m each Depth: 5 m each

Table A8.2-4: Long-Term Average Effluent Loads into the ENCE-CMB Treatment Plant and Removal Performance

Parameter	Units	Influent LTA	Effluent LTA	% removal	IPPC-BAT % removal
Flow	m^3/ADt	29	29	-	-
COD	kg/ADt	29	8,7	70	60 – 85
BOD	kg/ADt	12	0,6	95	85 – 98
AOX	kg/ADt	0,2	0,1	50	40 – 65
Suspended Solids	kg/ADt	6,0	0,9	85	85 – 90
ClO_3^-	kg/ADt	3,0	0,3	90	90 – 100[2]

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[2] This removal percentage range is taken from the RDPC-AMT recommendations

A8.2.4 Tertiary Treatment

Tertiary treatment is not a commonly-implemented technique used in modern pulp mills. The following section discusses tertiary treatment using a BAT perspective.

The IPPC-BREF document does not include tertiary treatment as part of BAT, even though it mentions that, in some cases, tertiary treatment of wastewater can be regarded as necessary when the nutrient concentrations in the effluent have to be lowered because the mill discharges into sensitive receiving waters. In most cases, tertiary treatment is simply chemical precipitation. The dissolved organic substances are separated by precipitation and subsequent filtration or clarification. The chemicals used for precipitation are usually the following:

- aluminium salts - $Al_2(SO_4)_3$ and $Al_n(OH)_m(Cl_3)_{n-m}$
- ferric salts (Fe(III)) - $FeCl_3$ and $Fe_2(SO_4)_3$
- ferro salts (Fe(II)) - $FeSO_4$
- lime

To optimize the flocculation, polyelectrolytes are used in the mixing phase.

IPPC-BAT (2001) also mentions that the precipitation of organic material in the effluent with inorganic chemicals results in a significant quantity of sludge that cannot be burned without the use of auxiliary fuel because of the (typically) high content of inorganic matter and water that makes it difficult to dewater and to landfill.

Tasmanian-AMT (2004) also discusses the implementation of tertiary treatment (i.e. chemical coagulation) and similarly, does not consider it to be AMT unless the environment is sensitive. The report states that while the chemical treatment can help further reduce the quantities of some recalcitrant compounds such as high molecular degradation products from lignin, the high sludge production can outweigh incremental benefits.

Tertiary treatment is carried out by Arauco in the Valdivia mill in Southern Chile, and was a technology required by the local regulator. This mill discharges into a river whose flow is much less than the Rio Uruguay at Fray Bentos, and there were concerns with color discharge. The use of tertiary treatment in this instance was criticised as not being beneficial by the World Wildlife Fund, who stated in a report on Valdivia that “the decision to use tertiary (chemical) treatment at CELCO's Valdivia plant was not appropriate, and is difficult to understand from a technical and environmental point of view.”[3]

The NCASI Technical Bulletin “Review of color control technologies and their applicability to modern kraft pulp mill wastewater”[4] reviewed known external color removal technologies,

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[3] Findings and Recommendations Report: WWF International Assessment Mission for the Carlos Anwandter Nature Sanctuary and CELCO pulp mill controversy in Valdivia, Chile, November 2005, pp.13-14; http://assets.panda.org/downloads/final_wwf_rio_cruces_report_english.

[4] Eva Mannisto, Review of color control technologies and their applicability to modern kraft pulp mill wastewater, NCASI Technical Bulletin No. 919, August 2006.

and found that many of these are neither economically nor technically justifiable because of the sludge handling issues, for example. The report highlighted the most promising technologies as being polymer treatment for brown color and aluminium-based treatment in the activated sludge treatment.

Botnia-Orion requested that a review on tertiary treatment be done by Pöyry Forest Industry Oy, in which a preliminary design for tertiary treatment at the Botnia-Orion pulp mill was proposed and the following points highlighted[5]:

- the addition of tertiary treatment for biologically treated effluent can lead to further but marginal reduction of COD, TSS, phosphorus, color and AOX;
- chemically enhanced dissolved air flotation (DAF) is considered as the most feasible method to reach good reduction results with reasonable ease of operation;
- in chemimechanical tertiary treatment, the high dosage of chemicals may also result in the formation of fine suspended solids which may slightly increase the solids concentration escaping to the receiving environment;
- high dosage levels are required in order to reach good reduction, e.g. with alum, the dosage can be 300 to 600 g/effluent-m^3, calculated as aluminium oxide;
- supplementary polymer dosage is usually 1 to 2 mg/L, calculated as 100% polymer. This leads to high operating costs;
- a side effect of high dosage is that sulphate/chloride and possibly residual aluminium or iron concentration in tertiary treated effluent becomes high; and
- tertiary treatment generates large quantities of sludge which is difficult to dewater. In Botnia-Orion's case, tertiary sludge would have to be disposed of by landfilling because it could not be mixed with biosludge for disposal in the recovery loop.

Based on this review, Botnia-Orion had not recommended tertiary treatment be installed. Also, based on an analysis presented in its EIA, Botnia-Orion does not find the Rio Uruguay to be a particularly sensitive recipient that would benefit from tertiary treatment of the mill effluent. The CIS project team agrees with this analysis. Nutrient loading to the Rio Uruguay could be more effectively mitigated by treating the Fray Bentos municipal effluent in Botnia-Orion's WWTP. ENCE-CMB has also recommended that tertiary treatment not be implemented, based on their experience in Spanish mills and on discussions with consultants and potential suppliers.

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[5] Pöyry Forest Industry Oy memorandum to Botnia-Orion, May 22, 2006.

Ekono (2006) reviewed color data for 21(out of the approximately 140) bleached kraft mills in the USA and Canada for discharges in 2004. The lowest color emission was 10 kg/ADt and highest 80 kg/ADt. The median was 26 kg/ADt. Generally only mills on sensitive receiving bodies are required to measure color, and this range will likely be skewed towards those with lower emission. Botnia-Orion's estimate of 9 kg/ADt and ENCE-CMB's estimate of about 6 kg/ADt indicate performance that will be among the best in the world, without tertiary treatment.

In conclusion, it world be environmentally undesirable for either mill to implement tertiary treatment because of the following reasons:

- the mill performance in respect to color is among the world's best without tertiary treatment;
- it may increase the chemical load on the environment;
- it adds cost and complexity to the treatment system;
- it is not required to meet water standards; and
- it is not considered to be part of neither IPPC-BAT (2001) nor Tasmanian-AMT (2004).

A8.3 Energy Issues

Steam and power are essential for operating the BEKP mills. Both the Botnia-Orion and the ENCE-CMB pulp mills have been designed using energy efficient standards, a strategy which is especially important and economically attractive in the current context of high and rising energy costs. Uruguay is not an oil-producing nation, and imports all of its fossil fuel requirements. The ENCE-CMB mill relies on black liquor and wood waste as the primary sources of fuel for the mill, whereas Botnia-Orion relies primarily on black liquor. Both mills will employ heavy fuel oil for supplemental fuel in the recovery boilers and biomass boiler (ENCE-CMB only), as well as the primary fuel in the lime kilns and systems for NCG disposal and emergency power.

The two mills will produce all necessary process steam and more electricity than they use, by burning biomass (black liquor and wood waste) which is greenhouse gas neutral, and is obtained entirely from local, sustainable and renewable forests.

A8.3.1 BAT Energy Management Guidelines

Most of the steam in the pulp mills is consumed for heating process streams and for evaporating water. Electrical energy is mostly consumed for pumping and mixing, for the operation of the process equipment, and for operation of the wastewater treatment plant aeration system.

IPPC-BAT (2001) states the following:

- Bleached kraft pulp mills consume about 10-14 GJ/ADt of steam (not considering steam used for electrical power generation), and consume about 600-800 kWh/ADt of electrical energy.
- The energy consumption for pulp drying is about 25% of the heat energy, and 15-20% of the electrical energy.
- Over 50% of the electrical energy consumed is used for pumping.
- The steam consumption depends on the process configuration, process equipment and process control efficiency.

To achieve these energy efficiency standards, the mill must be designed appropriately. A number of measures are presented in IPPC-BAT (2001), and have been reviewed with the mill proponents.

In order to reduce the consumption of fresh steam and electric power, and to increase the generation of steam and electrical power internally, IPPC-BAT (2001) proposes that the following measures be considered:

- high dry solids content of black liquor and bark;
- high efficiency of steam boilers, e.g. low flue gas temperatures;
- effective secondary heating system e.g. hot water about 85°C;
- well closed-up water system;
- relatively well closed-up bleaching plant;
- high pulp concentrations in process (so-called medium consistency processing);
- pre-drying of lime; and
- good process control.

IPPC-BAT (2001) summarizes the following measures for low consumption of electric power:

- higher pulp consistencies in screening and cleaning;
- speed control of large motors;
- efficient vacuum pumps;
- proper sizing of pipes, pumps and fans;

and the following measures for a high generation of electric power:

- high boiler steam pressures;
- outlet steam pressure from back-pressure turbines as low technically feasible;
- condensing turbines for power production from excess steam;
- high turbine efficiency; and
- preheating of air and fuel charged to boilers.

A8.3.2 Botnia-Orion Energy Profile

Figures A8.3-1 through A8.3-3 summarize the latest version of the Botnia-Orion pulp mill energy balances that were available at the time of writing the CIS. The balances are based on Siemens' calculations provided to Botnia-Orion concerned with optimizing the electricity generation, and vary somewhat from those presented in the Botnia-Orion EIA document.

High pressure steam (93 bars) produced at the recovery boiler will be fed through two turbines connected to two generators (one back-pressure and one condensing) which will generate electricity. The turbines can generate 70 MW electricity each, and discharge medium (9 bars) and low pressure steam (2,8 bars) for the pulping processes.

The criteria for selecting the turbogenerator plant design concept were:

- sufficient throughput in turbines even in situations where the mill production rate exceeds the nominal; and
- maximizing the power generation by sliding (variable) extraction.

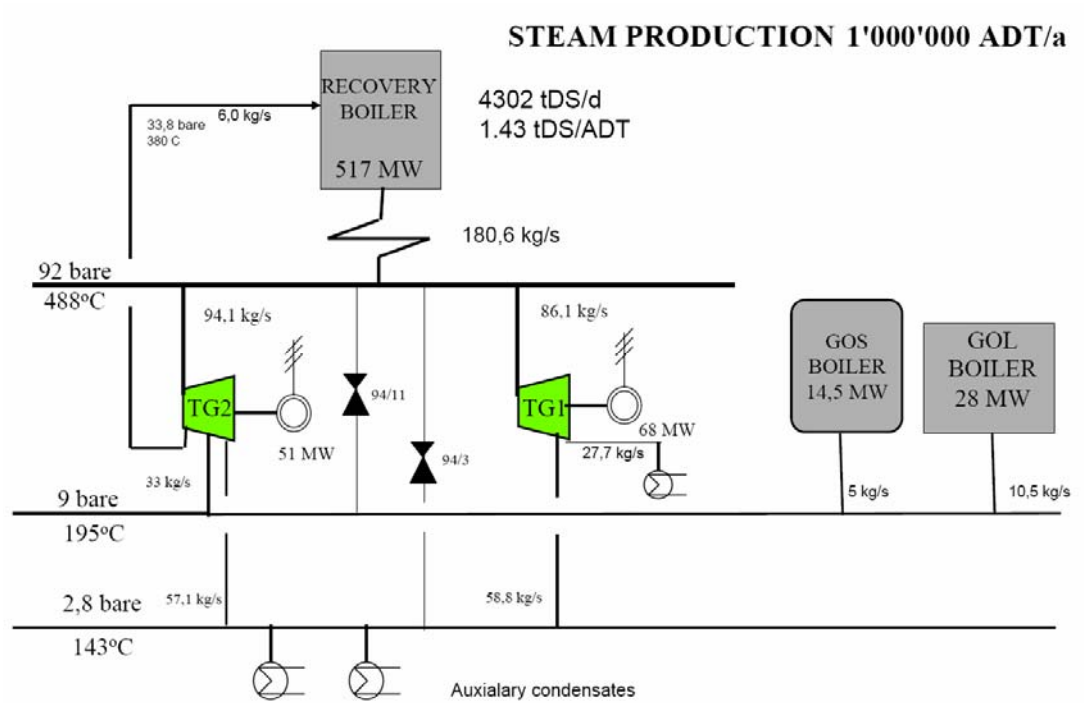

Figure A8.3-1: Botnia-Orion Pulp Mill Steam Production (taken from Botnia engineering documents, July 2006)

Note that the GOS/GOL Boilers are odorous gas boilers for backup, one for strong and another for diluted gases, firing heavy fuel oil as support. The capacity of the boilers is approximately 55 t/h steam at 16 bar pressure.

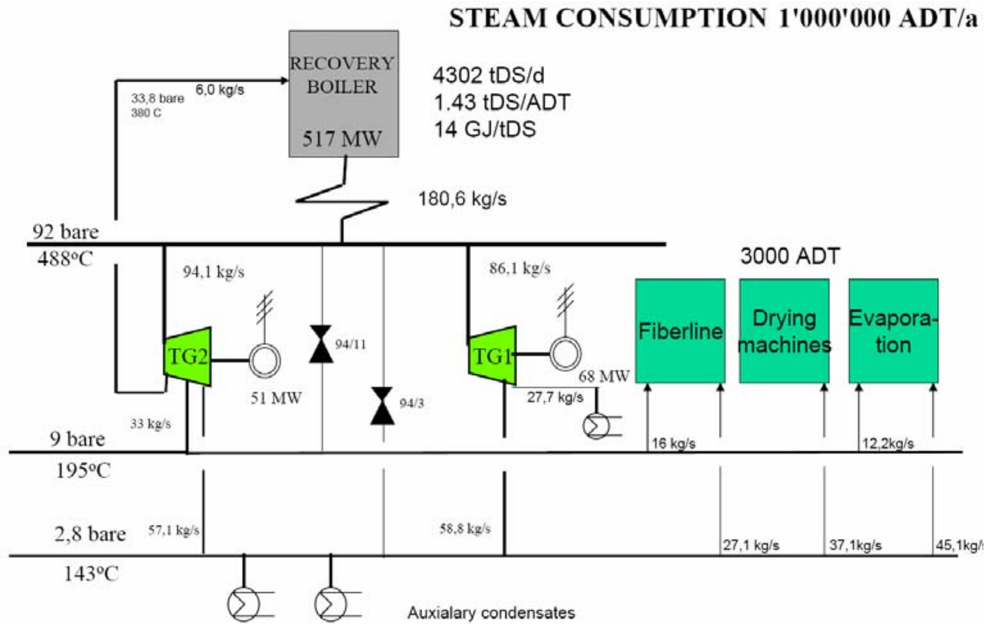

Figure A8.3-2: Botnia-Orion Pulp Mill Steam Consumption (taken from Botnia engineering documents, July 2006)

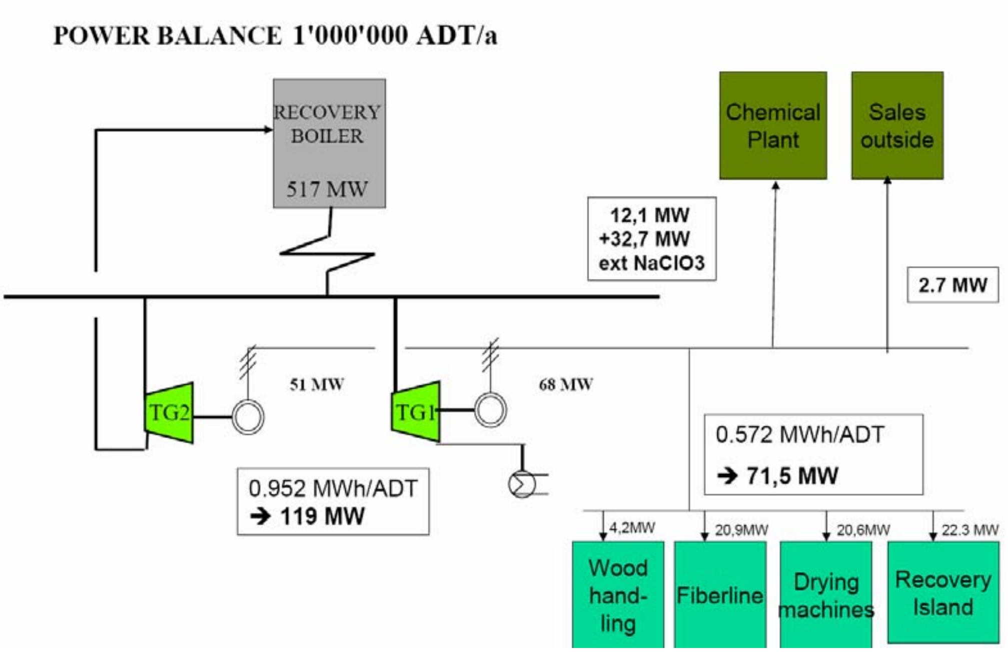

Figure A8.3-3: Botnia-Orion Pulp Mill Power Generation (taken from Botnia engineering documents, July 2006)

The energy efficient design of the Botnia-Orion mill can be summarized as having the following characteristics:

- *Evaporator efficiency*: The Botnia-Orion mill will employ an 1100 t/h capacity 7-effect evaporator train, which will provide high steam economies.

- *High dry solids content of black liquor*: The mill is designed to fire liquor solids as high as 80%, however there is some uncertainty of this due to the fact that eucalyptus pulping liquors have higher viscosity than other liquors. The mill thus expects that 78% solids liquor will be fired.

- *Recovery boiler design*: The recovery boiler performance guarantees include the following:

  - The outlet steam from the recovery boiler is 93-bars and 490ºC. This high temperature and pressure is suitable for efficient power generation
  - The flue gas temperature from the recovery boiler will be less than 160ºC

- *Design of power systems*:

  - High-efficiency turbines are being implemented for power generation

- *Design of steam systems*:

  - The mill generally employs low steam pressures for process applications (some 9-bar steam, and mainly 2,8-bar steam)
  - The hot water temperature of the mill will be 80ºC, and there will be cooling towers for its recirculation
  - The mill will employ medium consistency (MC) processing in the fiberline
  - Lime mud will be pre-dried by a cyclone dryer ahead of the lime kiln

Based on Table 4-12 of the Botnia-Orion EIA, which summarizes estimates of the steam and power consumption for the pulp mill for a nominal operating rate of 3000 ADt/d (including the chemical plant requirements), the power and steam consumption at the mill have been estimated as the following:

- 572 kWh/ADt (plus 13 kWh/ADt for the ClO_2 plant) electrical power consumption, and
- 9,97 GJ/ADt steam consumption.

These two values are in line with the ranges presented in IPPC-BAT (2001), and the mill is expected to run more efficiently than these performance values.

Based on an evaluation of the mill technology and design data presented, the Botnia-Orion mill is employing IPPC-BAT (2001), and may likely perform beyond this standard.

The surplus power availability from the Botnia-Orion mill can be summarized as follows[6]:

- Two turbines will be installed, one back-pressure turbine and one backpressure-condensing turbine.
- The excess power production with nominal production is expected to be 47,5 MW, from which Kemira will use 12,1 MW to produce Botnia's bleaching chemicals. At higher production levels, the amount of surplus power can increase substantially.
- Kemira can use a part of excess power to produce sodium chlorate for third parties.
- Discussions with Botnia-Orion indicate that the amount of surplus power available to the national grid is expected to be in the order of 15 MW, but might vary from 0-30 MW.

A back-up diesel generator of 1,4 MW will be installed to generate electricity in case of emergencies, connected to a 400 V mill grid. Combined with the emergency spill capacity, these design features protect against unacceptable effluent or atmospheric discharge in event of power failure.

The generator will start automatically if the voltage level decreases in the grid, and feed power to critical applications including the following:

- emergency lighting
- personnel lifts
- automation system
- electrically operated valves in the recovery boiler and for steam distribution
- certain agitators
- oil pumps for turbines
- drives for the lime kiln
- AST aeration

The fuel consumption is about 350 L/hour, and normally the generator will be tested weekly for about 10 minutes.

A8.3.3 ENCE-CMB Energy Profile

The ENCE-CMB mill energy needs will be furnished by a biomass boiler and the recovery boiler. Boiler steam will be produced at 84 bar and 485°C, and used for power generation.

Figure A8.3-4 shows a general diagram of the process, describing energy production.

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[6] Note: The main uncertainty in the mill estimates include the following:

- The heating value of the black liquor,
- The power consumption by the Kemira chemicals plant,
- The demand and selling price of power to the national grid.

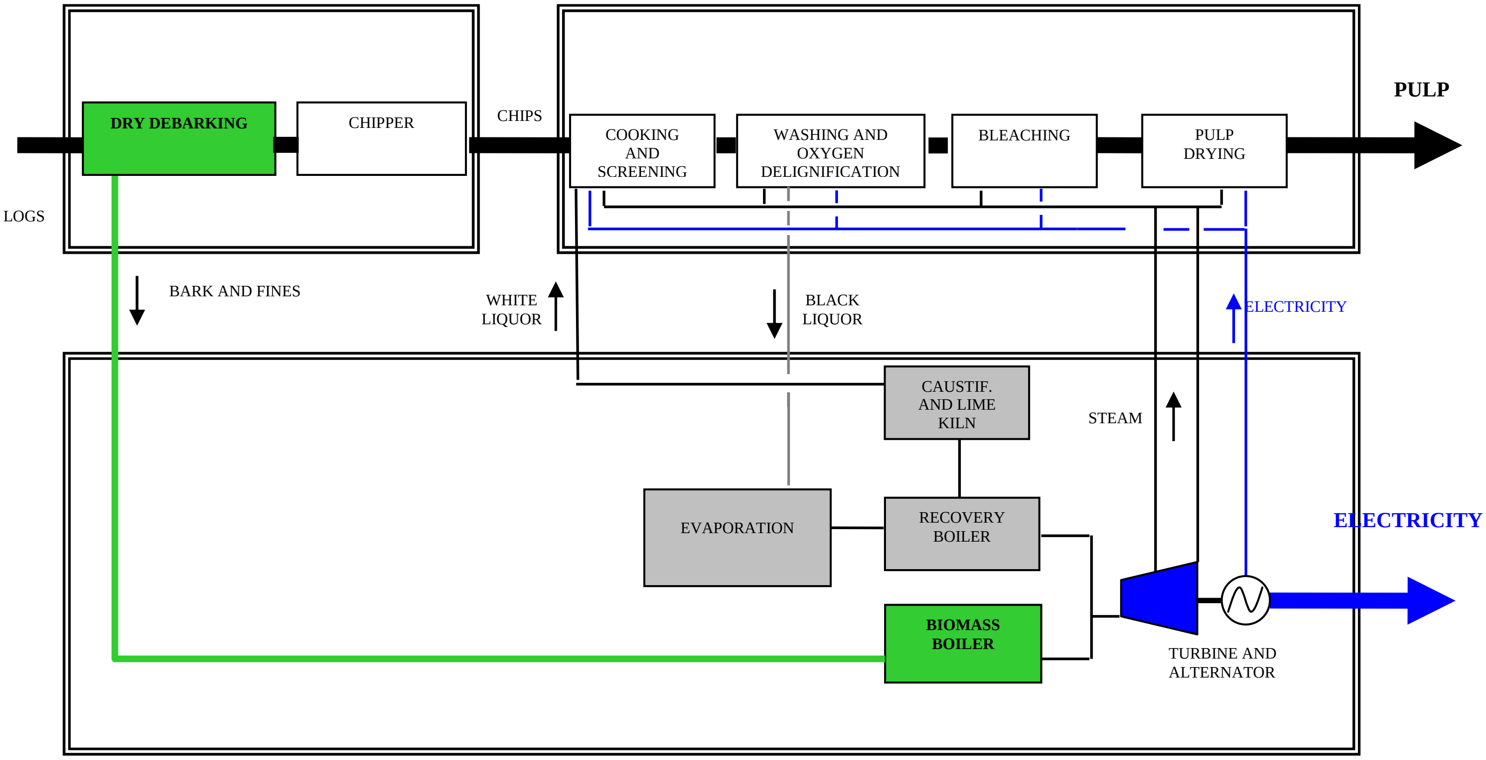


Figure A8.3-4: General Energy Production at the ENCE-CMB Pulp Mill

The biomass boiler will be fuelled by internally-produced hog fuel from wood preparation operations (bark and wood waste), i.e. no external biomass will be required. Primary sludge from the effluent treatment operations will also be burnt in the biomass boiler.

There will be one turbogenerator in the pulp mill, sized for all normally generated steam from the recovery boiler and biomass boiler. The turbine is of multi-extraction condensing type containing three extractions, as follow:

- first extraction; steam used for boilers soot-blowing
- second extraction; medium pressure steam for process heating
- third extraction; low pressure steam for process heating

The mill will be more than self-sufficient in energy, so the surplus steam will be used in the condensing turbine, and surplus power will be sold to the external grid as follows:

- the excess amount of steam not needed in the pulp mill processes is introduced into the condensing tail in order to maximize electricity production;
- steam leaving the condensing tail is condensed, and the water is recirculated back to the boilers;

- in the generator the turbine mechanical energy is converted to electricity, which is used at the mill and/or delivered to the national electricity net; and
- the maximum power of the generator is 94,4 MW.

The mill is designed for low steam consumption as a consequence of the following design characteristics:

- continuous digester technology;
- the use of low pressure steam in the mill, particularly in pulp drying and in the evaporation plant;
- high efficiency of condensate recovery;
- the high solids concentration of black liquor firing;
- a closed cooling water system;
- the use of medium consistency pumps and processing in the fiberline;
- lime mud dryer to reduce the fuel consumption;
- the use of the latest generation Emerson SCD to optimise the process control; and
- the use of frequency converters for speed control in high power motors.

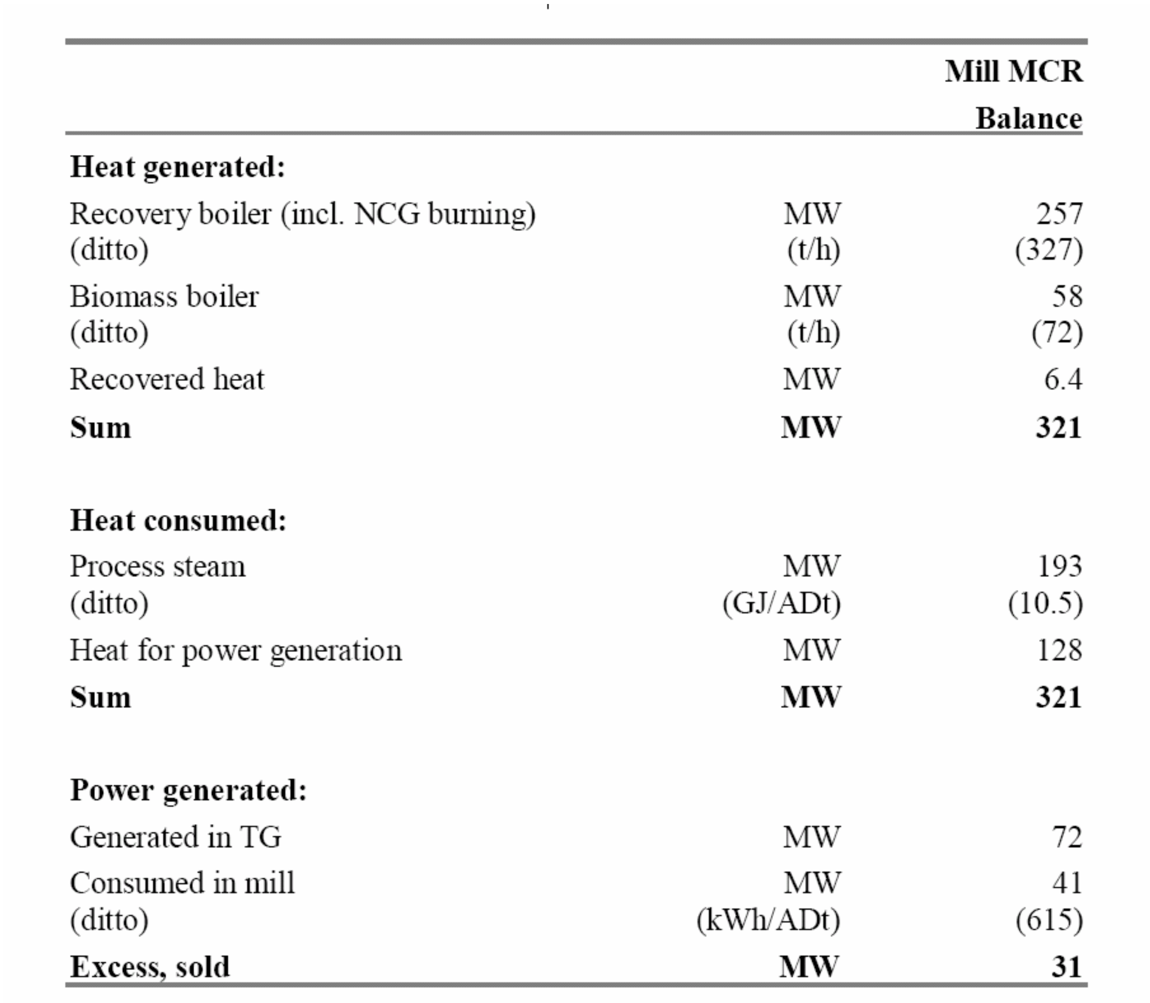
The power and steam consumption at the mill at 1500 ADt/d have thus been estimated as the following:

- 615 kWh/ADt electrical power consumption, and
- 10,5 GJ/ADt steam consumption.

Note that in contrast, mills built before 1990 typically consume between 900 and 1500 kWh/ADt pulp, and most have to purchase electric power from external sources, and may consume from 14-24 GJ/ADt of steam, often using auxiliary fuels.

Based on an evaluation of the mill technology and design data presented, the CIS project team concludes that the ENCE-CMB mill is employing IPPC-BAT (2001), and may likely perform beyond this standard. It should be noted that ENCE-CMB's engineering is at an earlier stage and certain adjustments with respect to final values may still be made.

Table A8.3-1: ENCE-CMB Mill Energy Balance for 1500 ADt/d Production (taken from ENCE project data – July 2006 AF project memorandum)



		Mill MCR Balance
Heat generated:		
Recovery boiler (incl. NCG burning)	MW	257
(ditto)	(t/h)	(327)
Biomass boiler	MW	58
(ditto)	(t/h)	(72)
Recovered heat	MW	6.4
Sum	**MW**	**321**
Heat consumed:		
Process steam	MW	193
(ditto)	(GJ/ADt)	(10.5)
Heat for power generation	MW	128
Sum	**MW**	**321**
Power generated:		
Generated in TG	MW	72
Consumed in mill	MW	41
(ditto)	(kWh/ADt)	(615)
Excess, sold	**MW**	**31**

A8.3.4 Overall Implications for the Uruguayan Power Grid

Hydropower is the main source in Uruguay, and supplies 95% of the need when rainfall is good. However in a dry year, the power production can fall to as low as 40% of the need. In this situation, additional power is produced with gas and heavy fuel oil, and Uruguay has a 150 MW power contract with Argentina. Both of these sources are very costly.

The electrical energy market is officially unregulated in Uruguay, however the number of potential suppliers is limited. In fact, all the electricity in Uruguay is produced by the state-owned company (UTE) and the Salto Grande dam, which is a hydro power plant owned by Uruguay and Argentina.

The two mills will produce substantially more electricity than they use, by burning biomass (black liquor and wood waste) which is greenhouse gas neutral, and is obtained entirely from local, sustainable and renewable forests. Summarizing the above analysis of engineering documents provided by Botnia-Orion and ENCE-CMB, the CIS project team expects the following surplus power to be available for sale to the Uruguayan power grid:

- from the Botnia-Orion mill: 15 MW
- from the ENCE-CMB mill: 31 MW
- total surplus power expected to be available to the national grid: 46 MW

This should represent a significant economic and environmental opportunity to Uruguay, and we believe that the benefit of this has not been clearly identified and exploited by the stakeholders including the Uruguayan authorities and the mill proponents. The power contribution by the mills should reduce Uruguayan oil imports and the air pollution from burning the oil power stations. These projects are in accordance with recent documents issued by the Energy Ministry about Uruguayan Energy Policy, which is clearly in the direction of promoting renewable private generation.

A8.4 Auxiliary Boilers

Wood residues or biomass (from bark and wood waste) are typically consumed for steam production in pulp mills. Steam and power generation from biomass are necessary to reduce emissions of fossil fuels. The Botnia-Orion mill will rely on the recovery boiler for steam and power generation, however ENCE-CMB mill is planning on supplementing their recovery boiler with biomass, to compensate for their smaller mill scale and to produce additional surplus power.

A8.4.1 BAT Auxiliary Boiler Guidelines

The main emission of concern from waste wood boilers is particulate matter to the atmosphere. The particles consist of ash and a residue of unburned material (often called fly ash). Older bark boilers have cyclones for particulate removal (which are only about 85% efficiency) whereas more modern biomass boilers are equipped with electrostatic precipitators (ESP's) with cleaning efficiencies of above 95%.

As bark contains negligible sulphur, there will typically be only low sulphur dioxide emissions from biomass boilers, and this primarily from other sulphur-containing fuels being added to the boiler. When bark and sulphur-containing fossil fuels are burnt together, the alkaline bark ash binds some of the sulphur and reduces the SO_2 emissions.

In bark boilers the emission of nitrogen oxides is also typically lower than for other fuels due to the lower combustion temperature. IPPC-BAT (2001) states that biomass boiler NOx emissions are typically 70-100 mg/MJ when only bark is fired, but at times when oil is used in the boiler, an increase to about 100–150 mg/MJ is typical. There is a trade-off with excess oxygen being employed in the biomass boiler which increases NOx formation, whereas lower excess oxygen levels increase CO and VOC.

According to IPPC-BAT (2001), the following techniques comprise auxiliary boiler BAT and are pertinent to consider for the ENCE-CMB mill evaluation:

- application of cogeneration of heat and power;
- use of renewable fuels such as wood or wood waste, to reduce the emissions of fossil CO_2;
- control of NO_x emissions from auxiliary boilers by controlling the firing conditions, and installation of low-NO_x burners. The total NO_x-reduction achievable in a bark boiler is about 30-50% by making changes in combustion techniques and/or applying an SNCR-process (Selective Non-Catalytic Reduction);
- reducing SO_2 emissions by using bark, gas or low sulphur fuels or controlling S emissions; and
- in auxiliary boilers burning biomass, efficient ESPs (or bag filters) should be used for the removal of dust.

Given a heat production from bark of about 7 GJ/t of bark the range of NOx emissions is about 0.3 - 0.7 kg/t bark. The lower figure represents optimised combustion conditions and/or use of the SNCR process. The NOx emissions would then be about 40-60 mg/MJ or 100-200 mg/m3 (NTP, dry gas).

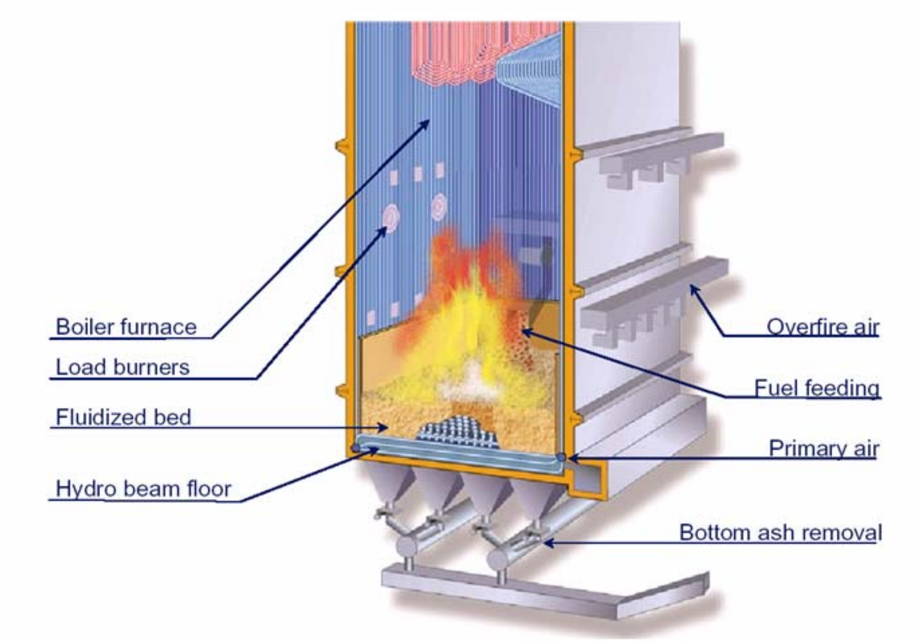
Particulate emissions are normally reduced to about 20-40 mg/Nm3 (dry gas) at 11% O2 when electrostatic precipitators (ESPs) are used, and about 200 mg/m3 with cyclones. Emissions of gaseous sulphur are small at about 5-20 mg/MJ when burning bark. Primary NO is formed in furnaces either through reaction with nitrogen in air (thermal NO) or through oxidation of nitrogen in fuel (fuel NO). Formation of thermal NO increases with increasing temperature of the flame. A part of the NO is further oxidised to NO2. In the SNCR process, NO is reduced by the addition of urea to nitrogen, carbon dioxide and water at around 1000ºC.

A8.4.2 ENCE-CMB Biomass Boiler

The ENCE-CMB biomass boiler is designed to burn bark entering the mill with the wood furnish, as well as the wood waste produced in wood processing. Before burning, the bark will be pressed to remove water, in order to increase the boiler energy efficiency. Primary sludge from the wastewater treatment plant, as well as biosolids in cases when they cannot be sent to the recovery boiler, are also burned in the biomass boiler. Dilute NCGs are normally burnt in the recovery boiler, but if this is not possible for any reason, then they are sent to the biomass boiler. Heavy fuel oil is used to start-up and shut-down the boiler.

Heat released from biomass combustion is recovered as superheated steam at 85-bar and 485ºC. The superheated steam is subsequently sent to a steam turbine for power production.

The boiler will employ bubbling fluidized bed (BFB) combustion technology (see Figure 8.4-1). BFB technology has come widely into common use over the past 15 years or so, and virtually all older mills use less environmentally desirable boiler technologies. In the BFB, combustion takes place in a dense fluidized bed at the bottom of the furnace, and above the bed. The bed temperature is quite low compared to other combustion technologies, and thus thermal NOx formation during combustion is much lower. Furthermore, ammonia injection will be used in order to minimize nitrogen oxide emissions from the BFB.



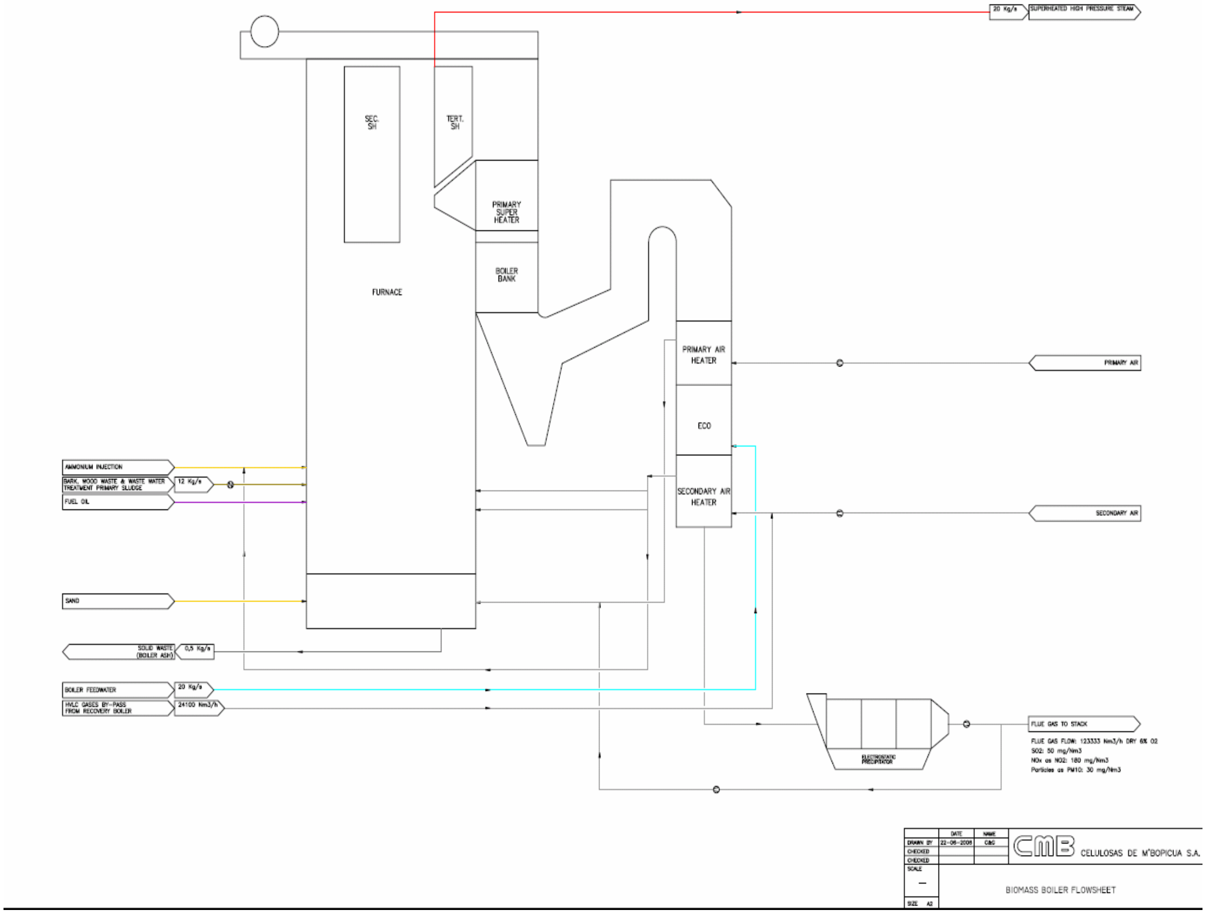


Figure 8.4-1: Schematics of ENCE-CMB Bubbling Fluidized Bed (BFB) Biomass Boiler

The BFB technology to be implemented meets the IPPC-BAT standard, and can be described as follows:

Bubbling fluidized bed boiler technology: The Biomass Boiler is a single drum BFB boiler consisting of furnace, superheaters, boiler bank, economizer and air preheaters.

BFB fuel: The BFB is fed by bark, wood waste and sludge, fed into the boiler through the fuel feeding chutes located on the furnace side walls overhanging the fluidized bed.

Auxiliary fuel: Heavy fuel oil is used in start-ups to heat the bed to the required temperature for the firing of the solid biomass fuel.

Combustion air: The combustion air is divided into primary (fluidizing) air and secondary (over fire) air.

Primary (fluidizing) air: Primary air is heated in a flue gas preheater and introduced into the furnace through fluidizing air nozzles penetrating the floor.

Secondary (over fire) air: Secondary air is preheated before the furnace in a flue gas preheater. Secondary air completes the combustion and is introduced into the furnace through secondary and tertiary air nozzles located above the fuel feeding chutes on the furnace walls.

Dilute NCG management: The biomass boiler is used as back-up to the recovery boiler for burning odorous dilute NCGs from the pulp mill, which will be fed with the secondary air into the furnace of the biomass boiler.

Flue gas: The flue gas flows from the furnace to superheaters and then to the boiler bank section. After boiler bank flue gas enters the primary air preheater, economizer and secondary air preheater section.

Electrostatic precipitator (ESP): Flue gases leaving the boiler are cleaned in an ESP before discharge to the atmosphere. A part of the flue gas is recirculated back to the furnace in order to control the bed temperature.

Emissions to the atmosphere: The emissions from the biomass boiler to the atmosphere are monitored continuously in the flue gas stack.

SNCR (ammonia water injection): NOx emissions in the flue gas are reduced by Selective Catalytic NOx Reduction, SNCR. Vaporized ammonia is injected into the furnace at two levels. The injection level is chosen according to the boiler load and fuel properties, in a manner suitable for NOx reduction reactions.

Fly ash: Fly ash is separated from the flue gases, as well as the bottom ash from the furnace, and will be sent to landfill.

A8.5 Evaporation and Recovery

The evaporation and recovery sections of kraft pulping provide the processes which enable heat, electrical power, chemicals and water to be recovered in a kraft mill. These processes recover more than 99% of the wood material dissolved in pulping and bleaching and washed in the fiberline.

The evaporators produce clean water for use in washing and liquor making, and do so typically reusing the energy contained in each tonne of steam 6 or 7 times. The recovery boiler is a special type of industrial boiler that burns a very low heat content fuel (compared with oil and gas) that has a high ash content (about 40%), and high sulphur content (3 – 5%). About 15% of the dry liquor weight consists of dissolved sodium. The recovery boiler burns this fuel with remarkably low SO_2 emissions. Due to the unusual boiler chemistry, emissions of dioxins and furans are only 0,1 to 1% of the values that a similarly fuelled regular industrial boiler (or open fire) would generate. The Botnia-Orion and ENCE-CMB pulp mills will also burn secondary treatment sludge in their recovery boilers, in effect, providing a means to recover a further fraction of the organic material removed from the incoming wood. Both mills have also included collection of the smelt dissolving tank vent into the recovery boiler, an advanced technique for reduction of emissions.

A8.5.1 BAT for Evaporation and Recovery

The IPPC-BAT (2001) requirements for BAT in the evaporation and recovery area are the following:

- stripping and reuse of the condensates from the evaporation plant;
- sufficient capacity of the black liquor evaporation plant and the recovery boiler to cope with the additional liquor and dry solids load;
- TRS emissions of the recovery boiler should be mitigated by efficient combustion control and CO measurement;
- NO_x emissions from the recovery boiler should be controlled through the firing conditions, and by appropriate design; in the recovery boiler this can be through ensuring proper mixing and division of air in the boiler; and
- flue gases from recovery boilers should be treated by efficient electrostatic precipitators.

Tasmanian-AMT (2004) guidelines are similar in various respects, and include the following:

- adequate size of black liquor evaporation plant and recovery boiler to handle additional liquor and dry solids loads due to collection of spills and possible recycle of selected bleach plant effluents,

- stripping and appropriate reuse of foul condensates,

- computerised combustion control and carbon monoxide (CO) measurement for the recovery boiler,

- inhibiting the formation of dioxins and furans within recovery boilers by appropriate design and by appropriate operation, including control of oxygen content, instituting systematic sootblowing, and the firing of fuels having minimum contamination with dioxins and furans and their precursors in order to minimise dioxins and furans in the flue gases,

- for the recovery boiler:

    - firing of black liquor with high solids concentration to mitigate SO_2 formation or flue gas scrubbing, or both
    - control of the combustion temperature profile, air distribution and excess air
    - appropriate design with focus on low NO_x emissions

- for the lime kiln:
  - control of firing conditions
  - appropriate design with focus on low NO_x emissions
- cleaning of the flue gases from the recovery boiler, with efficient electrostatic precipitators.

The IPPC-BREF for pulp and paper had limited experience with high solids firing (defined as concentrations greater than 70%). The analysis recognised that although this technique can drop recovery boiler TRS and SO_2 emissions by 80%, it may result in increases in NO_x emissions[7]. This can be mitigated to some extent through the use of staged overfire air (or quaternary air) systems. Both ENCE-CMB and Botnia-Orion have designed for liquor firing with dissolved solids in excess of 75% solids (Botnia-Orion is planning on firing close to 80% dissolved solids content), and have advanced staged recovery boiler air systems.

The recovery boiler design of both ENCE-CMB and Botnia-Orion is of a “low odour” design which means a boiler in which the final evaporation of liquor does not occur in direct contact with flue gases. Boilers with direct contact evaporators, in which liquors are concentrated from 50 to 65% solids through direct contact with flue gases, were common in the 1950’s and 1960’s. The last installation of a boiler of this type was about 1988 (in New Zealand). In a boiler with direct contact evaporators, the liquor is partially acidified through absorption of carbon dioxide in the flue gas, which can result in a release of hydrogen sulphide and other odorous TRS gases. Emissions of TRS gases from older boilers may be orders of magnitude higher than from a modern boiler, and these older mills may be smelt at 30 – 50 km distances.

A8.5.2 Botnia-Orion Evaporation and Recovery

The Botnia evaporator and recovery boiler areas are described in the revised Chapter 4 of their EIA. This description is summarised in the process description section of this Annex, namely Section A7.

Botnia-Orion has a state-of-the-art 7-effect evaporator and recovery boiler. The evaporator capacity is sufficient to recover spills and allow for possible future bleaching filtrate recycle. Key sizing criteria for the evaporator are shown below, with mill balance capacity for production at 3000 ADt/d.

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[7] IPPC-BREF for the pulp and paper industry, section 2.2.2.3.1.

Table A8.5-1: Key Sizing Criteria for the Botnia-Orion Evaporator

Parameter	Unit	Value
Evaporation MCR	tH_2O/h	1 100
- Balance value	tH_2O/h	892
- Extra capacity*	%	23

* Equals capacity reserve compared to balance value

The evaporator has an additional reserve volume in the storage tanks. The feed liquor tank is normally operated at a level of 50% (6 500 m^3) and the evaporators have a spill tank of 4 000 m^3. This provides an equivalent weak liquor storage time, without evaporation operating, of 10 hours which is sufficient to stop the fiberline and so prevent generation of weak black liquor and minimize weak liquor losses. The design feed rates to evaporation are the following:

- weak liquor from cooking plant: 290 L/s at 15,5% dry solids;
- biosludge from effluent treatment: 4,2 kg/s at 12,0% dry solids; and
- sodium sesquisulphate from the chlorine dioxide plant: 1,7 kg/s, with a density of 1,24 kg/L.

Cooling waters from the evaporator surface condenser are collected and returned to the warm and cooling water system for reuse.

The Botnia evaporators are equipped with advanced condensate segregation, with three levels of process condensate (A, B and C) in addition to the clean condensates returned to the steam system. The foul condensates (stream C) are steam-stripped and reused in recausticizing. The A condensates are reused for pulp washing. The overall mill water balance (for design) shows complete reuse of evaporator condensates within the process, although some presentations include slightly higher flows and 1.5 to 3 m^3 /ADt going to effluent. Key sizing criteria for the steam stripper are shown below, with mill balance capacity for production at 3000 ADt/d. The stripper and methanol plant can handle 14% over capacity and 43% as a “peak” over-capacity.

Table A8.5-2: Key Sizing Criteria for the Botnia-Orion Steam Stripper

Parameter	Units	Value
TRS reduction efficiency	%	98
Methanol removal efficiency	%	98
Foul condensate treatment capacity (MCR)	kg/s	55
- Balance value	kg/s	48,2
- Peak capacity value	kg/s	69
- Extra capacity*	%	14
- Extra peak capacity **	%	43

* Equals capacity reserve compared to balance value

** Equals capacity reserve compared to peak capacity value

The recovery boiler is a modern high efficiency design. It is fired at high black liquor solids to minimise TRS and SO_2 emissions and with overfire air to minimize NO_x emissions. It has a system with six levels of air from three fans (in a new vertical air system) and operates at a 94-bar pressure and a 490ºC steam outlet temperature. The flue gas discharge temperature is 160ºC. The main stack is equipment with online analysers of dust, CO, SO_2, TRS, NO_x, O_2 and opacity. The recovery boiler is controlled through a modern combustion control system, and the mill does not plan to use wood residuals or defoamers contaminated with dioxins, furans and their precursors, which could contribute to the formation of dioxins in the evaporator, recovery or fiberline areas.

The recovery boiler's capacity is shown below. It can handle an extra capacity of 9%, continuously, and a "peak" capacity of 27%, based on a 3000 ADt pulp production rate. These numbers are consistent whether evaluating in dry solids, steam production or gas flows.

Table A8.5-3: Key Sizing Criteria for the Botnia-Orion Recovery Boiler

Parameter	Units	Value
Recovery boiler capacity MCR	tDS/d	4 450
- Balance value	tDS/d	4 082
- Peak capacity value	tDS/d	5 200
- Extra capacity*	%	9
- Extra peak capacity**	%	27

* Equals capacity reserve compared to balance value.

** Equals capacity reserve compared to peak capacity value.

The recovery boiler also has a three-chamber high efficiency electrostatic precipitator.

In conclusion, IPPC-BAT (2001) emission levels and requirements are met. Tasmanian-AMT (2004) requirements can also be met in all recovery and evaporator areas with the exception of NO_x content. The NO_x emission rate should nonetheless be considered BAT for the high black liquor solids content (greater than 75%) in the fired liquor. NO_x values set in the BAT/AMT standards did not consider the high nitrogen content of eucalyptus black liquor, and higher combustion temperature temperatures. Higher temperature recovery boilers have lower SO_2 and TRS emissions, and have higher efficiency, producing more steam and electric power (from biomass) and so are environmentally desirable. But, they may result in slightly higher NO_x emission levels.

A8.5.3 ENCE-CMB Evaporation and Recovery

The ENCE-CMB evaporator and recovery boiler areas are generally described in ENCE-CMB's EIA, and is summarised in the process description section of this Annex, namely Section A7.

ENCE-CMB has contracted to purchase a state-of-the-art 6-effect evaporator and recovery boiler. The evaporator capacity is 600 t/h while the mill balance at maximum rated capacity would require 519 t/h of evaporation. This represents an extra capacity of 15%. The recovery boiler capacity is 2 700 tonnes per day of dry solids while the mill balance at maximum rated capacity would require 2258 tDS/d. This gives an extra capacity of 20%, which is sufficient to recover spills and allow for the planned and possible future expanded bleaching filtrate recycle. The recovery boiler sizing also allows for expected differences in pulp yield (and consequently in recovery boiler load) between the different wood species to be employed. ENCE-CMB also includes a potassium and chloride removal system (through leaching) on the recovery boiler dust precipitator to assist in controlling potassium and chloride levels in the liquor cycle. This is considered an advanced technology, and helps enable bleaching filtrate recycle.

The evaporator has an additional reserve volume in storage tanks, and the feed liquor tank is normally operated at a level of 50%. The evaporators have a spill tank of 1650 m^3. The size of black liquor tankage has not yet been established, however ENCE-CMB has committed to designing a liquor containment and recovery system.

Table A8.5-4: Design Criteria for the ENCE-CMB Evaporator Area

Parameter	Units	Value
Design capacities		
Evaporator - Evaporated water	t/h	600
Foul condensate treatment (stripper)	t/h	120
Black liquor from fibre line to evaporation plant		
Dry solids concentration	%	15
Methanol content	mg/L	850
By-products to evaporation plant		
Dry solids flow of neutralized sodium sulphate	tDS/24h	32
Secondary sludge from waste water treatment plant to evaporation, Dry solids flow	tDS/24h	20
Black liquor from evaporation plant to recovery boiler		
Dry solids concentration (including ash from ESP)	%	75

The ENCE-CMB evaporators are equipped with advanced condensate segregation, with three levels of process condensates (A, B and C) in addition to the clean condensates being returned to the steam system. The foul condensates (stream C) are steam-stripped and reused in recausticizing. The A condensates are reused for pulp washing.

ENCE-CMB has stated that the design is dimensioned to recycle 100% condensates. Clean condensates (A) are conveyed directly to the washing plant. Dirty condensates (B and C streams mixed) are stripped of COD and methanol and are conveyed to be recycled in the causticizing and bleaching plants. ENCE plan to recycle some evaporator condensates. ENCE has also developed working balances in which all secondary condensates are reused (in bleaching and brownstock washing) and the overall effluent flow would be reduced. The CIS project team understands that the mill is being designed with the ability to recycle almost all evaporator condensates, and would expect that increasing recycle will occur progressively after start-up.

Performance data and guaranteed values for the steam stripper where not available, but a standard modern design has been purchased, with a 98% design removal for TRS and 95% design removal for methanol. The methanol system is sized for 10 kg of methanol per ADt.

The recovery boiler is of a modern high-efficiency design. It is fired at high black liquor solids, to minimise TRS and SO_2 emissions and with overfire air to minimise NO_x emissions. It has a system employing four levels of air. The key recovery boiler guarantees below are given in Table A8.5-4, for the maximum capacity rated (MCR) load unless stated otherwise. The preliminary flowsheets show the main stack equipped with online analysers of SO_2, TRS, NO_x, O_2 and opacity. CO will also be monitored. The mill does not plan to use wood residuals or defoamers contaminated with dioxins, furans and their precursors that could contribute to formation of dioxins in the evaporator, recovery or fiberline areas.

Design and control of combustion and hearth temperature to maintain equilibrium of TRS/SO_2 is a key point of the low odour recovery boiler system designed for ENCE-CMB. The elimination of the dissolving tank and mixing tank emissions by incorporating the vents into the secondary air flow after scrubbing is another advanced technology feature of this new generation recovery boiler. The continuous computerized combustion control linked to the four level cross flows and the continuous regulation for combustion air will result in efficient mitigation of TRS emissions. The evaporation plant is designed to feed the recovery boiler with black liquor at a steady high solids concentration (75% dry solids) for optimal control and to reduce the SO_2 emissions.

The recovery boiler is designed for burning black liquor and for production of green liquor for causticizing and steam for turbine. High volume low concentrated gases (HVLC), low volume high concentrated gases (LVHC) as well as the methanol generated at the pulp mill are also burned in the recovery boiler. There is also a flare stack used as a back-up system for the incineration of strong odorous gases.

Table A8.5-5: Design Criteria for the ENCE-CMB Recovery Boiler

Dry Solids Capacity		
MCR (virgin liquor capacity)		2 700 tDS/d
Black liquor dry solids content (including ash from ESP)		75%
Steam pressure		85 bar(a)
Steam temperature		485ºC
TRS Content in flue gases		
For not more than 5% of the margin of the operation time, the TRS content in the dry flue gases after economiser, corrected to 6% O_2, does not exceed		
	For 2 240 tDS/d	4,2 mg/Nm^3
	For 2 700 tDS/d	4,2 mg/Nm^3
NO_x content in flue gases		
Average NO_x (calculated as NO_2) content in the dry flue gases after economiser, corrected to 6% O_2, does not exceed		
For 2 240 tDS/d, quaternary system and		
	N = 0,08% in virgin BL solids	158 mg/Nm^3
	N = 0,10% in virgin BL solids	180 mg/Nm^3
For 2 700 tDS/d, quaternary system and		
	N = 0,08% in virgin BL solids	140 mg/Nm^3
	N = 0,10% in virgin BL solids	160 mg/Nm^3
SO_x content in flue gases		
Average SO_2 content in dry flue gases after economiser, corrected to 6% O_2, does not exceed at the S/(Na_2+K_2) max. mol ratio of 32%		
	For 2240 tDS/d	52 mg/Nm^3
	For 2700 tDS/d	42 mg/Nm^3
CO content in flue gases		
Average CO content in the dry flue gases after economiser, corrected to 6% O_2, does not exceed		
	For 2240 tDS/d	130 mg/Nm^3
	For 2700 tDS/d	84 mg/Nm^3
Dust content in flue gases		
Average dust content in dry flue gases after the electrostatic precipitator, corrected to 6% O_2, at the black liquor dry solids content range of 70 – 75% does not exceed		
	Two chambers in operation, 100% MCR load	42 mg/Nm^3
	Two chambers in operation, 75% MCR load	42 mg/Nm^3

Electrostatic precipitators of high efficiency (more than 99,8%) are designed for all combustion sources at ENCE-CMB, and are being designed with two chambers with 3 fields in each of them. In addition to the corresponding electrostatic precipitator, a scrubber is designed to mitigate SO_2 and dust emissions from the lime kiln.

In conclusion, the CIS project team concludes that IPPC-BAT(2001) and Tasmanian AMT(2004) emission levels and requirements can be met in all areas of the evaporator and recovery areas, with ENCE-CMB's commitment to increase the level of evaporator condensate reuse, and to use best practices for spill control, containment and recovery.

A8.5.4 Overall Comments on Evaporation and Recovery

The evaporation and recovery design for both mills is modern, and is being purchased from vendors with good experience. The Botnia-Orion boiler is operating at higher pressure and temperature than the one that will be used at the ENCE-CMB facility. It is also designed to operate at higher black liquor solids content (close to 80%, although 75% is used as a design minimum). This feature results in a more efficient conversion of biomass to electric power and steam, and probably lowers specific SO_2 and TRS emissions as well. On the other hand, this may result in somewhat higher NO_x emissions. It also requires the boiler to have a more technically challenging design than boilers with lower steam temperatures and pressures. This design most likely requires higher order metallurgy or lower potassium and chloride levels in liquor, to maintain boiler convection passage cleanability and to protect against corrosion.

The ENCE-CMB boiler includes a potassium and chloride removal system, and combined with the slightly lower pressure and steam temperature, provides more flexibility with respect to accepting bleaching filtrates in the recovery system.

For the Botnia-Orion boiler, the NO_x emission rate is below the recommended IPPC-BAT (2001) level but above the Tasmanian-AMT (2004) guideline. It is useful in this case to review factors which affect NO_x emissions in mills[8]. Most of the NO_x emitted by combustion sources in mills is NO with only a small fraction (typically 5% or less) appearing as NO_2. The formation of NO_x occurs through three independent mechanisms:

- fuel NO_x: oxidation of organically bound nitrogen in the fuel;
- thermal NO_x: thermal fixation of molecular nitrogen and oxygen in the combustion air; AND
- prompt NO_x: formation first of intermediate hydrogen cyanide (HCN) via the reaction of nitrogen radicals and hydrocarbons in the fuel followed by oxidation of the HCN to NO.

The major mechanism responsible for the formation of NO_x in a recovery boiler is the fuel-NO_x mechanism. Recovery boiler temperatures are not sufficiently high to produce thermal-NO_x while prompt-NOx formation is of minor importance in all industrial furnaces.

The addition of biosolids (from an activated sludge treatment system) to the recovery boiler increases the nitrogen content of the liquor by about 30%. However, this nitrogen does not

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[8] Private communication, Summary of literature on NO_x emissions from recovery boilers, L Galloway, September 1st, 2006.

appear to increase NO_x emissions, possibly because the nitrogen is released from the biosolids during black liquor evaporation and ends up in the condensates.

Air staging (essentially the addition of quaternary air) in the recovery boiler can reduce NO_x emissions. In large furnaces (greater than 2500 tDS/day), quaternary air equal to about 10% of the total combustion air reduces NO_x emissions from 80 ppm @ 8% O_2 (when no quaternary air is used) to around 40 ppm @ 8% O_2. The quaternary air is added in the upper one-third of the furnace.

The following table summarizes emissions from 5 state-of-the-art recovery boilers and lime kilns[9]:

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[9] Adapted from Vakkilainen et al., Nitrogen oxide emissions from recovery boilers/pulp mills, Proceedings of the 2005 Tappi Engineering, Pulping and Environmental Conference, Philadelphia, PA, August 28-31.

Table A8.5-6: Emissions from State-of-the-Art Recovery Boilers and Lime Kilns

Parameter		Units	Values				
Species		-	Eucalypt	Eucalypt	Mixed	Mixed	Mixed Hardwood
Location		-	South America	Asia	Scandinavia	North America	Asia
Production		ADt/a	1 000 000	1 000 000	800 000	700 000	1 200 000
Black Liquor	Higher Heating Value	MJ/kgDS	14,0	14,0	14,0	14,4	14,0
	Dry Solids	%	80	77	85	85	80
	Dry Solids	kg/ADt	1 325	1 466	1 650	1 641	1 748
Recovery Boiler	Flue Gas Flow	$Nm^3/kgDS$	3,679	3,666	3,679	3,635	3,687
	NOx	tNO_2/a	780	860	777	751	1 392
	NOx	$kgNO_2/ADt$	0,78	0,86	0,97	1,07	1,16
	NOx	$mgNO_2/MJ$	42	42	42	45	47
	NOx	$mgNO_2/Nm^3$	160	160	160	180	180
Lime Kiln	Heat Consumption	kJ/kg lime	5 600	5 800	5 600	5 800	5 600
	Lime Consumption	kg lime/ADt	221	253	264	290	318
	Flue Gas Flow	Nm^3/kg lime	2,3	2,3	2,3	2,4	2,3
	NOx	$t\ NO_2/y$	305	235	291	244	526
	NOx	$kgNO_2/ADt$	0,31	0,24	0,36	0,35	0,44
	NOx	$mgNO_2/MJ$	246	160	246	207	246
	NOx	$mgNO_2/Nm^3$	600	404	599	501	599
Pulp Mill	Total NOx	kg/ADt	1,09	1,10	1,34	1,42	1,60
	Total NOx	tNO_2/y	1 085	1 095	1 068	995	1 918

The relationship between recovery boiler NO_x and fuel-NO_x is shown in the performance guarantees that ENCE-CMB and Botnia-Orion have for their respective boilers. Both boilers at MCR have NO_x guarantees that are dependent on the virgin black liquor solids nitrogen content. These are shown in Table A8.5-7.

Table A8.5-7: Comparison of NO_x Guarantees for ENCE-CMB and Botnia-Orion Recovery Boilers

Mill	Case	Black liquor nitrogen content (virgin)	Vendor guarantee
ENCE-CMB	MCR	0,10%	180 mg/Nm^3
ENCE-CMB	MCR	0,08%	158 mg/Nm^3
ENCE-CMB	Design	0,10%	160 mg/Nm^3
ENCE-CMB	Design	0,08%	140 mg/Nm^3
Botnia-Orion	MCR	0,10%	190 mg/Nm3
Botnia-Orion	MCR	0,07%	135 mg/Nm^3

The Botnia-Orion guarantees are slightly higher, but this is consistent with the higher temperature and higher black liquor solids fired (80% vs. 75%). The state-of-the-art vertical air system to be implemented by Botnia-Orion (see schematic below) is guaranteed at the same level as the quaternary air system at ENCE-CMB. The differences in boiler emission rates between ENCE-CMB and Botnia-Orion are primarily due to differences in estimated black liquor nitrogen content and in this respect, ENCE-CMB likely has more experience, having operated only eucalypt mills, and using Uruguayan wood for more than 10 years.

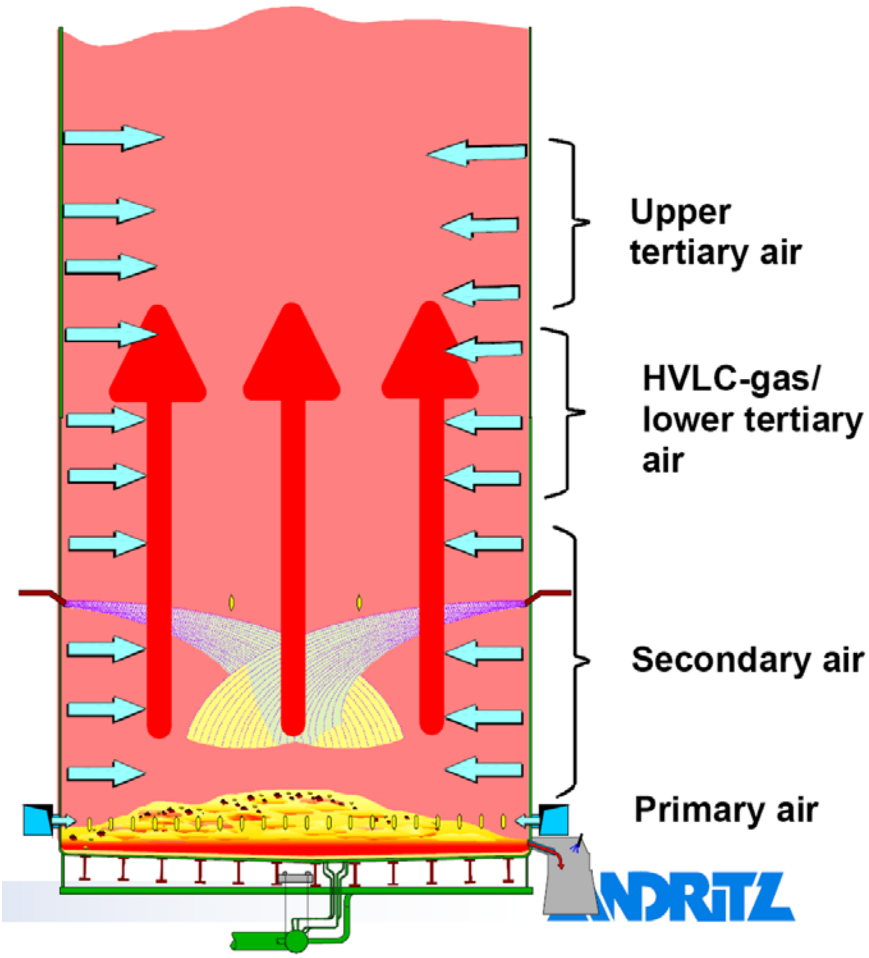

Figure 8.5-1: **General Schematic of Andritz Vertical Air System to be used at Botnia-Orion**

A8.6 Liquor Spills Collection

In-plant spills collection and recovery are critical for good environmental performance of pulp mills in order to minimize process discharges overall, optimize the BOD removal efficiency of the AST system, and avoid sudden large raw effluent loads into the effluent treatment plant which have the potential to reduce AST performance. In this section, the liquor spills facilities to be implemented by Botnia-Orion and ENCE-CMB are reviewed.

Pulping liquor can be lost from knotters and screens, from brown stock washing operations, pumps and valves in liquor service, evaporator boil-outs, or other intentional liquor diversions during maintenance, start-ups and shut downs. Liquor can also be lost in spills resulting from process upsets, tank overflows, mechanical breakdowns, operator errors and construction activities.

Spills of white liquor, wash liquor, lime etc. can occur in the causticizing area of the pulp mill. Most spills can be collected and recycled if adequate buffer volumes are used and appropriate procedures employed. Leakage from mechanical components such as pumps can be controlled by implementing appropriate seals and glands.

The conductivity or the fibre content of the effluent sewers from these mill areas is normally measured in order to decide when they should be recycled back to process, versus when they should be permitted to be discharged to the effluent treatment plant.

The information presented in the sections below that specifically describes the two pulp mills was provided directly by Botnia-Orion and ENCE-CMB.

A8.6.1 Liquor Spill Collection Guidelines

IPPC-BAT (2001) states that chemical pulp mill spill plans should be designed around the following design principles:

- collection of diverted or spilled liquor at the highest possible liquor solids concentration;
- return of collected liquor and fibre to the process at appropriate locations;
- curbing of isolate critical process areas (including tall oil and turpentine, however this is not pertinent in the case of eucalyptus furnish as these materials are not present) to avoid concentrated or harmful streams entering the external effluent treatment or contaminating clean water sewers; and
- conductivity or pH monitoring at strategic locations to detect losses and spills, and engage the facilities necessary to recover spills back into process.

The facilities noted in the last point include that contaminated effluent sewers should be arranged so that spills in key areas (pulp cooking, washing, screening, used liquor storage, evaporation, and cooking liquor preparation), are collected in sumps, and pumped either directly or via an intermediate tank into an appropriate liquor storage tank.

In order to accommodate collected spills and prevent discharges of high loads to the pulp mill AST processes, IPPC-BAT (2001) recommends that the process cooking, black liquor and dirty condensate storage capacities should be increased over normal operating volumes by about 30%. The increased storage volume requirement varies according to factors such as liquor solids in storage tanks, unbleached pulp washing efficiencies, condensate management strategy. As noted earlier, it is important that clean streams are diverted from potential spill areas to avoid dilution of recovered process liquors.

The storage volumes must be able to contain peak process flows of a few hours due to operational disturbances especially during start-up, shut-down or upset conditions, and facilities must be in place to recover weak and strong liquors from pulp production. For example, enough weak black liquor storage must be available so that the evaporation plant can operate normally during short shut-downs in cooking and washing, or so that the evaporator plant itself can be shut-down for short maintenance. The storage volume must also be large enough to store enough strong black liquor so that short-duration problems with the recovery boiler can be solved without reducing evaporator throughput.

In order to concentrate the collected liquor spills, 5-10 % more evaporation capacity is typically needed, which if employed fully would consume 5-10% more steam and power.

Green and white liquor storage tanks also need buffer capacity for short-lived peak flows, or for instances of shutdown in connected process units such as liquor filters. If sewered, these liquors can overwhelm pH control systems, cause pH shocks, and potentially result in treatment plant upsets.

The COD discharge associated with spills is normally between 2 and 10 kg/t of pulp produced. The lower figure is achieved when sufficiently large storage volumes are in place coupled with good process monitoring and regular spill systems maintenance.

Perhaps the best known regulation related to spills management is contained in the USEPA Cluster Rule (2000), called Best Management Practices or BMP. BMP was the first element of the Cluster Rule regulation that bleached papergrade kraft (pulp) mills had to comply with in the United States. Under BMP, mills were required to prevent or contain unintentional losses of spent pulping liquor (including turpentine and soap), and to control any related intentional losses. The objective of the regulation was to reduce discharges of organic material in mill effluent, by decreasing the amount and fluctuation of organic loading to mill effluent treatment systems.

There are a number of specific requirements that are required to comply with the USEPA BMP regulation. These can be grouped as follows:

- an Engineering Analysis, which is a review of the equipment in the spent pulping liquor areas, to identify the potential of this equipment for spills and appropriate spill avoidance or containment;
- a BMP Plan to document the equipment, systems, spill event reporting and monitoring programs that the mill will use to meet regulatory requirements;
- a system of monitoring and alarms to alert operators of situations that could lead to a loss of spent liquor, turpentine, or soap;
- equipment and procedures which enable containment, recovery, or diversion of spent liquor losses;
- a monitoring and reporting program to provide daily measurement of organic material leaving the mill operations and entering effluent treatment, for reporting to government; and
- an annual BMP training program for mill employees on their roles in using the above components to meet regulatory requirements.

A8.6.2 Botnia-Orion Mill Liquor Spills Collection System

Spills collection is not addressed systematically in the Botnia-Orion mill EIA, but rather the IPPC-BAT (2001) standard is described and there are occasional references to the collection of spills from specific mill areas. However extensive spills collection systems have been designed. For this, Botnia has relied on the IPPC-BAT (2001) standard, but also they have draw extensively on experience regarding spills handling from their Scandinavian and other mills. The following summarizes the spill management systems to be implemented.

General: The general design principles that Botnia-Orion has used to design the spills collection facilities include the following:

- Effluent pump sumps with conductivity measurement will be implemented to monitor sewer discharges. The conductivity set-point in each case will be determined in order to detect when spills are occurring and can be economically recovered (typically 2-3% dissolved solids). Under normal operating conditions the conductivity and liquor contamination is low, so that effluents are discharged to the main sewers and the effluent treatment plant.

- The main black and white liquor storage tanks are inside containment areas, in order to prevent leaks or spills from these tanks from discharge directly to the effluent collection sewers.

- Sufficient process tank storage volume will be implemented, including a reasonable reserve capacity in the evaporation, recovery boiler and causticizing plants.

- Condensates from malodorous gas handling systems will be collected for treatment or reuse.

Typical of mills with warm climates, most of the fibre line, evaporator plant and white liquor plant areas are without roofing. Under normal operation, the floor drains including stormwater are thus collected to the process effluent sewer for treatment at the mill effluent treatment plant.

Risk analysis has also been used to improve mill design and process operation, including spill minimization, prevention and management. The mill will establish quality standards for mill operations which target certification standards such as ISO. Statistics and reports on mill process performance, detected deficiencies and spills will be used as a tool to help consider corrective actions. Also benchmarking data and experiences from similar mills will be utilized.

Fibre Line: The fibre-containing spills in the brown stock fibre line and oxygen delignification are collected in an agitated spills sump, and along with various tank overflows, are directed to a 200 m^3 agitated spill collection tank. From this tank, the spills are recovered into the oxygen stage blow tank.

Evaporation Plant: The evaporation plant process area is curbed, and floor areas are sloped towards collection channels and sewers. No drains will exist from evaporator process area to the stormwater sewer.

Effluent from the evaporation plant will be directed into a sump, and in the event that the level and conductivity in the sump rises above limit values, the sump contents will automatically be pumped to a spill liquor tank of volume 4 000 m^3. If the conductivity in the sump tank remains below the limit values, the overflow will go to the effluent treatment plant (to the primary treatment) by gravity.

The weak black liquor storage area is surrounded by walls to retain liquor contents in case of tank overflow or leak. The volume is connected with an underground pipe to a similar containment area for white liquor storage tanks in the causticizing plant.

Recovery Boiler: Effluent from the recovery boiler house will be collected into a dump tank located at the ground floor of the recovery boiler house. The volume of the dump tank is 18 m^3. If the conductivity in the tank rises above a limit value, then the contents will be pumped to the spill liquor tank located at the evaporation plant.

If the conductivity in the dump tank remains below the limit value the tank overflow will flow to the process sewer and to the effluent treatment plant.

Recausticizing Area: Spills from the white liquor plant area are collected into an emergency basin and then flow to the causticizing sump well. The sump well will overflow to a process effluent sewer for feed to the effluent treatment plant under normal operating conditions. In case of high conductivity, the sump contents will be pumped to the weak white liquor tank.

Weak white liquor and white liquor tanks are located inside a curbed area in order to retain spills or leaks. This volume is connected via an underground pipe to the similar containment area for the weak black liquor storage tanks in the evaporator plant.

Storm Water Management: In the areas with high risk of spills (evaporation, fibreline, recausticizing) the storm waters are routed directly to the process sewer, leading to the effluent treatment, to avoid occasional spills in the storm water system.

Process streams and liquors are pumped between process departments through piping located on pipe bridges. Many of the main pipe bridges at the mill pass along roads, and have the potential to leak. Collection of most stormwater from the pipe bridge areas is normally directed to a network of stormwater sewers and several stormwater ponds on the mill site. If spills are detected in the stormwater pond contents, the spill pond contents can be retained and treated.

The evaporation plant and recovery boiler have been designed with adequate additional capacity:

- evaporation capacity: 20% above normal operation; and
- recovery boiler: 27% above design capacity for peaks (9% for continuous operation).

The CIS project team concludes that the facilities and management systems to be implemented at the Botnia-Orion pulp mill meet the standard of IPPC-BAT (2001), and it is likely that the COD discharge associated with spills will be in the vicinity of 2 kg/t of pulp produced or less.

A8.6.3 ENCE-CMB Mill Liquor Spills Collection System

ENCE-CMB recognizes that a well-designed and well-operated spill recovery system is an important part of the environmental design, and has designed their facilities according to the IPPC-BAT (2001) standard.

General: The general design principles that ENCE-CMB has used to design the spills collection facilities include the following:

- Level measurements and operating practices will be implemented which minimise the risk for overflow of tanks and equipment.
- Connections for tanks and other equipment to the spill system will be made in order to collect remnant process liquors, in instances when there is a need for emptying and maintenance. The process liquors will either be taken to other process units, or sent to the spill tank and returned to process.
- There will be curbing around tanks and equipment where concentrated liquors are handled. Leaks and spills from the tanks will be collected within the area, and can be returned directly to the process.
- Sumps will be included in each mill area as appropriate, which segregate spills containing fibres from those not containing fibres.
- Floor trenches in areas of potential spills will be collected into sumps with conductivity monitoring, from where when required, high conductivity liquids can be pumped back to process.
- The flow of uncontaminated water to sumps which may contain spills will be minimized.
- Rainwater in the process areas will be collected and treated.
- The emergency spill pond in the effluent treatment area will be used in the event a major spill should not be contained by the upstream spill collection provisions, or in the event of upset conditions in primary treatment.
- A good supervisory system and training will be implemented to support operators for events of accidental discharges requiring corrective measures.
- Good operator training, operations management and reporting systems will be implemented.

The effluents will be segregated into four different sewers (namely the low solids sewer, the condensate sewer, the general sewer and the storm sewer), depending on their suspended solids content, dissolved solids content, and odorous components.

Fibre Line: There are five streams in this area that will be monitored, as follows:

Trenches:

- the trenches from the cooking, screening, washing and oxygen delignification areas (including dirty rainwater);
- the trenches from contaminated areas in the screening area;
- trenches from bleaching plant (tank overflows);
- process effluents;
- acidic and alkaline bleach plant filtrates (continuous flow); and
- hot water overflow (intermittent).

The trenches from the cooking, screening, washing and oxygen delignification areas collect in the low conductivity sump pit, which is equipped with an agitator and pH control. Under normal operation, this sump overflows to the general mill sewer and then to the mill effluent treatment plant. If the pH rises above set-point, then the sump contents are directed to the digester blow tank.

The flow coming from the contaminated areas in the screening area may contain black liquor as well as fibres, and is directed to the high conductivity sump pit which is equipped with agitator and level control. When the level in the sump pit is high, the contents will be pumped back to the digester blow tank. In the case of low conductivity in this sump pit, it overflows to the low conductivity sump pit and is combined with the flow coming from the cooking, screening, washing and oxygen delignification areas.

Evaporator Plant: Flows coming from drains, overflows, rainwater in the evaporator area are collected in a sump pit equipped with a pump and pH control. If the pH is high then pump starts and the spills are taken to the spill tank. If the pH is low, the pump stops and the pit overflows to the general mill sewer.

There will be a spill tank which collects the following streams:

- overflows of foul, intermediate and clean condensates;
- the evaporation plant sewers when a spill is detected; and
- spills coming from the boiler plant dump tank.

The contents of the spill tank are pumped to the weak black liquor storage tanks and recovered.

Recovery Boiler: Flows from this area are collected in a sump pit, where spills can be detected and sent to a dump tank. This tank will also collect the overflow of the mixing tank in the recovery boiler area. From the dump tank, the spills containing black liquor are pumped to the spill tank in the evaporator plant area.

If the spills do not contain black liquor, they will overflow from the sump pit directly to the general mill sewer.

Recausticizing Area: There are two main areas from which flows will be collected:

- the green & white liquor area, and
- the lime mud area (lime kiln).

There are two sump pits which are equipped with pump, agitator and consistency control. If the sump pit consistencies are high, the pump starts and the spills are taken to the weak white liquor tank and recovered. If the consistency is low, the sumps overflow to the general mill sewer.

The facilities and management systems to be implemented at the ENCE-CMB pulp mill are quite similar to those expressed by Botnia-Orion, and meet the standard of IPPC-BAT (2001), and it is likely that the COD discharge associated with spills will be in the vicinity of 2 kg/t of pulp produced or less.

A8.7 Odorous Gas Management

A8.7.1 Odorous Gas Issues

Historically, one of the most characteristic impacts of a kraft pulp mill is odour where the main odorous compounds from a mill are sulphur-based. People can smell these at very low concentrations, in the parts per billion range (0,4 – 10 ppb odour thresholds), whereas most odorous gases are smelt in the parts per million range. These gases are similar to the smell from decomposing meat, or odours given off from town sewers.

Physical health effects (apart from discomfort with the smell) from TRS gases occur in the parts per million range (at about 1000 times the concentration that can be first smelt). After exposure to low levels of these sulphur gases over time, people loose the ability to smell them at very low concentrations. For this reason some mills use “citizen panels or networks” to help identify odour events in a community. One TRS gas (hydrogen sulphide) also may not be smelt at high concentrations (due to olfactory fatigue), and for personal safety, local in-mill alarms are used for workplace safety.

The reduced sulphur compounds present are mainly hydrogen sulphide (H_2S), methyl mercaptan (CH_3SH), dimethyl sulphide ($(CH_3)_2S$), and dimethyl disulphide ($(CH_3)_2S_2$). These compounds are commonly referred to as Total Reduced Sulphur (TRS).

The main generation of TRS occurs in the wood cooking process, when sulphide in cooking liquor (sodium sulphide) reacts with methyl groups in wood. The rate at which compounds are formed is related to the liquor sulphidity. Hardwood mills, in general, and eucalyptus mill more specifically, usually have lower generation rates of TRS than softwood mills, as pulp yields are higher, the cooking liquor sulphide content is lower (lower sulphidities are generally preferred for hardwood), and the cooking charge (active alkali) is lower.

A typical composition of pulp mill TRS gas is 13% hydrogen sulphide, 48% methyl mercaptan, 8% dimethyl sulphide and 31% dimethyl disulphide.

These TRS compounds materials are volatile, with the boiling points of hydrogen sulphide (-62ºC), methyl mercaptan (6ºC), dimethyl sulphide (38ºC), and dimethyl disulphide (118ºC). The low boiling point means that these gases can volatilise in the liquor system. The hydrogen sulphide and methyl mercaptan emissions are strongly influenced by pH, being held more strongly in alkaline solution, and liquor pH is the most important control parameter for H_2S and CH_3SH emissions from liquid to gas phase, while emissions of other organic sulphides are controlled by controlling the liquor temperature.

The malodorous gases that are associated with kraft pulp mills can be grouped according to the following categories:

- CNCGs: (concentrated non-condensable gases): these gases are typically low volume and high concentration. They are often referred to as LVHC gases. Botnia-Orion refers to them as GOS and generally they are described as strong gases
- DNCGs: (dilute non-condensable gases): these gases are typically high volume and low concentration. They are often referred to as HVLC gases. Botnia-Orion refer to them as GOL and they may be described as lean or weak gases
- Recovery boiler and lime kiln flue gases
- Diffuse sources of odour

Typical sources, flowrates and concentrations for sources in a kraft mill are shown in the table.

Table A8.7-1: Main Sulphur Emission Sources of the Kraft Pulping Process[10]

CNCG	kgS/ADt	m^3/ADt
Batch cooking blow gases	0,4 – 0,8	5 – 15
Batch cooking off-gases	0,1 – 0,2	1 – 3
Continuous cooking gases	0,1 – 0,4	0,5 – 1,5
Evaporator line	0,4 – 1,0	1 – 10
Foul condensate stripper	0,5 – 2,0	15 – 25
Methanol treatment	0,5 – 0,2	1 – 2
Black liquor heat treatment	2,0 – 3,0	1,5 – 3,0
Superconcentrator off-gas	2,0 – 5,0	1,5 – 6,0
CNCG total	*1,5 – 7,5*	*0,4 – 0,8*
DNCG	**kgS/ADt**	**m^3/ADt**
Pulp washing off-gas	0,01 – 0,1	1 – 5 000
Tall oil plant	0,5 – 2,0	2 000 – 3 000
Tank venting	0,5 – 2,0	20 – 30
DNCG total	*0,5 – 1,0*	-
Flue gases	**kgS/ADt**	-
Recovery boiler, new	0,01 – 0,1	-
Recovery boiler, old	1,0 – 14	-
Lime kiln, new	0,05 – 0,2	-
Lime kiln, old	0,04 – 0,5	-

Note: only certain of the potential TRS emission points in above table exist in the Botnia and ENCE mills.

Both mills are using continuous cooking equipment. Botnia-Orion includes a form of black liquor heat treatment in the evaporators while ENCE-CMB does not. Neither plant has tall oil present (as these are only present in softwood, typically pine mills). A description of the main sources in a kraft mill follows.

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[10] Janka K, Haaga K, Tamminen A, Wallin E, Advanced recovery boilers reduce odour gases cost effectively, SPCI Conference, Stockholm, 1999.

- **CNCGs (LVHC or GOS**)
  - The CNCGs originate from the digester, evaporation plants, and the foul condensate stripper. The original TRS concentration in CNCGs is normally 50 000 to 200 000 mg/Nm^3
- **DNCGs (HVLC or GOL)**
  - The DNCGs originate from a number of tanks and equipment vents both from the fiberline and the recovery island. Normal TRS concentrations in DNCGs range from <10 – 500 mg/Nm^3. The required dilution factors to reach odour thresholds without any control measures are in the order of less than 2 000 – 100 000. Both ENCE-CMB and Botnia-Orion have extensive dilute gases collection systems with incineration in the recovery boiler with an alternate back up system
- **Recovery Boiler and Lime Kiln Flue Gases**
  - Normal TRS concentrations in these gases are less than 1 – 50 mg/Nm^3. In the recovery boiler flue gas, the average TRS concentration is normally less than 5 mg/Nm^3, in the dissolving tank vent gas, less than 50 mg/Nm^3, and in the lime kiln flue gas, less than 30 mg/Nm^3
- **Diffuse Sources of Odour**
  - Diffuse odour emissions originate primarily from the effluent collection system and the effluent and sludge treatment plants. Typically, in pulp mills that have effluent direct cooling towers, these are the major contributors to diffuse odour emissions. Solid waste storage areas can also cause odour emissions. Measurements in a number of kraft pulp mills have found that normal levels of TRS emissions from these sources are in the order of 0 – 5 mg/Nm^3. Due to the low initial concentrations however, diffuse emissions only have highly localised impacts within the pulp mill site.

At the current time, it is reported that 80% of mills in Scandinavia collect and destroy dilute NCGs, and that 80% of the dilute NCGs emitted in these mills are collected[11]. This section will focus on the strong and weak gas management systems, and estimation of diffuse emissions from the wastewater treatment plant.

A8.7.2 BAT Odorous Gas Guidelines

This section reviews the IPPC-BAT (2001) and Tasmanian-AMT (2004) considerations with regards to odorous gases.

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[11] Gunns Bell Bay Pulp Mill, Draft integrated Emission Statement, Vol1B, Introduction and Overview. July 2006.

The systems for odorous gas management in as described in IPPC-BAT (2001) include:

- Collection and incineration of concentrated malodorous gases (concentrated NCGs or LVHCs), and control of the resulting SO_2 emissions. The strong gases can be burnt in the recovery boiler, in the lime kiln, or in a separate low NO_x furnace. The flue gases of the latter have a high concentration of SO_2 that should be treated in a scrubber.
- Diluted malodorous gases (dilute NCGs or HVLCs) from various sources must be collected and incinerated, and the resulting SO_2 controlled.
- TRS emissions of the recovery boiler should be mitigated by efficient combustion control and CO measurement.
- TRS emissions of the lime kiln should be mitigated by controlling the excess oxygen, by using low-S fuel, and by controlling the residual soluble sodium in the lime mud fed to the kiln.

The Tasmanian-AMT (2004) guidelines include:

- Collection and incineration of CNCGs in:
    - either the recovery boiler
    - or a standalone incinerator
- Back-up system of the main system for CNCGs, consisting of:
    - a flare/incinerator and secondary incineration unit (e.g. lime kiln), or
    - pre-purged alternative disposal point immediately available to a power boiler
- Collection and incineration of DNCGs in the recovery boiler
- Methanol recovery from foul condensate stripper off-gases
- Computerised combustion control and CO measurements for the recovery boiler
- Excess oxygen control, low-sulphur fuel, and residual soluble sodium control of the lime mud for the lime kiln
- Spot monitoring by measuring odour with a gas chromatograph – mass spectrometer (GC-MS)

A8.7.3 Botnia-Orion Odorous Gas Management Profile

This section presents a summary of Botnia-Orion's situation relative to IPPC-BAT (2001) guidelines defined in the above Section A8.7.2. The Botnia-Orion odorous gas management system is well described in the updated EIA, in Section 4.

Weak Gas System

The dilute gas system (GOL, HVLC, or DNCG) at Botnia-Orion collects gases in the fiberline – chips area, in the evaporation and recovery areas and in the white liquor plant. The different sources are enumerated below.

1. Fiberline – Chips

- Chip bin
- Chips meter
- Liquor surge tank
- Spill collection tank
- Reversible screw conveyor for knots
- Knots washer
- Rejections washer
- Light rejects tank
- Blowtank
- Brownstock washing filtrate storage tank
- Oxygen stage feed tank
- White liquor oxidation reactor (previously passing through the jet condenser)
- Oxygen stage discharge tank
- Spill collection tank
- Unbleached stock storage
- Post oxygen DD Washer 1
- Post oxygen DD Washer 2
- Brownstock DD washer 1
- Brownstock DD washer 2
- Brownstock DD washer 3
- The MC pump deaeration or vacuum pump for vacuum pump prior to oxygen delignification
- Vacuum pump off post oxygen and brown stock DD washers

Most of the fiberline streams are collected through a Venturi scrubber, and are then sent to the dilute gas system.

2. Evaporation and Recovery Plant

Dilute gas streams are collected in the evaporation and recovery plant from:

- Secondary condensates storage tank
- Weak liquor storage tanks (tank 1 and 2)
- Evaporation plant pit
- Spillage tank
- Heavy liquor storage tank

- Black liquor mixing tank
- Dissolving tank (these gases are washed in an additional gas washer)

3. White Liquor Plant

- All tanks and equipment of the recausticizing process except for the lime mud tank, the lime mud filter, the dregs filter and the hot condensate tank

The dilute gases from the recovery and evaporation area are scrubbed in the DNCG's scrubber of the evaporation plant and, together with all other dilute gases are burned through the rear wall of the recovery boiler, at the secondary air level of the recovery boiler.

A separate flame tube boiler (the DNCG boiler) will be used during start-ups and shutdowns and in cases in which the recovery boiler is not in operation.

This DNCG boiler is designed to work at an 11-bar pressure and is connected to the medium pressure network of the plant. It is also used to produce steam for the mill during start-up and shutdown.

The system's normal flows at a 3 000 ADt/d (lean gas flows) are shown in the table below.

Table A8.7-2: Dilute Non Condensable Gas Flows and Characteristics at a 3 000 ADt/d Production

NCG Sources	From tanks	After cooling
From cooking/ fiberline	+75ºC/6,6 m^{3}n/s	+50ºC/4,7 m^{3}n/s
From evaporation	+85ºC/2 m^{3}n/s	+50ºC/1 m^{3}n/s
From recausticizing	+95ºC/1,1 m^{3}n/s	+50ºC/0,2 m^{3}n/s
TOTAL Mill gases	9,7 m^{3}n/s	+50ºC/5,9 m^{3}n/s
From Dissolving Tank: (including Mixing Tank Vent 1 m^{3}n/s)	+100ºC/18 m^{3}n/s	+50ºC/10,2 m^{3}n/s
TOTAL Mill Gases + Vent Gases: 27,7 m^{3}n/s	16,1 m^{3}n/s	

Strong Gas System (GOS, HCLV, CNCG)

Strong gases are collected from:

- Cooking flash tank
- Firing liquor storage tank
- Methanol production plant

- Foul condensate storage tank
- Evaporator vacuum pit

Strong gases are incinerated in the recovery boiler through an independent burner. A separate flame tube boiler is to be used as an auxiliary incinerator (and also at times in parallel). The boiler will be used in start-up and shutdowns, if the recovery is not available. Fuel oil and/or liquid methanol will be used as support fuel. Steam is produced at medium pressure.

Flue gases (rich in SO_2) go through a system of 3 gas scrubbers producing $NaHSO_3$ as by-product. This bisulphite will be used in the bleaching plant for elimination of residual chlorine dioxide. Flue gases from the boiler will be discharged through a duct into the main stack.

Table A8.7-3: Concentrated Non Condensable Gas and Sulphur Flows at a 3000 ADt/d Production

Source	Flow (kg/h)	Sulphur (kg/h)
From Cooking:	0 – 560	0 – 85
From Evaporation:	760	260
From MeOH liquefaction	660	330
Liquid methanol	250 – 890	< 85
Total sulphur		675 – 760
Excess liquid methanol fuel	1 090	105

The back-up odorous gas boilers (GOL/GOS boilers) are to be kept online (hot and pressurised) during all normal operating periods. The GOS boiler will additionally have part of the strong odorous gases combusted in the boiler under normal operation to generate sodium bisulphite for use in the bleach plant. The gas systems are designed to allow “bumpless transfer” of both the strong and weak gases between the primary point of incineration (the Recovery boiler) and the back-up devices (GOS/GOL boilers) without venting. This is an advanced technology in excess of BAT requirements.

In conclusion, the Botnia-NCG system meets and goes significantly beyond BAT requirements. They have provided for comprehensive collection of odorous gas streams. For example, the collection of dilute gases from recausticizing and the provision of a back-up boiler for dilute gas incineration are significantly better than at most new and BAT mills, and go beyond IPPC-BAT (2001) standards.

A8.7.4 ENCE-CMB Odorous Gas Management Profile

This section presents a summary of ENCE-CMB's situation relative to IPPC-BAT (2001) guidelines defined in the above Section A8.7.2.

ENCE have contracted to purchase a comprehensive odorous gas collection system, and intend to pick up all dilute odorous gas sources in the fiberline, evaporation and white liquor preparation areas.

The odorous NCGs collected in the fiberline, evaporation plant and white liquor plant are burned in the recovery boiler. As stand-by, the CNCGs are burned in a flare stack while DNCGs are sent to the biomass boiler. The emissions from the recovery boiler and biomass boiler to the atmosphere are monitored continuously in the flue gas stack. System design and equipment is not yet fully defined, as ENCE-CMB has not yet begun detailed engineering. The following information is from the preliminary flowsheets and descriptions, together with ENCE staff descriptions.

Weak Gas System

The dilute gas system (HVLCs or DNCGs) at ENCE-CMB collects gases in the fiberline – chips area, in the evaporation and recovery areas, and in the white and green liquor systems. The different sources are enumerated below.

1. **Fiberline**

- From chips from steaming and impregnation of chips
- In screening from the blow tank, screening, reject tank and liquor storage tank
- From oxygen delignification
- From the pre-oxygen washers and washing liquor tanks

2. **Evaporation and Recovery Plant**

- Intermediate condensates storage tank
- Clean condensate tank
- Weak (feed) liquor storage tanks (tanks 1 and 2)
- Spill liquor tank
- Biological sludge handling system

3. **White and Green Liquors System**

- All tanks and equipment of the recausticizing process except for the lime mud filter, the dregs filter and the hot condensate tank
- Green liquor equalizing tank
- Green liquor clarifier
- Green liquor storage tank
- Green liquor dregs tank

- Dregs filter vacuum pump
- Green liquor cooler vacuum pump
- Slaker, causticizers
- White liquor filter
- Lime mud storage tank
- Lime mud filter vacuum pump
- White liquor storage tank
- Weak white liquor storage tank

The key dimensioning flows at MCR (1 587 ADt/d) are presented in the table below:

Table A8.7-4: Dilute Non Condensable Key Dimensioning Flows at a 1 587 ADt/d Production

Source	Flow (Nm^3/h)
MCR from evaporation	6 000
From fiberline	12 500
From white liquor preparation	5 600
MCR to recovery or biomass boiler	24 100

Strong Gas System (LVHC, CNCG)

The CNCGs are collected in:

- Cooking flash tank
- Firing (pressurised) liquor storage tank
- Methanol production plant (column and storage tank)
- Foul condensate storage tank
- Evaporator vacuum pit

Strong gases are incinerated in the recovery boiler, through an independent burner. A flare stack using propane as a support fuel is used as a stand-by system for burning the strong gases. The flare is permanently ignited during start-up, and after commissioning will operate in an automatic mode. In this mode, if the interlocks divert the strong NCG's to the flare, the gases are "bottled" in the piping system for the period the flare takes to ignite (approx. 40 seconds) and then released to the flare.. This occurs automatically and does not require operator action. These steps are designed to result in a bumpless transfer of gases during all periods of operation (start-up, commissioning and normal operation).

The biomass boiler is used as a backup for the dilute odorous gases, and is normally always operating. The NCG system is to be designed to allow for switching between the primary point of incineration (the recovery boiler) and the secondary point (the biomass boiler) without venting. This is an advanced technology in excess of BAT requirements

In conclusion, the ENCE-CMB system is not yet fully designed. As currently planned, the ENCE-CMB system would appear to meet and go significantly beyond BAT requirements. They have provided for comprehensive collection of odorous gas streams. For example, the collection of dilute gases from recausticizing and the provision of a back-up boiler for dilute gas incineration are significantly better than at most new and BAT mills, and go beyond IPPC-BAT (2001) standards.

In a preliminary flowsheet review, the CIS team found that the knots system (knotter, washer and drainer) in the brown fiberline was not shown to be connected to the dilute NCG system, as it is customary. In follow-up, ENCE-CMB assured that it will be connected, if the devices are not sealed. As the NCG system is finalized in the detail design, care will need to be taken to ensure all appropriate sources are connected to the system.

A8.7.5 Concluding Remarks on Odorous Gas Management

Operational Issues

The proposed Gunns pulp mill in Australia has reviewed operational issues surrounding NCG venting. There observations are relevant to Uruguay and are given below.

Direct venting of concentrated NCG streams to atmosphere may happen for a number of operational reasons. If this venting is for more than a few minutes, noticeable odour in the surrounding communities may result. Venting can result from:

- Unavailability of the main CNCG destruction unit
- Unavailability of the CNCG back-up unit
- CNCG by-passed to stack for other reasons, such as:
  - Failures in interlockings
  - Mechanical failure of valves
  - Instrumentation errors

The unavailability of the CNCG destruction units and consequent venting to the atmosphere has been reviewed as part of the detailed design in existing best practice modern pulp mill odorous gas collection and destruction facilities. The annual results from three Scandinavian pulp mills that have been operating for a number of years are presented below. The number of hours that the pulp mills vent directly to atmosphere per annum is shown.

Table A8.7-5: Annual CNCG Emissions from Three Scandinavian Pulp Mills

Venting of CNCGs to Atmosphere			
	Mill A	Mill B	Mill C
Hours per annum	9	14	5
% of operating time	0,11%	0,16%	0,06%

Reference: Gunns Bell Bay Pulp Mill, Draft integrated Emission Statement, Vol1B, Introduction and Overview. July 2006.

The mills above have a main destruction unit and a back-up unit.

ENCE's Huelva and Pontevedra mills were visited by a member of the CIS team in Spain. Both mills have certified environmental management systems (EMS's), which include recording of environmental complaints, observations and inquiries from members of the public or employees. The record of complaints was reviewed for odour-related complaints.

For the Pontevedra bleached kraft eucalypt mill, from October 4th 2005 to August 1st 2006, 31 notifications were recorded as shown in Table A8.7-6. The member of the public that complained about odour apparently lives close (within 500 m) to the effluent treatment plant at the Pontevedra facility.

Table A8.7-6: Number of Complaints at the ENCE Pontevedra Mill from October 4th, 2005 to August 1st, 2006

Source	Noise	Odour	Black smoke	Fire/fire risk
External (public)	8	2	3	0
Employees	2	3	9	4

The category of "black smoke" relates to a mill request for the gatehouse staff to identify and notify the operators if the power boilers are emitting "black smoke", which can happen on start-up.

In a similar manner the records at the ENCE Huelva were examined from October 28th 2004 to June 7th 2006. There were 61 environmental notifications, and not one was an odour complaint. At the ENCE mill in Huelva, Southern Spain, a record of venting of the concentrated NCG system is kept and reported on. The collection of concentrated odorous gases opened the safety valve in 2005 for a total of 47 times, for a period of more than 30 seconds.

Table A8.7-7: Safety Valve Openings on the Strong Gas System at the ENCE Huelva Facility in 2005

Month	01/05	02/05	03/05	04/05	05/05	06/05	07/05	08/05	09/05	010/05	011/05	012/05	*Total 2005*
Safety valve openings	3	7	5	1	0	5	2	0	5	12	5	2	*47*

The total vent time in 2005 was less than 24 minutes. This venting time is remarkably short. Mills with systems in North America or Scandinavia would often have concentrated system vent times of 1 – 8 hours per month. The systems at both Botnia-Orion and ENCE-CMB are expected to perform better than existing mill systems.

For the purpose of air-emission modeling the following venting time and rates are estimated for upset conditions in each mill.

In the first year of operation, the concentrated NCG system vents for two 4 hour periods, 4 - 15 minute periods and 10 periods of 15 seconds. In the subsequent years the 4 hour periods are avoided, and replaced by two 30 minute periods, 4 - 15 minute periods and 10 periods of 15 seconds.

This estimate is based part on ENCE Huelva record (less than 24 minutes venting in 2005, of concentrated NCG system), on the European mill experiences in the section above and on the observation of initial odour problems at Botnia, Stendal, Valdivia and Rauma. These initial events may not occur, as these mills all had a more complicated batch digester system (with swings in gas flows) and we are using continuous systems in both mills.

In the first year of operation that the dilute NCG system vents for two 8 hour period, 8 - 15 minute periods and 10 periods of 30 seconds. In subsequent years that the dilute NCG system vents for one 4 hour period, 8 - 15 minute periods and 10 periods of 30 seconds.

Half of the dilute events should coincide with the concentrated events (i.e. based on recovery boiler driven events) and the balance are independent.

There should be no coincidence of events (only as called for statistically) between the ENCE-CMB and Botnia-Orion mills. The venting occurs should occur in the main stack, as consistent with system design.

Table A8.7-8: NCG System Venting Estimated Emission Rates during Process Upset Conditions (for air emission modelling)

	Concentrated NCG System venting rate as TRS	Dilute NCG System venting rate as TRS
Botnia-Orion	500 kg/hr for the first 15 minutes then 250 kg/hr	75 kg/hr , 16,1 normal m^3/s 50 C
Ence-CMB	260 Kg/hr for the first 15 minutes then 130 kg/hr	40 kg/hr as TRS 6,6 normal m^3/s at 50 C 3

The reduction in strong gas vent rate after 15 minutes is consistent with mitigation through stopping operation of the super concentrators and condensate stripper, which will reduced concentrated NCG flow by about half. The worst case event from Botnia would be in the first year, in the first hour of a coincident weak/strong gas venting of 387.5 kg/hr, The worst case from ENCE would be in the first year, in the first hour of a coincident weak/strong gas venting of 176.5 kg/hr.

These events are estimated by the project team to support air emission modelling, based primarily on older mills, with less back-up and redundancy than used for ENCE-CMB and Botnia-Orion. These events may not occur, and any odour event from events such as these should be viewed as speculative (an event that could occur, but may not necessarily occur).

Estimation of emission rates of TRS gases from effluent treatment

The CIS project team reviewed the literature, mill measurement data, comparative engineering data and experience to guide an estimation of emission rates from effluent treatment in kraft mills.

Effluent treatment equipment can emit reduced sulphur gases. Traditionally these would be associated with discharge of the foul condensates or high strength wastewater into the effluent treatment facilities during leaks and/or tank overflows.(Esplin,1989)[12] . A secondary source can be from anaerobic activity in the treatment plant, resulting in formation of sulphide material, and subsequent emission.

Some mills which use aerated stabilizations basins have very large areas of lagoons (20 – 400 ha). These mills may have emission levels in the 45 to 1000 g/ADt range[13]. There has been little regulatory focus on emission from treatment in the past, but these issues have been investigated in response to community odor concerns. Two states in the USA are

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[12] Esplin, G., "Total reduced sulphur emissions from effluent lagoons," Pulp and Paper Canada, 90 (10), pp. 105-107 (Oct. 1989).

[13] Pinkerton, J. Trends in U.S. kraft mill TRS emissions, Tappi Journal, Vol 82. No. 4, pp 166-169 (April 1999)

now requiring information to be measured or assessed on emissions from wastewater treatment. In North Carolina this is only for mills using aerated stabilization basins (ASB) for treatment. The North Carolina regulatory agency considers that simply having an activated sludge effluent treatment system is adequate for odor control, and is requiring mills with ASB system to undertake engineering and economic studies to replace ASB systems with AST, as a prelude to regulatory pressure to do so.

Sources of emission in the ASB process include the settling ponds or primary clarifier, spill ponds, equalization ponds, open channels and the aerated stabilization basins. The final effluent clarifiers and any treated effluent holding ponds do not release significant amounts of TRS compounds[14].

Emissions from all sources are the result of dissolved sulphide levels in the effluent forming a vapour pressure of TRS in air above the liquid surface. The sulphide level in primary clarifiers, spill and equalization basins are primarily the result of dissolved sulphide levels from the mill, associated with liquor and foul condensate loss. The dissolved sulphidity level in the aerated stabilisation ponds in older mills is primarily the result of anaerobic activity, due to poor mixing or incomplete treatment.

In mills which have installed steam stripping and controlled spills, the amount of TRS emission from treatment systems (ASBs) has dropped by about 98% (Taflin[15] , Young[16]). This is as a result in reduced sulphide levels into treatment.

Measured emission rates for Finnish mills, in which use of steam stripping is close to universal, (and will be by 2007, as part of IPPC BAT) is reported as from 5 to 27 g/ADt. This includes both ASB and more modern systems.

Use of ASB treatment technology was accepted as part of IPPC-BAT(2001) but was not seen as sufficient for the Australian AMT(2004), in which the more compact and efficient Activated sludge (AST) treatment process is required. Both Botnia-Orion and ENCE-CMB use the modern activated sludge treatment (AST) process.

The activated sludge treatment process has negligible emissions from the aeration tanks, secondary clarifiers and any treated effluent storage. Emissions from processes prior to aeration may be similar to those from mills using an ASB process, and are primarily the result of mill sulphide emissions.

Mills in which sulphide containing streams are introduced directly into the aeration tanks, do not see increased TRS emissions in the aeration tanks. In the United States this is referred

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[14] Personal Communication, A Jain, NCASI Southern Region, 19 September 2006

[15] Taflin, D., Winter, P., and Krzysik, B. 1998. Air and effluent quality improvements through condensate stripping. TAPPI International Environmental Conference Proceedings.(1998).

[16] Young, S.R. Kraft Mill Odor Sources, A Summary of Accomplishment,, Manual 73, Georgia Pacific Corporation, Camas, Washington, January 2001.

to as “hardpiping” and is used in many mills, as an alternative to condensate stripping, to avoid atmospheric emissions.

At both Botnia-Orion and ENCE-CMB, the primary clarifier is only used for part of the mill effluent. It is used for those streams that may contain fiber or solids. At Botnia-Orion, the mill systems are arranged so that any condensates that may contain significant sulphide loadings are always recovered, and do not come to effluent treatment. At ENCE-CMB, the low-solids stream, containing condensates and most liquor area losses, is introduced directly into the aeration basins. This reduces the concentration of sulphides in the parts of the process that can emit TRS gases, and so reduces odour potential.

Currently there is active investigation and research into emissions from secondary treatment systems. This is primary focused on ASB’s, as these are the largest emitters, but this program has included measurements of AST technologies. Part of this work is to provide an engineering basis for estimation of emissions from secondary treatment. This work is not yet complete, or fully in the public domain, and was not used to estimate emissions for this project.

The mill proponents did not have engineering estimates or explicit effluent treatment plant measurement data (for example as measured flux rates of TRS component gases) from their existing mills. They did supply ambient air monitoring information and information on the frequency of odour complaints, together with anecdotal information on odour perception and causes in effluent treatment.

To corroborate the pulp mill experience of the CIS project team members, mills of new design were contacted for specific discussions on odours from wastewater treatment. Generally, treatment systems in new mills do not emit noticeable odour. At times of higher liquor loss, some odour may be noticeable in the treatment plant area, but not more than 1 to 2 km from the mill.

The Botnia and ENCE mills are designed with advanced spill control, containment and recovery systems and are also equipped with adequately sized condensate strippers. Additionally any condensate loss will be introduced directly into the activated sludge system.

The National Council of Air and Stream Improvement of the Paper Industry (NCASI) currently have a program of measurement and modeling of emission from treatment ponds. They have conducted comprehensive measurements of emission from 5 treatment systems, 4 of which have been reported on. The specific emission rate of TRS from a primary clarifier at Roanoke Rapids, NC, expressed in terms of clarifier surface area, was determined by NCASI[17] as 13 ug/sm2 (13 micro gram per second per square meter).

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[17] Hydrogen Sulfide Air Dispersion Monitoring Analysis for International Paper Roanoke Rapids Mill, URS Corporation, North Carolina, June 30th 2006

O'Conner and Ledoux (2001)[18] measured the emission rate at an older Canadian kraft primary clarifier as 14 ug/sm2. For Weyerhaeuser, New Bern, NC, NCASI[19] calculated a similar number.

These mills are older, with higher losses (and higher flows) than either ENCE-CMB or Botnia-Orion. Additionally all or most effluent flow passes through the primary clarifier, whereas at ENCE and Botnia, streams higher in sulphide may be bypassed directly into the aerated treatment tank.

Gunns, in Australia, who are proposing a similar system design to ENCE-CMB and Botnia-Orion (modern activate sludge, with advanced spill design) are using a calculated specific emission rate for normal operation of 0.47 ug/sm2 in the primary clarifier. This is about 3.5% of the older mills measured data above, which is somewhat consistent with the 98% drop expected in modern systems (Taflin, Young). The basis and detail of this calculation (for example the calibrated Henrys Law coefficients, design wind velocity over the pond and expected free sulphide concentrations) have not been published or accessible to date, and so have not been independently verified.

To estimate emission rates for ENCE-CMB and Botnia-Orion we have used a emission factor of 5 ug/sm2. This is a little less than half the older mill measured values and about ten times that used for Gunns. This value is expected to be conservative, and if specific measurement data on newer mills (such as Veracel in Brazil) or advanced calculation techniques (such as those being developed by NCASI and used by Gunns) become available, the result most likely would be a lower value.

This emission factor has been applied to all tanks, storages and clarifiers before the aeration stage of treatment. No emission has been estimated from the aeration stage and subsequent stages. In the normal case, this factor has been applied to tanks normally in service, and for the maximum rate, it is assumed that the emergency basins are also full. No specific additional allowance for increased sulphide levels due to high levels of anaerobic activity in the spill ponds or clarifiers has been allowed for, and this emission rate is consistent with pH control being maintained.

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[18] O'Connor, B., and Ledoux, C. 2001. Use of TRS inventories and air dispersion modeling as a tool, for odour reduction strategies: TRS emissions from a kraft mill with an activated sludge

treatment plant. 2001 Tappi International Environmental Conference Proceedings, Tappi Press,

Atlanta, GA.

[19] Hydrogen Sulfide Air Dispersion Monitoring Analysis for Weyerhaeuser New Bern Pulp Mill, URS Corporation, North Carolina, June 30th 2006

Table A8.7-9: Estimated TRS Emission from the ENCE-CMB WWTP Process Units

Equipment item	Characteristics	TRS Emission mg/s
Mill drains channels and weirs	Open area allowance 300 m^2	1.5 mg/s
Primary clarifier	Diameter: 40 m Depth: 4 m Area 1256 m^2	6.28 mg/s
Emergency basin	Volume: 50 000 m^3 (2 x 25 000 m^3)	50 mg/s
Equalization basin	Volume: 5 000 m^3	5 mg/s

Regular emission	12,8 mg/s (0,70 g/ADt)
Maximum Emission (spill basins full)	62,8 mg/s (3,42 g/ADt)
Compared with Gunn's estimate (Australia)	
Regular Emission	0,015 g/s (0,4 g/ADt)
Maximum	0,051 g/s (1,4 g/ADt)

Table A8.7-10: Estimated TRS Emission from the Botnia-Orion WWTP Process Units

Equipment item	Characteristics	TRS emission estimate
Mill drains channels and weirs	Open area allowance 450 m^2	2,25 mg/s
Primary clarifier	Diameter: 46 m Area: 1 662 m^2 Volume: 7 500 m^3	8,31 mg/s
Safety basin	Volume: 25 000 m^3	25 mg/s
Equalization basins (2)	Volume: 25 000 m^3 each	50 mg/s

Regular emission	60,6 mg/s (1,74 g/ADt)
Maximum Emission (spill/safety basins full)	85,6 mg/s (2,46 g/ADt)

Compared with Gunn's estimate (Australia)	
Regular Emission	0,015 g/s (0,4 g/ADt)
Maximum	0,051 g/s (1,4 g/ADt)

The estimates of TRS emissions from the WWTPs above assume that they will be operated as proposed by mill proponents. It is noticeable that most of the emission is from the emergency and equalization basins. Should these prove to create unacceptable odour in the region, mitigative measures could be taken rapidly. These include addition of aerators in the basins, or simply avoiding using the basins most of the time. While these basins provide an extra margin of reliability to the WWTP, only their presence is essential. There are alternative ways of using them that have been successful in other mills, in which they are empty most of the time, and these may be able to be adapted to the Fray Bentos mills if required.

A9.0 BLEACHING PROCESS ISSUES

The pulp mill fibreline has the objective of forming good final pulp properties. The three main parts of the fibreline (digester, oxygen delignification and bleaching) act together to determine the final pulp quality. The arrangement of stages and equipment must be customized for the type of wood used, and the pulp market. In a modern mill, the only part of the fibreline process that generates effluent is bleaching. The bleaching area contributes about half of the flow and a good deal of the load of organic material to the total mill effluent into treatment. The decisions made in terms of bleach plant configuration and the selection of chemicals used for bleaching are based on a set of complex considerations.

Process and equipment selection from the IPPC-BAT(2001) standard includes:

- increased delignification by extended or modified cooking,
- highly efficient brown stock washing and closed cycle brown stock screening,
- increased delignification before bleaching plant by additional oxygen stage,
- elemental chlorine free ECF with low AOX or TCF bleaching, and
- recycling of some, mainly alkaline, process water from the bleach plant.

Additionally, the USEPA Cluster Rule (2000) includes the following:

- use dioxin- and furan-free defoamers (i.e. water-based defoamers or defoamers made with precursor-free oils,
- oxygen- and hydrogen peroxide-enhanced extraction (which allows elimination of hypochlorite and/or use of a lower kappa factor in the first bleaching stage), and
- use of strategies to minimize kappa factor and dioxin & furan precursors in brown stock pulp.

The Tasmania AMT (2004) includes in addition to the above:

- use of high shear chemical mixing, and
- partial bleach plant closure (i.e. increased recycle of filtrates within the bleach plant and possible recycle of some filtrates to the brownstock or chemical recovery area.

In this Annex section we discuss the background, investigations made, and certain fundamental data on the choices made by Botnia-Orion and ENCE-CMB with respect to:

- Kraft pulping and oxygen delignification,
- Kraft pulp bleaching,
- Botnia-Orion bleaching sequence,
- ENCE-CMB bleaching sequence,
- Dioxins and furans,

- ECF, ECF-Light and TCF Bleaching, and
- Alkaline bleaching filtrate recycle.

Key sources of information have included the IPPC-BREF (2001) [1] UNEP (2006)[2] RPDC (2004)[3] and RPDC (2006)[4], ENCE and Botnia laboratory and mill trial reports, mill engineering documentation and specific responses to questions. A CIS team member visited the Huelva and Pontavedra mills of ENCE in June 2006, the Pietarsaari and Rauma mills in Finland, the Varo mill in Sweden, Stendal mill in Germany, Aracruz mill in Brazil and Valdivia mill in Chile, all in 2005.

Kraft Pulping and Oxygen Delignification

From a pulp and paper perspective, wood has three main components: cellulose concentrated in individual pup fibres, lignin which is the “glue” that holds the fibre together, and hemicellulose. Kraft pulp is made by dissolving most, but not all, of the lignin originally present in wood. Much of the hemicellulose is also removed, however the cellulose remains, whose quality is responsible for pulp strength. The remaining lignin, called “residual lignin”, is responsible for the dark brown colour of unbleached kraft pulp. The brightness of pulp is measured after the digester and oxygen delignification and is about 35-50 ISO% brightness, which is a similar shade to brown cardboard boxes.

A number of modified cooking (MC) techniques have been developed in the last two decades, which modify the conditions in kraft digesters with the aim of lowering the kappa number while minimizing strength and yield losses. These techniques are considered BAT [both IPPC-BAT (2001) and Tasmanian-AMT (2004)], and will be employed by both the Botnia-Orion and ENCE-CMB pulp mills. The adoption of these technologies is shown in Figure A9.1 below.

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[1] [IPPC BREF, 2001] Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Technologies (BREF) in Pulp and Paper Industry, European Commission, EIPPCB, December 2001 http://eippcb.jrc.es

[2] “UNEP 2006, Draft Guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants”, Revised working draft version 25 April 2006 [www.chem.unep.ch/pops], [www.pops.int], [UNEP, 2006].

[3] www.rpdc.tas.gov.au/projects_state_signif/pulp_mill/pm_reports_publications.html

[4] www.rpdc.tas.gov.au/projects_state_signif/pulp_mill/pm_reports_publications.html

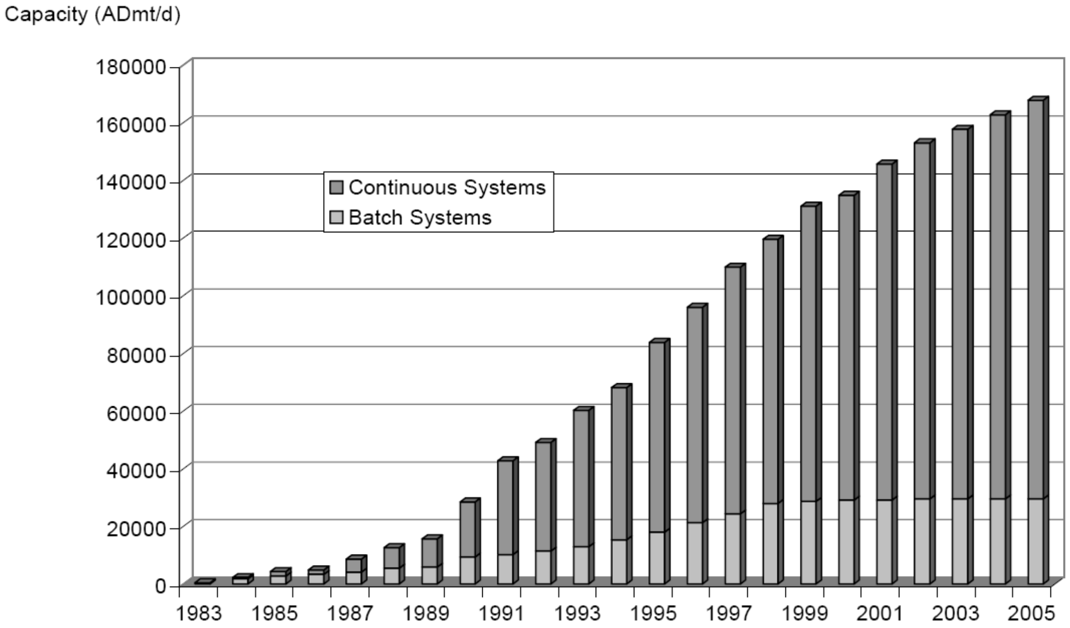

Figure A9.1: Worldwide Production of Pulp from Modified Cooking Processes (RPDC 2004)

After cooking, the fibres still contain some lignin which must be removed to ensure low environmental impact bleaching. To preserve pulp strength, the lignin must be removed selectively, with minimum damage to cellulose and minimum loss of yield. Oxygen delignification has become the dominant technology to achieve these aims and is also considered BAT.

The residual oxidisable material in pulp (largely lignin, lignin-carbohydrate residues and hexenuronic acids or HexA) in kraft pulp is measured by the kappa number test. After cooking, hardwood pulp for papermaking may have a kappa number of 16 to 30, after oxygen delignification 10 to 18 and after bleaching 0.5 to 7. Despite the widespread adoption of modified pulp and oxygen delignification technologies, there is a lower limit for kappa number below which strength and yield losses become unacceptable. Further kappa number reduction needs to be carried out by using “milder” and more selective processes, these additional processes are carried out in the bleach plant.

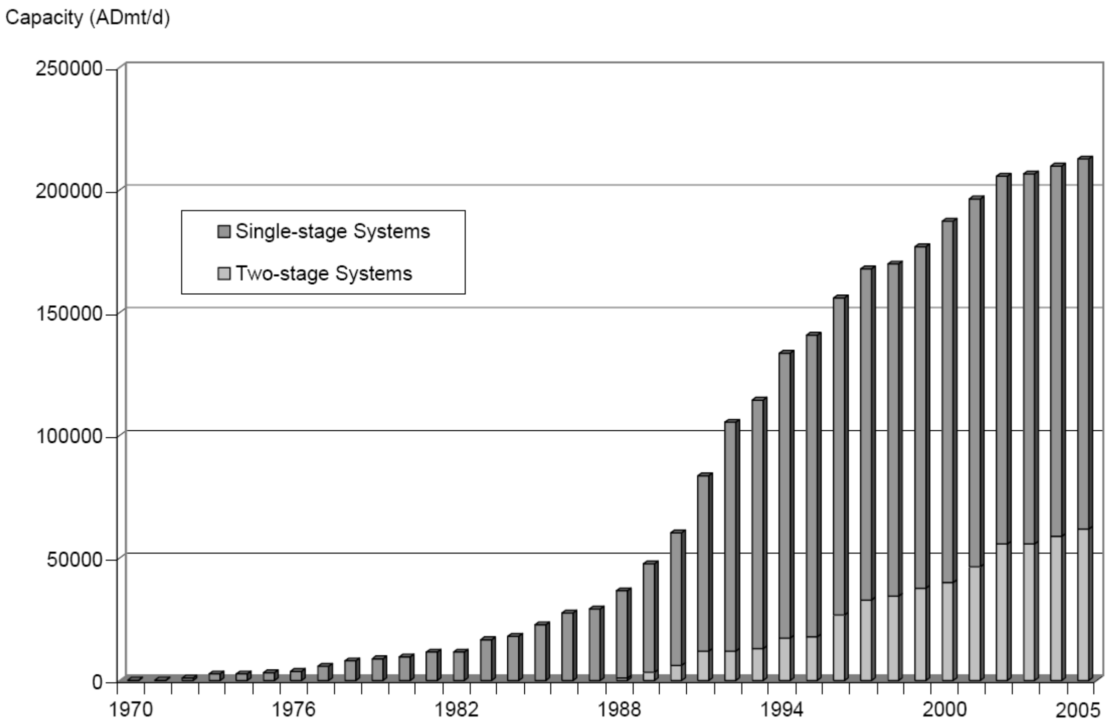

Figure A9.2: Worldwide Production Capacity of Oxygen Delignified Pulp (RPDC 2004)

In developing the fibreline configuration for Uruguay, Botnia-Orion selected a two-stage oxygen delignification and ENCE-CMB initially selected a single-stage-system. On softwood pulps such as pine, two-stage systems offer a clear advantage in the amount of delignification possible. On hardwood pulps and specifically on eucalyptus, two stage systems may not significantly increase the amount of delignification (offering only a minor improvement), due to the presence of HexA which is not removed in oxygen delignification. However two stage systems give more operating flexibility and better control. The Botnia-Orion and ENCE-CMB mill designs now both include a two stage-oxygen delignification system.

Kraft Pulp Bleaching

Chemical pulp bleaching removes colored residual lignin from the pulp and increases its brightness, brightness stability and cleanliness while preserving the strength (cellulose integrity) and carbohydrate yield (cellulose and hemicellulose) of the unbleached fibre, with due regard for potential effects on the environment[5].

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[5] [McDonough, 1997] McDonough, T.J., in “Latest developments in pulp bleaching”, Australian Pulp and Paper Institute (APPI) Course, May (1997)

Bleaching increases the brightness from about 40-50% (ISO brightness) to 90-92% for market grade bleached eucalypt kraft. Pulp and paper properties are important for bleached eucalypt kraft market pulp in addition to brightness, include reversion (the amount that a pulp property, particularly brightness, changes with time), opacity (a measure of sheet transparency), strength (both wet and dry strength, important for paper machine operation and final product properties), air resistance and fibre coarseness.

The bleach plant consists of a sequence of separate bleaching stages where different chemicals are added. The bleaching stages are designated by using symbols according to the bleaching chemical applied, as shown in Table A9.1 below. Each bleaching stage includes the following:

- a device for mixing chemicals, steam and pulp,
- a bleaching reactor (for example a tower) which is designed with a suitable residence time for completion of chemical reactions, and
- washing equipment for separation of residual chemicals, lignin and other dissolved compounds from the pulp.

ENCE-CMB will use wash presses and Botnia-Orion will use drum displacement (DD) washers. In some stages two different chemicals may be added in the same stage and two mixers and/or two towers may be used.

Table A9.1: Bleaching Stage Designation

Stage name	Description	pH
A	Acid stage to remove either transition metal ions or HexA, or both. Hot acid stages specifically designed to remove HexA formed in kraft pulping of hardwoods are designated A_{hot}, $(AD)_{hot}$ and $D_{HOT.}$ The acid is usually sulfuric acid (H_2SO_4)	Acid
C	*Chlorination stage using either chlorine (Cl_2) gas or a solution of Cl_2 in water*	*Acid*
D	Chlorine dioxide stage using a solution of chlorine dioxide (ClO_2) in chilled water	Acid
(D_N)	Chlorine dioxide stage with subsequent neutralization	Acid/ Neutral
E	Extraction stage using sodium hydroxide (NaOH)	Alkaline
(E_O)	Extraction stage using NaOH with subsequent addition of gaseous oxygen (O_2) as a reinforcing agent	Alkaline
(E_{OP})	Extraction stage using NaOH with subsequent addition of O_2 and hydrogen peroxide (H_2O_2) as reinforcing agents	Alkaline
(EP)	Extraction stage using NaOH with subsequent addition of H_2O_2 as a reinforcing agent	Alkaline
H	*Hypochlorite stage using sodium hypochlorite (NaClO)*	*Alkaline*
O	Pressurized oxygen delignification	Alkaline
(OP)	Pressurized peroxide stage using H_2O_2 with O_2 (low peroxide charge)	Alkaline
P	Atmospheric peroxide stage using H_2O_2	Alkaline
Paa	Peracetic acid (CH_3COOOH) stage	Slightly acid
(PO)	Pressurized peroxide stage using H_2O_2 with O_2 (high peroxide charge)	Alkaline
Q	Acid stage where a chelating agent, EDTA or DTPA, has been used for removal of transition metal ions. More efficient than an A stage for this purpose. The acid is usually H_2SO_4	Acid
Z	Ozone stage using gaseous ozone (O_3)	Acid

The most common and widely used bleaching chemicals in modern bleach plants are ClO_2, O_2 and H_2O_2. Ozone (O_3) is also used, but not as much as ClO_2, O_2 and H_2O_2. Peracetic acid is also used in some European mills, but is less common than ozone.

Bleaching is usually carried out in alternating acid or alkaline stages, with sodium hydroxide (NaOH) and sulphuric acid (H_2SO_4) generally used to get the correct pH conditions. Additionally NaOH extracts the oxidised structures formed by the other bleaching chemicals (and is so called an “extraction stage”).

A unique component of hemicellulose in kraft pulp was identified for the first time in the mid 1990s, as Hexenuronic acid. A majority of wood hemicellulose consists of xylan, which under pulping conditions produces hexenuronic (4-deoxy-β- L-threo-4-enopyranosyluronic) acid groups or “HexA”. HexA comprises a good deal of the residual materials after pulping, measured by the kappa number. Hardwood kraft pulps and especially eucalypt kraft pulps may contain high amounts of HexA. HexA results in increased consumption of bleaching agents such as chlorine dioxide to reach target brightness, results in increased brightness reversion, and contributes to the formation of oxalates, causing scaling in bleaching equipment.

In a well-designed bleaching process, each bleaching stage takes care of a clear task of its own. The typical roles of bleaching stages are lignin reactions, leaching of lignin, removal of metals, increasing pulp brightness and in the modern bleaching of hardwood pulps, the removal of hexenuronic acids (HexA). Each bleaching chemical works according to its characteristic reaction mechanism. At the beginning of bleaching, chlorine dioxide reacts with lignin, after which an alkaline leaching stage (E/ Eo/ Eop) is needed in order to remove the reaction products. The main role of hydrogen peroxide is the brightening of pulp. For this reason, peroxide works well at the end of bleaching where most lignin has already been removed. By emphasizing the characteristic working mechanism of each bleaching stage and combining the stages into a sequence of efficient units, an effective bleaching process can be developed.

Botnia and ENCE have developed their bleaching sequences within their own research and development organisations. This involves use of each company’s experience with both the bleaching stages and the type of wood to be used in Uruguay. In this respect Botnia has a wider range of operating experience with different bleaching stages, and ENCE has eucalypt and specifically Uruguayan eucalypt experience.

Different eucalyptus species and similar species from different locations can have varying bleaching responses. In general, eucalyptus pulp is more easily bleachable than other hardwoods such as birch pulp. Typically the hexenuronic acid content of eucalyptus pulp is higher than that of birch pulp (with birch the kappa number quota due to HexA is 4 kappa units, with eucalypt it can be 5-7). Removing hexenuronic acids is important for lowering bleaching costs, for minimizing the yellowing tendency of finished pulp, and to reduce AOX load in bleaching effluents. HexA-groups can be removed to a significant extent by means of hot acid treatment, the so-called A-stage (the removal efficiency of HexA may be 40-70%). In ENCE’s experience at its Pontevedra mill, with an inlet kappa number of 10, between 42-45% of the kappa number is formed by hexeneuronic acids. Their experience with the A-stage is that reasonable efficiencies of HexA removal between 40 and 50% can be achieved. Ozone is also effective against hexenuronic acids. This has often been used in a combined Z/D for hardwood pulps. Botnia have observed that the effect of the Z-stage has been reduced after introducing an A-stage prior to the ozone stage. The reason for this is that both the A-stage and the ozone stage react primarily with hexenuronic acids. A hot chlorine dioxide stage (D_{HOT}) is also able to reduce the bleaching chemical demand with hardwood pulp due to the improved removal of HexA.

The latest eucalypt pulp bleaching plants have employed the following bleaching sequences:

• Brazil, Aracruz C-line	A/D-Eop-DND
• Brazil, Veracel	A/D-Eop-DN-D (option for a P-stage)
• Brazil, VCP Jacarei	Ze-D-P
• South Africa, Richards Bay	D_{HOT}-Eop-D-D
• China, Hainan	D_{HOT}-Eop-D-D

Each plant has used a combination of $D_{HOT,}$ A or Z at the front end of bleaching, tailored specifically for HexA removal. The relative advantage of each of these different stages with respect to HexA removal, and the specific configuration with respect to chemical addition, washing location and time is still a matter of debate.

Laboratory Bleaching Trials and Bleaching Development of Eucalyptus Pulp by Botnia

Botnia has long experience related to pulp bleaching, and also draws on the experience of one of its owners and major customer, UPM-Kymmene. The Pietarsaari mill of UPM-Kymmene has led, piloted or been an early developer of many technologies in pulp and paper. This includes oxygen delignification, filtration equipment in recausticizing, ozone bleaching, TCF bleaching and modified cooking (including split sulphidity and other cooking techniques). A member of the CIS review team has visited the Pietarsaari and Rauma mills a number of times.

In the Pulp Center in Pietarsaari (UPM-Kymmene), pulps of four different Uruguyan eucalyptus species were bleached by using the sequence O-A-D-Eop-D. All eucalyptus grades were easy to bleach, but there were clear differences between the grades.
E. Dunnii and E. Globulus were the easiest to bleach, while E. Grandis had an inferior bleaching response. The result of this work was the selection of a lignin removal profile of cooking kappa number 17 – 20, after oxygen delignification 11 – 12, and after removing hexenuronic acids in the A-stage, the inlet kappa number to ECF-bleaching should be
7 to 8.

Botnia-Orion prefer to design a flexible bleach plant. This is one that is one that can tailor the raw material (pulp) into paper with varying technical properties, from differing wood inputs, i.e. different eucalypt species or different mix of eucalyptus species. The fibreline is also at world scale (at 3000 ADt/d) and selection of a flexible bleach plant offers possibility to overcome possible shortcomings that may result from scale-up of equipment and process units from smaller mills. On this basis Botnia-Orion selected a four-stage bleaching sequence, and either of the following sequences was recommended:

O/O – AD – Eop – D1 – P, or
O/O – D_{HOT} – Eop – D1 – P

The advantages of these sequences are as follows:

- they can produce effluents with low AOX, and can limit chlorine dioxide usage to less than 10 kg CLO_2/ADt,
- their flexibility,
- they are effective for hexenuronic removal, and
- they have a clear role for peroxide bleaching.

The efficiency gained through using displacement washing (DD) and the ability to use fractional washing and recycle of bleaching filtrates supported the use of modern filter washing technology. The Botnia-Orion mill final selected bleaching sequence is O/O - AD – OP- D – P. The target from modified cooking is kappa 18, and from two stage oxygen delignification is kappa 10. The bleaching chemical consumptions (MCR, balance, per ADt basis) are expected to be 7.7 kg ClO_2 , 8 kg peroxide, 18 kg NaOH, 12 kg H_2SO_4, and smaller quantities of magnesium sulphate and sulphur dioxide.

The Botnia-Orion bleach plant fully meets BAT requirements.

Laboratory Bleaching Trials and Bleaching Development of Eucalyptus Pulp by ENCE-CMB

ENCE are historically the most experience manufacturer of bleached eucalypt kraft pulp (BEKP) in the world. The Iberian Peninsula is the only location in Europe where eucalyptus grows, and ENCE have been manufacturing BEKP for 44 years. Today ENCE are the second largest supplier of BEKP with 1.045 million tonnes in 2005, or about 11% of the world market. Only Aracruz in Brazil sells more BEKP.

ENCE has been operating in Uruguay since 1989, and have been using Uruguayan eucalypt in all three of their pulp mills in Spain. ENCE see significant differences in the pulping and bleaching response between wood from Northern Spain (eucalyptus globulus from the Galicia area), southern Spain and Uruguay.

In ENCE’s Huelva mill, in Andalusia, southern Spain, 40-50% of the total wood used is from Uruguay. At the Pontavedra mill, 0 to 10% the wood used is from Uruguay and at the Navia mill, 0 to 30% of the wood used is from Uruguay. Spanish and Uruguayan wood is blended together in all mills. The Pontavedra mill uses an O-O-Q-Po-P sequence; the Navia mill an O D Eo D sequence and Huelva a O-O-D-PO-D bleaching sequence.

The individual wood species from Uruguay are E. maidenii, E. Bicostata E. grandis and E. dunnii. When compared with E. globulus from Northern Spain, the Uruguayan woods require significantly more alkali and have lower yields than the Iberian E. globulus from Galicia.

Using chlorine dioxide based bleaching, the following consumptions were indicated:

Chlorine dioxide required (kg ClO_2/ADt) in an ECF sequence to reach 90% ISO brightness Eucalyptus coming from Uruguay.					
	E. globulus	***E. maidenii***	***Bicostata E.***	***E. grandis***	***E. dunnii***
Metering of ClO2 (kg/ADt**)**	13.3	13.8	13.8	15.3	16.1
Source: Research and technology centre of ENCE					

In addition to bleach sequences used in each of the ENCE mills (O-O-Q-Po-P, O-D-Eo-D, O-O-D-PO-D), ENCE investigated a number of bleaching sequences, including the following:

- Ze-Q-PO- P
- Q Po ZQ -PO
- ZQ –PO- P
- Q – PO -P
- D_{HOT}-PO D
- D Eo D

The D_{HOT}-PO D sequence resulted in 90.5 brightness and good strength and viscosity properties. The dioxide charge was 10 kg/t and peroxide charge 5 kg/t. The final kappa was 1.4.

ENCE's initial sequence selected for CMB was a O-D-Eop-D sequence, with single oxygen and bleaching using 12 kg/ADt of chlorine dioxide and 3 kg of peroxide. This sequence was primarily based on the operational experience at Huelva. ENCE has now selected a sequence of O/O – D_{HOT}- PO – D sequence, i.e. incorporating a double oxygen stage. The kappa number to bleaching is expected to be less than 10 and the bleach chemical consumptions less than 10 kg/ADt. ENCE's choice of a three stage bleaching sequence is based on their long experience with Eucalyptus and the laboratory and mill experience with the Uruguayan woods. The ENCE-CMB bleach fully plant meets BAT requirements.

A9.1 Oxygen Delignification

Botnia-Orion and ENCE-CMB are both using two stage as discussed in the above section on bleaching sequence development. Post oxygen washing filtrates are fully recovered. The oxygen delignification follows modified cooking, in continuous digesters. As such, these sections of the mill fully comply with the IPPC-BAT(2001) and Tasmanian-AMT(2004) standards.

A9.2 AOX, Dioxin and Furan Generation in ECF, ECF-Light and TCF Bleaching

From the 1950s to the 1980s bleached pulp manufacture primarily used chlorine (Cl_2) as the main delignification chemical after cooking, followed by caustic, sodium hypochlorite and possibly chlorine dioxide stages. Sequences from this time may be CEH, CEHD, CEHDED. In Europe and North America sequences such as these are no longer used.

Sequences such as these are still common in Argentina and Uruguay[6], e.g. in Argentina in eucalypt mills at Puerto Piray, Missiones (CEHH sequence); Capitane Bermudez, Sante Fe (C Eop H sequence) and on baggasse or semichemical pulps at Liberator General San Martin, JuJuy (C Ep H) and Lules, Tucuman (H P sequence). They are also used in Uruguay at Juan Lacaze, Colonia (C Eop H). To date, the only mill reported to use a modern bleaching sequence in Uruguay or Argentina is at Puerto Esperanza, Missiones, which is a market kraft mill operating on pine (O-O-D Eop D Ep D). The existing Uruguayan and Argentine bleached chemical eucalypt mills primarily use chorine gas-based bleaching sequences based on chlorine gas (C) and hypochlorite (H). This is similar to mills in North America and Europe in the 1970s. A contributing factor to continuing use of these outdated bleaching chemicals is likely poor and non competitive supply of alternate bleaching chemicals. Botnia is enabling the establishment of merchant chlorate and peroxide in Uruguay, by hosting Kemira's manufacturing facilities on the Orion site. This will likely create a market environment for the reliable and economic supply of chlorate and peroxide bleaching chemicals in Uruguay and Argentina, providing trade is open and unrestricted, and a potential significant improvement in the environmental performance of these mills. It is also likely that local engineering expertise will develop in these technologies, as a result of construction and operation of the ENCE-CMB and Botnia-Orion mills. These factors may provide an opportunity for the existing mills to use more modern bleaching sequences such as D-Eop-D or D-Eop-P.

The use of chlorine for delignification has been found to produce dioxins and furans[7]. Most of the formation of the 2378-TCDD and 2378-TCDF is generated in the chlorination-stage via the reaction of chlorine with precursors of TCDD, namely dibenzo-p-dioxin (DBD), and with the precursor of TCDF which is unchlorinated dibenzofuran (DBF). When these

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[6] Bleaching sequence and pulp production data are from a commercial database, Fisher Pulp and Paper, Worldwide, V 5.0, Norwalk, CT, USA updated as of August 6, 2006.

[7] An introduction to the formation of dioxin in pulp bleaching is presented, primarily drawn from UNEP (2004, 2006) documents. The 2006 document is previously referenced and the 2004 document is DRAFT GUIDELINES ON BEST AVAILABLE TECHNIQUES, AND PROVISIONAL GUIDANCE ON BEST ENVIRONMENTAL PRACTICES, Development of guidelines on best available techniques and provisional guidance on best environmental practices relevant to the provisions of Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants Third session, Tokyo, Japan, 11– 16 October 2004, Item 3 of the provisional agenda http://www.pops.int/documents/meetings/Default.htm

precursors are chlorinated, the key reaction is electrophilic aromatic substitution. The rate of this reaction will depend both on the concentration of the precursor and the concentration of chlorine. The unchlorinated dioxin precursors are prevalent in certain mineral oils, which are part of some defoamer formulations used in the pulp and paper industry and are the major source of precursors. Wood itself may act as the source of dioxin precursor. Compression wood in particular contains higher concentrations of precursors than normal wood. The compression of wood also entails higher levels of coumaryl-type lignin which may be a source of DBD- and DBF-like precursors. Preventing the formation of 2378-TCDD and 2378-TCDF in the bleaching will be achieved mainly by decreasing the amount of chlorine used in the first bleaching stage. This can be accomplished by reducing the atomic chlorine multiple by improving washing prior to chlorination, by using an oxygen and peroxide-reinforced extraction stage as well as by increasing chlorine dioxide substitution. Figure A9.2-1 demonstrates how the formation of 2378-TCDF will be reduced by increasing ClO2 substitution: when the ClO2 substitution level is higher than 85%, 2378-TCDF is undetectable. Note this work was first published by Paprican in Canada in 1989, and today limits of detection are substantially lower than at that time.

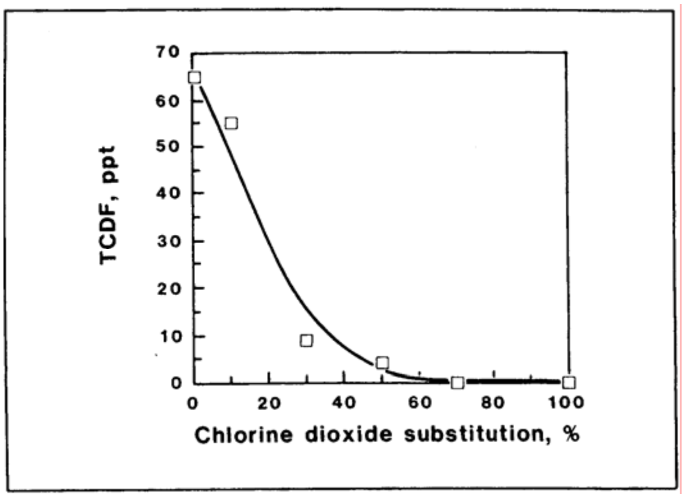


Figure A9.2-1: 2378-TCDF Formation with Different Chlorine Dioxide Substitution Levels; 2378-TCDF formation will be reduced and ultimately eliminated by increasing chlorine dioxide substitution

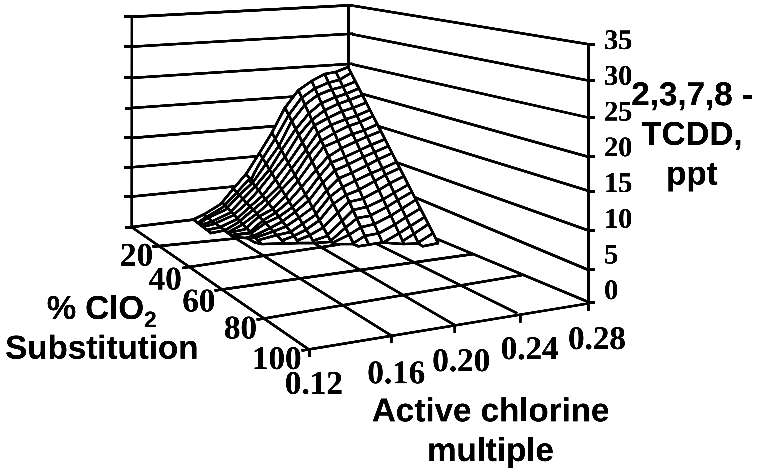


Figure A9.2-2: The Effect of Active Chlorine Multiple and the Chlorine Dioxide Substitution Level on 2378-TCDD Formation

The summary effect of active chlorine multiple and the chlorine dioxide substitution level can be see in Figure A9.2-2. The level of dioxin formation under these conditions, i.e., high active chlorine multiple and low chlorine dioxide substitution, is expected to vary, depending on the DBD content of the brownstock.

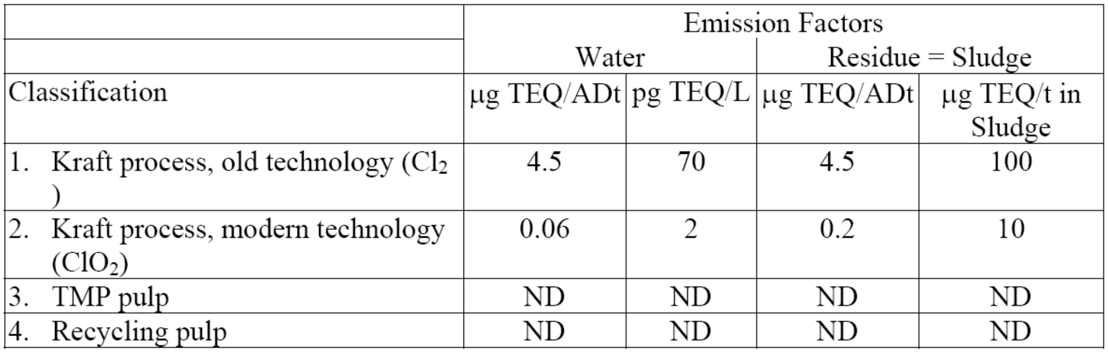
Elemental chlorine can be completely replaced by chlorine dioxide (Elemental Chlorine-Free bleaching [ECF]). In comparison with chlorine bleaching, ECF bleaching using chlorine dioxide leads to the formation of a relatively small amount of chlorinated compounds, but it does not lead to the formation of 2378-TCDD/F. ECF pulp bleached with chlorine dioxide holds the predominant position within the industry, accounting for roughly three-quarters of the bleached pulp produced worldwide. TCF pulp accounts for about 5% and is primarily produced in mills in Northern and Central Europe. Approximately 20% of the bleached pulp produced worldwide is bleached with some elemental chlorine.

In summary, the following measures can be taken to eliminate or decrease the formation of 2378-TCDD and 2378-TCDF (UNEP, 2006):

- reduce application of elemental chlorine by decreasing the multiple or increasing the substitution of chlorine dioxide for molecular chlorine;
- eliminate elemental chlorine by replacing it with chlorine dioxide (ECF-bleaching); and
- minimize precursors like DBD and DBF entering the bleach plant by using precursor-free additives and good washing.

The steps outlined above were implemented in North America and Europe through the 1990s.

This virtual elimination of dioxin in pulps produced without chlorine gas or hypochlorite shown above is also seen in the emission factors used in dioxin emission assessments carried out under the UNEP persistent organic pollutant assessments[8].



	Emission Factors			
	Water		Residue = Sludge	
Classification	µg TEQ/ADt	pg TEQ/L	µg TEQ/ADt	µg TEQ/t in Sludge
1. Kraft process, old technology (Cl_2)	4.5	70	4.5	100
2. Kraft process, modern technology (ClO_2)	0.06	2	0.2	10
3. TMP pulp	ND	ND	ND	ND
4. Recycling pulp	ND	ND	ND	ND

Figure A9.2-3: Emission Factors for Effluents (UNEP 2003)

Using the calculation techniques of the UNEP Dioxin toolkit, the magnitude of the dioxin and furan reductions available with use of modern bleaching sequences can be calculated. The emission factor to water for old production is 4.5 microgram/ADt versus modern production at 0.06 microgram per ADt (as shown in Table A9.2-3 above). There is about 719 t/d of “old bleached process” chemical pulp in Argentina (including three mills) and 350 t/d in Uruguay. If conversion was enabled for all of this capacity, the reduction in emission from these mills would be 4746 micrograms per day or 1.67 g TEQ/y, using the UNEP factors. The same calculation technique would indicate that the Botnia and CMB combined emission would be 0.097 g TEQ/year (the actual number may be lower) and so that the merchant chlorate and peroxide opportunity created by Botnia-Orion may enable a 20-fold reduction in regional PCDD/PCDD TEQ emission to rivers.

AOX

Figure A9.2-2 shows that TCDD formation occurs at high chlorine concentrations (and not at all with chlorine dioxide bleaching) Dioxin and furans analyses are difficult and time consuming. In the 1980’s, the bulk parameter AOX or adsorbable organic halides was introduced as a measure of the total amount of chlorinated organic in pulp.

Sequences that were used in the 1980s, without oxygen delignification and employing a chlorine based sequence, result in AOX discharges from bleaching of 3 to 7 kg/ADt. AOX limits were introduced in many jurisdictions at the 1.5 to 2.5 kg/ADt in the early 1980s to ensure that bleaching conditions were modified largely through addition of chlorine dioxide,

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[8] United Nations Environment Programme, Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases, Edition 2.1, December (2005) http://www.pops.int/documents/meetings/cop_2/meetingdocs/English/170306/INF11%20K0650640%20COP-2-INF-11.pdf

to the point where dioxins were not detected. Over time AOX regulations have fallen further with today's typical international regulation ranging 0.25 to 1 kg/ADt AOX.

An AOX measurement or observed level does not indicate the harmfulness of the effluent as such. AOX indicates only the possibility for multiple chlorination. With values of AOX above 1 kg/ADt, the probability of multiple chlorination is elevated, with values above 3, multiple chlorination is likely. With values lower than 0.5 kg/ADt practically no tetrachlorinated substances are created. Thus AOX is a rather good indication of the environmental performance of bleaching (IPPC-BREF 2001).

The chemical reactions of wood components with chlorine gas results in chlorination. Most of the attached chlorine is replaced by hydroxide in the subsequent alkali stage. In using chlorine gas there is sufficient time and sufficient amount of chlorine for polychlorination (i.e. several chlorine atoms attaching to one molecule). Also the probability that some of the chlorine atoms are not substituted by hydroxide, is higher. Polychlorination makes a substance persistent (POP) and as such, may be harmful in nature. Chlorine dioxide does not chlorinate wood components. AOX which is found in chlorine dioxide bleaching effluent, originates from chlorination by the small amount of chlorine, which is created in the side reactions during the production of chlorine dioxide. The amount of chlorine in the chlorine dioxide stage is so small that there is no chance for creating POPs. AOX compounds formed during modern ECF bleaching are similar to AOX compounds created in nature itself.

Figure A9.2-4 presents a comparison of AOX concentrations in a number of different areas.

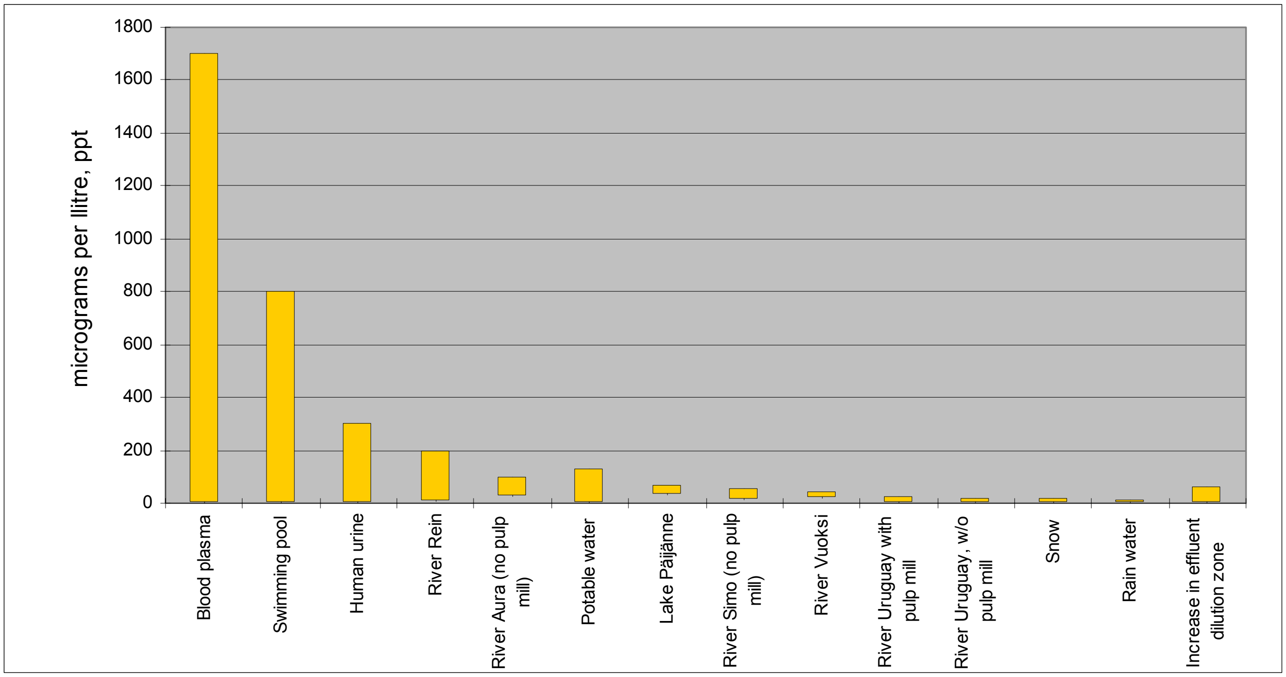

Figure A9.2-4: AOX in Different Samples

ECF and TCF Bleaching

In response to concerns on dioxin emission two approaches have been taken by pulp manufacturers, as follows:

1. To eliminate molecular or elemental chlorine based chemicals, and so eliminate dioxin formation as indicated above. This approach is referred to as ECF bleaching (bleaching sequences in which molecular chlorine (Cl) and hypochlorite are not used).
2. The second approach was to bleach with no chlorine based chemicals, and is called TCF bleaching (TCF bleaching refers to bleaching use only uses oxygen-based chemicals, such as oxygen, ozone, alkaline or acidic peroxide).

The worldwide adoption of these technologies is shown below, and shows that most of the world has eliminated bleaching with chlorine.

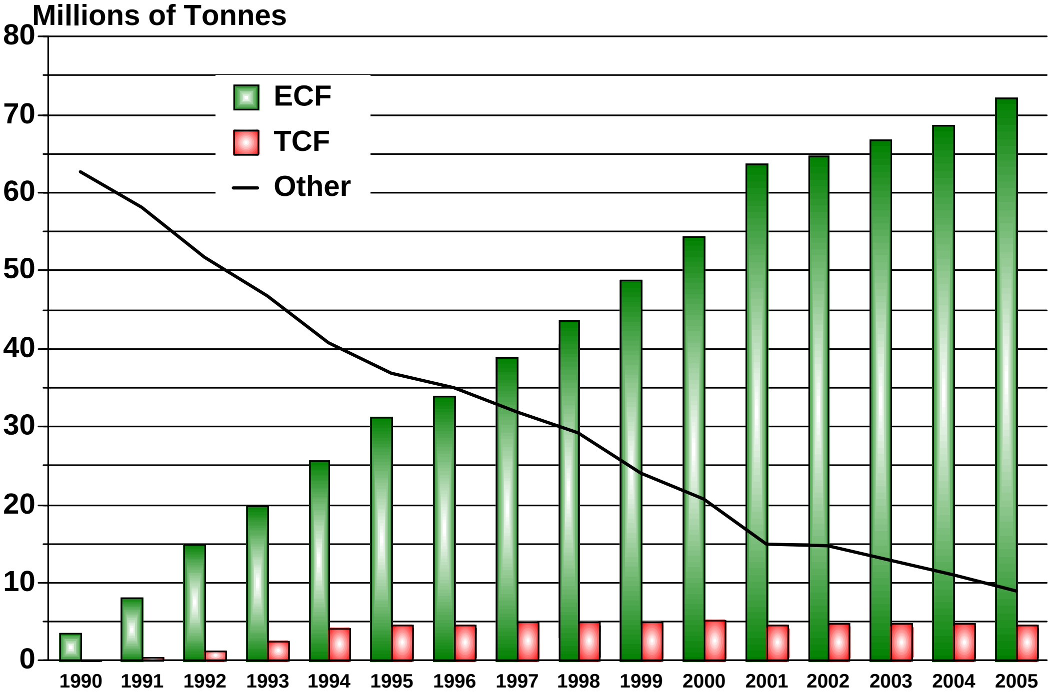

Figure A9.2-5: Trends in the Bleached Chemical Pulp Production in the World, excluding China and India Sources: American Forest & Paper Association, [UNEP, 2006]

Both Botnia and ENCE were early developers and adopters of TCF technologies. However these technologies have not proved to be environmental superior, or capable of producing a pulp which is truly competitive in the market place with ECF pulps. The world pulp market is about 90 million tonnes/year, and of this TCF pulp is about 4 million t/y, or a little less than 5%.

In 2004 Botnia made 2.45 million tonnes or a little less than 3% of total world pulp production, and 628,000 tonnes of TCF, about 16% of the world TCF production. ENCE's production in 2005 was 1045 million t/year and of this 392,000 tonnes were TCF. Both mill developers (ENCE and Botnia) know TCF, and have been making it for more than 10 years. Both ENCE and Botnia evaluated TCF bleaching sequences as part of the process development for Uruguay.

ENCE has a stable TCF market in Europe of about 400,000 tonnes per year. The TCF pulp it produces at Pontavedra is for this specialist market, and does not sell on the general eucalypt market. Pontavedra pulp properties fall below market level and chemical consumptions increase, when as little as 10% Uruguayan Eucalypt is mixed into the wood supply. With the ECF sequences at Navia and Huelva, there is no such effect. The overall yields from Uruguayan wood are lower and more variable, indicating a different and more variable composition (balance between lignin, hemicelluloses and cellulose). Uruguayan Eucalypt typically has up to twice the iron and manganese content of the northern woods, a key parameter for TCF Bleaching.

TCF bleaching at Pontavedra is based on a O-O-Q-PoP sequence. The final pulp from this sequence has a brightness of 90.5 ISO. The final kappa number is about 6 units, indicating a relatively high level of residual lignin, and the pulp has significant brightness reversion over time. Pontavedra is located close to most of its customers and this minimises the transit times, to help overcome this deficit. The brightness reversion from ENCE's commercial pulps is shown in Figure A9.2-6. The TCF pulp has a kappa number of about 6 and the ECF about 0.8.

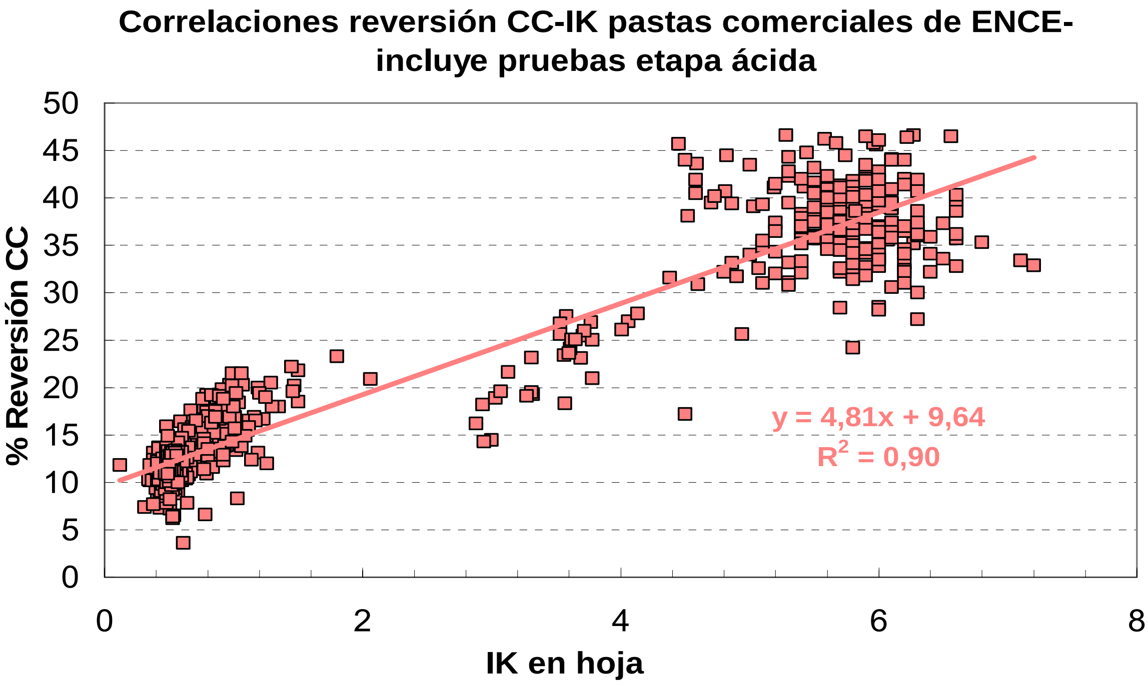

Figure A9.2-6: Brightness Reversion (ISO%) versus Residual Kappa Number for ENCE Pulp (reversion is measured after 48 hours at 80ºC and 65% humidity)

Botnia also are knowledgeable about TCF and considered TCF sequences in their evaluation for Uruguay. Botnia selected an ECF sequence to best meet customer demands. Some of the difficulties Botnia identified with respect to TCF include the following:

- TCF bleaching produces inferior fibre quality such as fibre strength, which translates to less recyclability of the fibre.
- Cooking yield is lower for TCF sequences, as they require a lower kappa number into the bleach plant, and this results in higher wood consumption.
- Based on the current knowledge, switching to TCF would not bring any environmental benefits as such[9].

It should be noted that 80% of Botnia's pulp is sold to its owners (UPM and Metsliito), who prefer ECF pulp for papermaking because of its superior properties.

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[9] Tana, J., Ruonala, S., Ruoppa, M., 1999. Environmental effects of effluents from ECF- and TCF-bleaching The Finnish Environment 350, Environmental protection, p. 60 http://www.ymparisto.fi/default.asp?contentid=84821&lan=EN

TCF bleaching was, and is still favored by some groups such as Greenpeace, and is currently being promoted by the WWF (formerly the World Wildlife Fund). These groups claim that mills practicing TCF bleaching are environmentally less damaging, and will be easier to adapt to zero-discharge. The ECF vs TCF question was recently examined by the Tasmanian Government Agency (RPDC) responsible for permitting new pulp mills in Tasmanian, Australia. This study was to examine issues raised in a WWF report on Valdivia pulp mill in Chile. WWF had recommended that TCF bleaching technologies should be used for new mills. The RPDC review was carried out in May 2006, and the report has more than 140 references, covering experiences in North America, Europe and South America.

The report concluded that TCF pulp and ECF pulp have similar environmental impacts from air, water and solid water emissions, and neither emit dioxins at the level of quantification in North America. ECF and TCF offer similar possibilities and challenges for process closure, but no paper grade bleached kraft pulp mill operates with zero-discharge (closed-cycle) today. The report concluded that TCF pulps generally have poorer strength at equivalent brightness, and lower yields (need more wood) than comparative ECF pulps. Neither technology offers significant advantages in terms of operating risk, safety and occupational health considerations. Both technologies are accepted as acceptable under the Stockholm Convention of POPs, IPPC-BAT, USEPA and all significant national permitting authorities.

The general conclusion to be drawn by readers of this report is that based on review of the literature and available evidence, the position taken by WWF and Greenpeace with respect to TCF technologies is not technically valid or supportable.

A9.3 ECF and ECF Light

The term “ECF-Light” bleaching has been suggested as a name to be applied to mills that use additional oxidants to delignify in conjunction with chlorine dioxide. This has been proposed as people wish to differentiate between bleach plant operation considering more than just the type the bleaching chemicals used (ECF or TCF), but also would indicate of the amount of bleaching work done with chlorine dioxide versus oxygen, ozone and peroxide. For example a conventional cooked hardwood pulp with out oxygen delignification may use 35 kg/ADt of chlorine dioxide. The sequence proposed by Botnia-Orion is expected to use about 8 kg/ADt, and ENCE-CMB less than 10 kg/ADt of chlorine dioxide. The term “low kappa ECF” has been used to describe sequences that have oxygen delignification and advanced cooking ahead of bleaching (with kappa number to bleaching of less than 16 for softwood and 12 for hardwood)

ECF-Light has been used to describe bleaching sequences using chlorine dioxide (D) in combination with peroxide (P), and those using peroxide and oxygen (PO) are called “ECF light” and “ECF super light” respectively (RPDC 2006). This terminology has not been universally accepted. However both ENCE-CMB and Botnia-Orion could be described as low kappa ECF-Light bleach plants, or for those who prefer hyperbole “Low kappa ECF Super-Light” bleach plants. The CIS team would recommend that the fibrelines be described as containing modified cooking, two stage oxygen delignification and ECF-Light bleaching incorporating Hexenuronic acid removal technology.

A9.4 Alkaline Filtrate Recycling

Alkaline filtrate recycle was identified as both an emerging technology by IPPC-BAT (2001) and Tasmanian-AMT (2004). Partial recycle within the bleach plant and from bleaching to brownstock washing was included as a BAT technology by IPPC-BAT (2001), but not Tasmanian AMT (2004). In the study report for the Tasmanian regulation which is more specific to eucalyptus furnish, no eucalyptus mills were identified as having implemented the practice of recycling bleach plant filtrates. Part of the explanation for this may be the high oxalate levels in eucalyptus pulp (from oxidation of HexA), and also the relatively low color and COD content of alkaline filtrates from eucalyptus bleaching (and so lower environmental gain and higher risk associated with filtrate recycle).

Both the ENCE-CMB and Botnia-Orion mills plan to recycle filtrates within the bleach plant, which enables low bleach plant effluent flows. In addition, the ENCE-CMB plant is to recycle part of the alkaline filtrate to brown stock washing. The Botnia-Orion mill will seek to implement this practice once operation is well established.

Alkaline filtrate recycle is practiced at a limited number of mills, and is considered as a basic step towards full system closure. With modern bleaching systems, the almost universal use of secondary treatment, and the virtual elimination of aquatic environmental effects due to the effluents from modern pulp mills, much of the driving force for system closure has disappeared. System closure has also proven to be much more difficult that originally anticipated. Difficulties with system closure in general and with alkaline filtrate recycle in particular can include carryover to bleaching and increased first stage chemical use, increases in potassium and chloride content in the recovery circuit, increase in oxalate concentrates in liquor, and the possibility of scaling in evaporators.

ENCE's design balances show that they hope to eventually recycle 40% of the alkaline filtrate flow, and "capture" about 20% of the flow back to brownstock washing. The increase in COD carryover from brownstock to bleaching associated with filtrate recycle would be about 35% of the total COD loss for the ENCE-CMB mill (wash loss COD would increase from 6 kg/ADt to 8 kg ADt). ENCE-CMB has included a precipitator dust leaching system to remove additional chloride load from the recovery system. The design employs wash presses, and this gives a slight advantage with respect to alkaline filtrate recycle to brownstock when compared with Botnia-Orion.

The Botnia-Orion mill initial design balances show that full implementation of Eo filtrate recycle would decrease overall environmental performance, due to increased carryover, chemical demand and AOX from bleaching. Alkaline filtrate recycle to brownstock washing is practiced by Botnia at Rauma. This has resulted in significantly increased evaporator scaling and associated loss time and increased periodic emission due to the requirement to clean the evaporator surfaces. UPM-Kymmene at Pietarsaari recently stopped filtrate recycle from their softwood line, as a new recovery boiler has been installed operating at high pressure (104 bar) and high temperature (steam temperature of 505ºC), and they were concerned over the possibility of corrosion from increased potassium and chloride levels in liquor due to filtrate recycle.

Given the lack of experience with alkaline filtrate recycle in eucalyptus pulp mills and related operating impacts in other mills, the approach taken for each of the Botnia-Orion and ENCE-CMB mills with respect to alkaline filtrate recycle is justified. ENCE-CMB will implement alkaline filtrate recycle shortly following start-up, whereas Botnia-Orion will examine this practice after production has been achieved and start-up process issues resolved.

Conclusions

ENCE and Botnia have relied on their operating experience and process knowledge, coupled with state-of-the-art information from equipment vendor to develop fibreline (and complete mill) configurations. In virtually all respects ENCE and Botnia have put together the best process technologies that they can, and these new mills are likely to perform better than any of their existing mills, with respect to overall environmental performance.

The selection of two-stage oxygen delignification, ECF-Light bleaching and the cautious approach to alkaline filtrate recycling taken by both mills in consistent with BAT for bleached eucalypt kraft mills, and with the Hexenuronic acid specific acid and D_{HOT} stages are completely modern. The expected performance with respect to bleaching effluent flow, COD content and color will be among the best in the world.

In conclusion ENCE-CMB and Botnia-Orion fibreline configurations (digesting, oxygen delignification and bleaching) are BAT.

Conclusions from the Review of ECF and TCF bleaching processes and specific issues raised in the WWF report on Arauco Valdivia, RPDC 2006.

No.	Conclusion
1	Chlorine dioxide can potentially generate molecular chlorine Cl2 in ECF bleaching but this chlorine is converted to hypochlorous acid at the typical conditions of pH and temperature of a D stage.
2	Hypochlorous acid generates small amounts of substituted chlorinated organic compounds (measured as AOX in bleach plant and OX in ECF bleached pulp), however: Compounds identical or similar to those produced in ECF bleaching are formed as a result of natural processes. These naturally produced compounds range from simple alkanes, such as chloromethane, to numerous complex halogenated alcohols, ketones, carboxylic acids, carboxylic amides, aldehydes, epoxides and alkenes and chlorophenolic isomers such as 2,4,6-trichlorophenol and its methylated analogue 2,4,6-trichloroanisole. Chlorinated compounds formed during ECF bleaching are biologically degradable in the environment. Pulp mill AOX will ultimately be mineralised through photochemical and

No.	Conclusion
	biological processes and during mineralisation the chlorinated organic material will be released as chloride and carbon dioxide (CO2).
3	Hypochlorous acid also generates PCDD and PCDF from their precursors CDD and CDF but the probability of their formation is so low that they are undetectable with present sampling and analytical techniques (i.e. at low pg/L or ppq level).
4	PCDD and PCDF are emitted as a consequence of combusting a wide variety of materials including fossil fuels, wood, and municipal solid wastes and are, therefore, widely distributed in the environment. The ubiquitous presence of these compounds could explain their detection in bleached pulp and filtrate samples from ECF and TCF mills through contamination of either the raw materials or product samples, or both.
5	ECF bleaching is at present (Q2 2006) the dominant bleaching method worldwide (75% of total bleached kraft pulp production) and has been adopted in most new installations.
6	A rapid decrease in the concentration of PCDD/ PCDF has been measured at several pulp mill locations in North America and Europe either in sediments or biota after the introduction of either ECF or TCF bleaching.
7	PCDD and PCDF emissions in ECF and TCF effluents are about the same.
8	If ECF bleaching is used, the emissions of 2,3,7,8-TCDD and 2,3,7,8-TCDF to water are lower than the limit of quantitation (US EPA Method 1613[10]).
9	If TCF bleaching is used, the emissions of 2,3,7,8-TCDD and 2,3,7,8-TCDF to water are lower than the limit of quantification (US EPA Method 16131).
10	TCF bleaching developed in the early 1990s and reached a market share of around 5% of the total bleached kraft pulp production. Since then, this market share has gradually declined to around 4%. The TCF market is at present stagnant or decreasing, no premium is paid for TCF pulps and the expectation for less problematic recycle of effluents has not been realised. Thus, mills in Germany and the Nordic countries have either abandoned or reduced TCF production in favour of ECF production.
11	The treatability of ECF and TCF bleaching effluents in a biological treatment plant is for all practical purposes about the same. Because of this, the treated effluent characteristics depend more on the pulpwood, mill geographical location and pulping process than on the selected bleaching process.
12	The COD removal efficiency in effluents from BKP mills using hardwood is commonly above 80% but is in the range 60-70% for kraft mills using softwood.
13	Treatment efficiency in ECF mills varies between 85-98% BOD removal, 60-80% COD removal and 40-65% AOX removal. Phosphorus is reduced by 40-85% and nitrogen by 20-50% (calculated on net incoming amounts before addition of nutrients). Overall TSS removal for the primary and secondary stages is around 85-90%.

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[10] US EPA Method 1613 for Analysis of Dioxins and Furans in Wastewater, which has a minimum level of 10 pg/L for 2,3,7,8-TCDD and 2,3,7,8-TCDF.

No.	Conclusion
14	Tertiary treatment with inorganic chemicals is not regarded as AMT unless the recipient is very sensitive because of its very high sludge production. If polymer is used instead of inorganic salts or lime, the sludge generated can be burned in the recovery (Tembec Skookumchuk BKP mill in Cranbrook, BC, Canada).
15	Chlorate ion formed in ECF bleaching may be toxic to large brown algae, such as kelps, which are common in many parts of the Australian marine environment, because of a competitive uptake with nitrate. Chlorate formation can be reduced by adopting ZD or DZ stages in ECF bleaching.
16	Emissions to the atmosphere from the chemical recovery area of BKP mills are for all practical purposes identical whether ECF or TCF bleaching is employed. Two additional emissions sources to the atmosphere in ECF kraft mills are the ClO2 plant environmental scrubber and the bleach plant scrubber, which may occasionally emit minor amounts of either inorganic or organic chlorinated compounds, or both. Collection and scrubbing with alkaline scrubbing solutions of residual chlorinated compounds from the bleaching chemical preparation plant and the bleach plant is standard practice in ECF kraft mills and this technique is considered AMT.
17	The amounts, composition, handling etc. of the solid wastes from BKP mills employing either ECF or TCF bleaching are comparable.
18	Possible methods of disposal for biosludge are: Addition to weak black liquor, evaporation and burning in the recovery boiler. Stabilisation by a drying and composting process, then utilisation as a soil conditioner. Utilisation as cover material on old landfills due to its low water permeability. Dewatering, mixing with either fibre sludge or bark, or both and burning in the power boiler.
19	Approximately 50-70% of the dioxins/furans in BKP mill are transferred from the water phase onto the biological sludge
20	Traces of dioxin were detected in late 2005 in tank deposits in the chlorine dioxide plant of 3 Swedish BKP mills. The process used in all cases is Cellchem's Hydrogen Peroxide Atmospheric (HP-A®) process (http://www.cellchem.com/docs/products-services/chlorine_dioxide.htm) To the best knowledge of the authors of this report, no dioxins have been emitted to the environment from this source.
21	The legal detection limit (minimum level) for 2,3,7,8 TCDD and 2,3,7,8 TCDF in the USA is 10 pg/L and is measured in the bleach plant effluent. Virtually all the analyses report values less than this level, however, there is insufficient data available to calculate the margin by which bleach plant discharges are below the legal detection limit. It is estimated that treated effluents discharged from American mills may contain less than about 2-3 pg/L of 2,3,7,8 TCDD.
22	Virtually all Canadian mills are at present authorised by Environment Canada to reduce sampling, analysis and reporting of dioxin and furan discharges to once annually, and virtually all analyses are undetectable at the regulatory levels of 15 pg/L for 2,3,7,8 TCDD and 50 pg/L for 2,3,7,8 TCDF. Environment Canada verifies that mills report discharges as required, but does not maintain a database of actual values, since all are considered "non-measurable".

No.	Conclusion
23	Discharges of PCDD/ PCDF in Canada and the USA are dramatically below the levels of the early 1990s, but there is insufficient data available to quantify the current discharge levels.
24	TCF and ECF mills have the same non-process elements (NPE) entering with their pulpwood and water. This includes an array of heavy metals, chloride and potassium ions. These combine with organic and inorganic material in the mill systems and form scales and deposits in tubes and on equipment leading to operational upsets and a need to shut down to carry out cleaning cycles. These problems are equally difficult to handle in BKP mills employing either ECF or TCF bleaching, hence, bleaching effluent recycle to chemical recovery must include some treatment and purge of NPE. Chloride and potassium ions are soluble and enter the liquor circuits in both ECF and TCF mills and the lower concentration in the TCF mills has not proved to be an advantage.
25	The overall conclusion from the review of recent studies of environmental impact of bleached kraft mill effluents confirms that neither ECF nor TCF bleaching gives clear environmental advantages. It is noted that EDS have also been shown to occur in the effluent from a BKP mill employing TCF bleaching.
26	Chelant charge in TCF bleaching is normally about 2 kg/ADt. There is concern about the ability of chelants to remobilise toxic heavy metals out of sediments and their biodegradability. The chelant DTPA is not degraded in biological treatment but up to 30% of the DTPA charged may be adsorbed onto the biological sludge and up to 50% may be chemically precipitated with metal salts. The chelant EDTA is resistant to aerobic biodegradation in an activated sludge plant operated under “normal” conditions (about 10% reduction at pH 7 and short sludge age). EDTA does not absorb onto sludge so it passes through the treatment plant without significant removal. EDTA is however biodegradable under special conditions. If the pH is higher than 8 and the sludge age (retention time of the biosludge in the biological treatment) is long enough (>20 days), the reduction will be about 75% as an annual average.
27	There is no systematic difference in effect intensity or effect pattern between the whole mill effluents from mills employing ECF or TCF bleaching.
28	There is no indication of a difference between ECF and TCF bleaching in terms of acute and chronic toxic effects on aquatic eco-systems The remaining environmental effects of modern mills (e.g. sub-lethal toxicity to aquatic organisms) cannot be predicted from the bleaching sequence alone. Future evaluations of these environmental effects should focus also on other unit operations within the mill (e.g. wood handling, cooking, washing, screening, spill and foul condensate handling).
29	ECF pulps have better paper-making properties than TCF pulps. TCF bleaching offers no advantage over ECF bleaching in terms of reducing or eliminating an effluent discharge.
30	Biological toxicity tests carried out at the Mercer International Rosenthal BKP mill in Blankenstein, Germany, while producing both ECF and TCF pulps, indicate no difference in ECF and TCF effluent quality.
31	A secondary effluent treatment is a prerequisite for both ECF and TCF wastewaters to minimise long term toxic impacts on aquatic ecosystems.

No.	Conclusion
32	Organic halogen (OX) content of pulp is a suitable parameter for assessing the aquatic eco-friendliness of ECF pulp production.
33	There is growing evidence that endocrine disrupting substances (EDS) are either derived from wood or are chemical or bio-degradation by-products of naturally occurring chemicals, and not organochlorine compounds. Consequently, the impacts are likely to be the same whether the mills use ECF or TCF bleaching sequences.
34	Both ECF and TCF bleaching offer paths to process closure. Based on current knowledge, the degree of closure in TCF mills can be only partial whereas ECF mills are more likely to offer full bleaching closure. As of Q2 2006 there are no papergrade BKP mills that operate fully closed on a continuous basis, more specifically there are no bleach plants in papergrade bleached kraft mills that operate fully closed on a continuous basis. The principal impediment to closure in a BKP mill is the recycle of bleach plant effluents, which typically comprise about half of the total effluent volume. For ECF mills the prime concern has been the build-up of chloride in the chemical recovery cycle, with secondary concerns with pulp quality and mill operability. For TCF mills the prime concern has been pulp quality (strength and brightness) with secondary concerns in operability, and potassium and chloride build-up in the recovery system. Both ECF and TCF bleaching closure can cause operating difficulties with increased chemical consumptions, poorer pulp quality and provide challenges in minimising deposition and scaling on equipment.
35	The methanol process (ERCO R8/ R10 and Cellchem SVP-Lite/ SVP-SCW) is the dominant modern method for generation of chlorine dioxide with low chlorine content. There are a few installations using H2O2 as the reducing agent (ERCO R11 and Cellchem SVP-HP). The advantage of this method is that the risks associated with methanol handling as an additional hazardous chemical are eliminated whereas H2O2 is also used as a bleaching chemical. In all other respects the process conditions and the unit operations are similar to those used in the generation of ClO2 using methanol. Due to the relatively short operating time of the existing installations and the consequent lack of consistent track record for low Cl2 contamination of the ClO2 solution, the low-chlorine integrated chlorine dioxide plant (IDP) is at present considered to be an emerging technology.
36	The analysis of properties of ECF and TCF bleached market pulps produced in different regions of the world has shown that these pulps display different properties. Possible reasons for this observation include climate, harvest age and maturity, wood species, processing conditions including the bleaching sequence, and customer requirements. Consequently, this analysis is influenced by many more factors than ECF and TCF bleaching processes alone and it is not possible to generalise about which bleaching process is superior with respect to pulp properties.

No.	Conclusion
37	Property comparisons made between ECF and TCF bleached pulps produced at the same mill using the same pulpwood are more representative than those of pulps from different regions. The following results are reported: Hardwood ECF and TCF bleached pulps produced at UPM-Kymmene Pietarsaari, Finland: Can be equal in brightness (89% ISO) and strength provided the refining energy for the TCF bleached pulp is sufficiently high Softwood ECF and TCF bleached pulps produced at Mercer International Rosenthal, Germany: o ECF bleached pulp reaches a certain tensile strength at a higher freeness than TCF bleached pulp. o ECF bleached pulp has higher tear strength and loses it less rapidly with refining than TCF bleached pulp. o ECF bleached pulp has higher brightness than TCF bleached pulp. o TCF bleached pulp needs more refining energy to reach a certain strength level.
38	The level of delignification in cooking, the cooking process and oxygen delignification determine the final pulp yield. The yield loss in bleaching is in the range 1-3% (on wood) and is most likely independent on whether an ECF or TCF sequence is employed. There is a tendency for increased yield loss if either alkaline peroxide or ozone bleaching are carried out. This is particularly noticeable in the bleaching of hardwood pulps. Because TCF bleached pulps tend to have lower oxygen-delignified pulp kappa number, they have a lower overall bleached yield than ECF bleached pulps.
39	According to present knowledge it is difficult to achieve full brightness (+90% ISO) with alkaline peroxide based TCF sequences, e.g. Q(OP)Q(PO), on softwood pulps. If acid stages are included in the bleach sequence, e.g. Paa, and in particular Z, a full brightness can be reached but then it is difficult to get high pulp strength.
40	Brightness reversion for ECF and TCF bleached pulps is a complex issue which has not been completely elucidated so far.
41	The following is a summary of the strength characteristics of eucalypt and pine BKP at comparable operation of the mill: Eucalypt kraft pulp: TCF pulp strength properties11 are 90-100% of those for ECF pulp. Pine kraft pulp: TCF pulp strength properties are 85-95% of those for ECF pulp.
42	ECF bleached pulp dominates the world bleached chemical pulp market. Data shows a widening gap between ECF and TCF bleached pulp production. ECF bleaching continues to grow whereas TCF, at approximately 5% of the world market at present (Q2 2006), is declining. There are mills originally built with the intention of producing TCF bleached pulp that have converted or plan to convert to ECF bleaching with the capability of producing TCF bleached pulp as required.

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[11] Eucalypt pulp strength properties are arguably not the most important parameters, whereas light scattering coefficient, opacity and parameters promoting formation are more important.

No.	Conclusion
43	TCF bleaching has continued to develop, for example Södra no longer uses ozone to produce TCF softwood pulps, and UPM-Kymmene has similarly discontinued the use of ozone. Södra and UPM-Kymmene indicated strength concerns with ozone during mill visits carried out in 2005 and advised they are developing better alternative bleaching techniques. All major companies that pioneered kraft TCF bleaching in their fibrelines have recently purchased, built or plan to build new ECF capacity. This includes Metsä-Botnia, UPM-Kymmene and ENCE.
44	The risks identified in a risk inventory of TCF and ECF bleaching are all in the low risk area in the risk matrix where additional risk mitigating measures normally can be regarded to have low priority. All risk scenarios are either "less likely" or "unlikely" or "very unlikely" to occur, i.e. the probability for their occurrence is once in 10 years to once in over 1000 years. Even though there are two more risk scenarios identified for ECF bleaching and the probability level for some ECF scenarios is slightly higher than for TCF, the overall risk levels for the two processes may be considered comparable.
45	A review of the Driscoll report prepared for the Commission in 2005 and a discussion of the extremely low potential for exposure to organochlorines in ECF mills leads to the tentative conclusion that the risk level for any health effects from working in ECF and TCF mills is comparable.
46	As the ECF and TCF bleaching processes are considered BAT in [IPPC BREF, 2001] and acceptable for use in pulp bleaching in [UNEP, 2006], they should also be acceptable for pulp bleaching according to: BAT and BEP as defined in Article 5 and qualified in Annex C of the Stockholm Convention. General prevention measures relating to BAT and BEP as defined in Annex C of the Stockholm Convention. In Annex C to the Convention process changes such as moving to closed systems are recommended. This may however lead to build up of non-process elements such as chloride in the systems which could increase any formation of TCDD and TCDF in the recovery boiler.
48	The WBG and its private sector arm International Finance Corporation (IFC) adopt the guidelines contained in [PPAH, 1999] as benchmarks to decide whether to approve investments. Because the PPAH was published in 1999 and probably researched and written from 1995 and onwards statements like "the trend is to avoid the use of any kind of chlorine chemicals and employ "totally chlorine free" (TCF) bleaching" are not quite relevant in 2006 when TCF bleaching accounts for less than 5% of the global production capacity of bleached chemical pulp and there has in fact been a reduction in total TCF capacity over the last few years. Another statement in the PPAH "TCF processes allow the bleaching effluents to be fed to the recovery boiler for steam generation, thereby reducing the amount of pollutants discharged" was a high expectation of the 1990s, however, the recycling of bleach effluents from TCF processes has proven equally difficult to manage as from ECF processes. Zero-effluent discharge from kraft pulping is at present (Q2 2006) not a feasible option and the possible recycle and incineration of bleach effluents (from ECF and TCF bleaching alike) is limited. The PPAH states that "ECF processes are acceptable, and, from an environmental perspective, TCF processes are preferred". Except for the statements discussed above there is no further evidence given to support this preference in the text.

A10.0 MANAGEMENT OF RESIDUALS

In this section, the mill proponents' strategies for the management of residuals will be compared with the IPPC-BAT (2001) with regards to solid residuals for kraft pulp and paper mills. The Australian Government's Resource Planning and Development Commission (RDPC) report on recommended environmental emission limit guidelines for any new bleached eucalypt kraft pulp mill in Tasmania (Tasmanian-AMT (2004)) is also taken into account to add a more recent source of information to assess the technology to be used at the proposed mills from a "best available technology" point of view.

After a general presentation of BAT recommendations for the management of residuals estimates of solid waste to be landfilled will be given in Section A10.2. The methods for proper management of residuals used by the mill proponents will be further compared with IPPC-BAT (2001) and Tasmanian-AMT (2004) guidelines in Section A10.3.

A10.1 BAT Management of Residuals Generated from Kraft Pulp Mills

Solid wastes generated from kraft pulp mill operations generally consist of the following:

- Wood preparation waste – bark, sand, grit and other debris associated with wood handling and preparation.
- Raw water treatment sludge – a mixed organic and inorganic materials resulting from the chemical treatment and filtration of water for use in the production process.
- Green liquor dregs, grit and lime mud – primarily inorganic solids generated from the chemical recovery process. They consist of impurities from the wood or chemicals used in production that must be removed to prevent build up of inert materials and non-process chemicals.
- Effluent treatment sludge – generated from the primary and secondary treatment of effluent. Primary sludge is a combination of non-recoverable fiber from the pulp mill and inorganic materials that settle in the primary clarifier. Secondary sludge is mostly excess organic biomass from biological wastewater treatment.
- Ash/sands – generated from combustion of wood residues and sludges and can include solids from air pollution control systems.
- Municipal solid waste – generated from non-production processes such as offices, kitchens and building materials from construction and workshops activities.
- Hazardous waste – pulp mills generate an assortment of hazardous wastes in very small quantities, including oily rags, waste from spillage containment of chemicals and fuel, and used containers, among others.

IPPC-BAT (2001) recommends the following with regards to solids management:

1. Minimization of the generation of solid waste and recovery, recycle and reuse of these materials as much as possible
2. Separation of collection of waste fractions at source and, if necessary, intermediate storage of residuals/waste to make possible an appropriate handling of remaining waste products
3. Incineration of all non-hazardous organic material (bark, wood waste, effluent sludge, etc.) in an auxiliary boiler, especially designed for burning moist, low calorific value fuels (e.g. fluidised bed boilers)
4. External utilization of residuals/waste as substitutes in forestry, agriculture or other industries, if possible

IPPC-BAT (2001) also gives an indication in Table A10.1-1 of the amounts of residuals that might be expected at kraft pulp mills that apply BAT and notes that there is little detailed and reliable information available on achievable amounts of solid wastes in Europe. Also, there is a lack of statistical data and various terms for different waste fractions are used in Europe. Some countries report only the solid waste - primarily inorganic solid wastes - which no longer can be recycled or reused, but have to be disposed off to landfill. This implies that all the organic wastes which have a reasonable heating value and/or which can be incinerated without the risk of hazardous emissions in the auxiliary boiler of a mill are already excluded from the given solid waste amounts (bark and wood waste, primary and biosludge from wastewater treatment). Hence, the solid waste disposed of at landfill comprises mainly boiler ashes, causticizing dregs, lime mud, green liquor sludge, some wood and bark waste rejects and miscellaneous cleaning and mixed household-type wastes. It is therefore difficult to present achievable values on the amount of non-hazardous solid waste. The waste amounts presented in the following table are given as bone dry kilos per tonne of final product (100% DS).

Table A10.1-1: Example of the Amount of Solid Waste for Landfilling That Can Be Expected from a BAT Kraft Pulp Mill [adapted from IPPC-BAT (2001)]

Type of waste	Amount (kgDS/ADt)	Total (kgDS/ADt)
Lime mud	9,7	43
Green liquor dregs	8,1	
Bio- and primary sludges	8,7	
Rejects from woodhandling	2,1	
Wood ashes	3,9	
Other	10,5	

With regards to hazardous waste generated in all kraft pulp and paper mills, IPPC-BAT (2001) notes that the quantities generated at kraft mills normally amount to about 0,05 to 0,1 kg/t of product.

The Tasmanian-AMT (2004) guidelines also indicate that because of the lack of reliable data, it is difficult to suggest achievable levels on the amounts of non-hazardous waste generated at a bleached eucalyptus kraft pulp mill. The report refers to the IPPC-BAT (2001) example shown in Table A10.1-1 and lists the following additional AMT guidelines for the reduction and handling of solid waste:

- Biosludge may be burned in the recovery boiler
- Transport and disposal of controlled wastes must be undertaken only by persons authorised to do so under the law
- Any landfill sites used by the mill operator for disposal of solid wastes that are water soluble should be chosen and managed in agreement with relevant State agencies. They should include, as a minimum, cut-off drains, leachate collection drains and storage and subterranean collectors capable of accommodating run off from the site of a volume equal to a 10-year recurrence interval storm, and from areas surrounding the site of a volume equal to a 50-year recurrence interval storm. Sufficient groundwater monitoring wells per site to satisfy the regulatory authorities that adequate monitoring and reporting of leachate, if identified, will be possible should also be included.
- Material that cannot be reused, recovered or has to be handled differently should be taken to a landfill that is approved to receive the type of waste to be disposed of. Only inert, primarily inorganic waste should be landfilled. Organic waste should not be landfilled
- Sections of the landfill that have been completely filled should be covered and sealed according to appropriate procedures
- Generation of dioxins and furans can occur in the convection back passes (the cooler sections) of power and recovery boilers. Depending on concentrations, dusts from these sections should be managed in the same way as other controlled wastes and not be landspread
- Efficient washing of green liquor dregs prior to disposal to landfill, to minimise leaching of caustic
- Efficient washing of lime mud prior to reuse in the lime kiln to minimise the formation of hydrogen sulphide (H_2S) during the mud drying process
- Liquid wastes are not permitted to be disposed of at a landfill

A10.2 Proposed Mills Solid Waste Estimates to Landfill

In this section, a comparison will be performed between the mill proponents' solid waste estimates to the landfill area and the cited example by IPPC-BAT (2001) in table A10.1-1. Table A10.2-1 summarizes that comparison as well as the quantity of hazardous waste to be disposed of by each proposed mill.

Table A10.2-1: Comparison of Solid Waste to be Landfilled from Each Mill Proponent with the Amounts Given in the IPPC-BAT (2001) Example

Waste	Quantity (kgDS/ADt)[1]		
	IPPC-BAT (2001) example	Botnia-Orion estimate	ENCE-CMB estimate
Lime mud	9,7	2,8	1,4
Green liquor dregs	8,1	18	7,0
Grits	-	5,1	0,9
Primary and biosludge	8,7	0	0
Rejects from wood handling	2,1	0	0
Wood ashes	3,9	-	-
Biomass boiler sand and ashes	-	-	12,6
Other	10,5	-	-
Total landfilled waste	*43,0*	*29,5*	*21,9*
Total hazardous waste	0,05 – 0,10	0,10 – 0,15	<0,10[2]

It can be seen from Table A10.2-1 that, as previously mentioned in the IPPC-BAT (2001) document, it is difficult to compare the mill estimates in terms of solid residuals with the quantities assembled by the IPPC, primarily because of the various terms and sources for solid waste. For example, for green liquor dregs, grits and lime mud, these wastes are often mixed and it is very difficult to give separate figures for each one. In terms of lime mud and total landfilled waste, both Botnia-Orion and ENCE-CMB estimates fall within the proposed quantities by the IPPC-BAT (2001) and the Tasmanian-AMT (2004) documents. While Botnia-Orion's estimates for the quantity of lime mud to be landfilled is far below the IPPC-BAT (2001) example's, the quantity of green liquor dregs is substantially higher. With modern dregs removal devices, lime mud is often discharged through the dregs system to enable efficient dregs removal: this likely accounts for these differences. Botnia-Orion is considering the future possibility to take the dregs from the recausticizing plant back to the forest plantations. This would reduce the estimated quantity of dregs to landfill to a level below the IPPC value given in Table A10.2-1 and could normally be permissible if dregs washing is sufficient to reduce the alkalinity to non-hazardous levels. On the other hand, all of ENCE-CMB's estimates fall below the values showed in this example.

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[1] Assuming a pulp production of 1 000 000 ADt/y for Botnia-Orion and 500 000 ADt/y for ENCE-CMB.

[2] This value is a long term average.

The quantities of total hazardous waste should be re-examined by Botnia-Orion as their estimates for that type of waste are marginally acceptable. It is to be noted that another example in the IPPC-BAT (2001) document reports an acceptable average value of hazardous waste of 0,2 kg/ADt taken from the Finnish BAT report published in 1996. This value takes into account the production of bleached and unbleached kraft pulp in Finland at both integrated and non-integrated mills and thus shows once again that it is difficult to compare solid waste quantities.

Both companies have thoroughly looked at a hazardous waste management plan and this type of waste should be handed over to environmentally sound disposal operations.

An additional comparison exercise was performed to benchmark the mills' estimates of landfilled solid waste with the help of the 2006 Ekono Report on Environmental Performance, Regulations and Technologies in the Pulp and Paper Industry.
Figure A10.2-1 is used to benchmark Botnia-Orion (in red) and ENCE-CMB (in orange) against North American and European bleached kraft mills. In this figure, total solid waste refers to the heterogeneous group of waste materials produced at the kraft pulp mills, which cannot be or are not sold, reused or incinerated and typically includes materials such as wood residues, ashes, dregs and grits, paper and board, effluent treatment sludges, as well as a group of miscellaneous wastes (construction materials, soils, metals). This figure compares all wastes landfilled expressed as 100% dry material. It can be shown that both mills would perform relatively well at these estimated levels as compared with most North American mills and about 50% of non-Finnish kraft pulp mills in Europe.

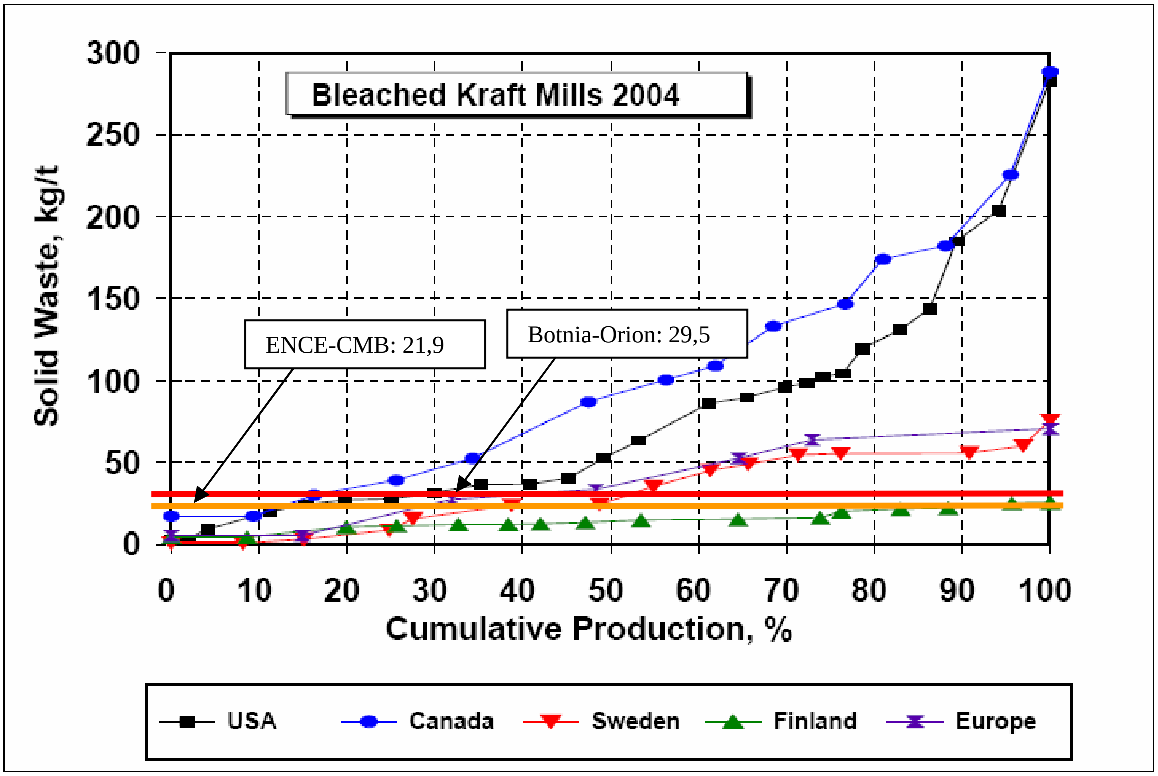

Figure A10.2-1: **Average Solid Waste Discharge to Landfill from Bleached Kraft Pulp Mills in 2004 Compared with Botnia-Orion's and ENCE-CMB's Estimates**

A10.3 Methods for the Management of Residuals

A10.3.1 Management of Residuals at the Botnia-Orion Pulp Mill

Table A10.3.1-1 summarizes the management and disposal methods to be used for each solid waste category at the Botnia-Orion mill.

Table A10.3-1: Management of and Disposal Methods for Solid Residuals at the Botnia-Orion Mill

Waste	Management – disposal
Non-hazardous solid waste	
Domestic/household waste	Sent to the municipal landfill
Primary sludge	One option could be to sell it to ENCE-CMB, to a local biofuel plant or to the Mercedes tissue and board mill. Other options include mixing with bark and wood residues and applying as fertilizer in the plantations or composting
Biological sludge	Mixed with the weak black liquor tank and then burned in the recovery boiler
Green liquor dregs	Sent to the on-site industrial landfill or recycled in the future
Grits	Sent to the on-site industrial landfill or recycled in the future
Lime mud	Sent to the on-site industrial landfill or recycled in the future
Water treatment sludge	Sent to the on-site industrial landfill or recycled in the future
Wood yard, bark, ashes	Sent back to the plantations and applied as fertilizer in the plantations or composted
Rejects from sand traps	Sent back to the plantations and applied as fertilizer in the plantations or composted
Hazardous solid waste	Off-site disposal facility per approved plan

From this table, it can be clearly shown that Botnia-Orion committed to maximizing the recovery, recycle and reuse of its generated solid waste materials. At the Botnia-Orion facility, all non-hazardous organic waste will be used externally as substitutes in the company's plantations or for other industrial facilities except for secondary sludge which will be burned in the recovery boiler. Only inert, primarily inorganic waste will be landfilled while no liquid waste will be landfilled.

From discussions with the mills proponent, some innovative solids and sludge management strategies will also be studied such as the possibility to take the dregs from the recausticizing plant back to the forest plantations. Dregs contain many of the micronutrients originating from wood which could be beneficial to the plantations if returned to the soil. A number of mills sell dregs for agricultural use, either on its own, or mixed with bark, where it helps to provide a pH-balanced product (Tasmanian-AMT (2004)). Tests will be done before this can be implemented as well as for the return of primary sludge to the plantations, as sodium can be of concern.

The final disposal unit at Botnia-Orion's facility has a surface area of 110 000 m^2 and has a useful volume of 930 000 m^3. The mill proponent has designed for a landfill which has an effective use of 20 years on site. Only part of the landfill to be built was designed for two reasons: first, from a landscape point of view, only one part of the landfill should be open. It was not considered reasonable to collect rainwater from the total projected area of the future landfill area; second, it is planned to increase the recycling of waste and not to continue for the next 40 years to generate the current estimates for solid waste. In Botnia-Orion's case, this means, as mentioned above, that most of the inorganic waste (i.e. dregs) will be returned to the plantations following the first years of operation. This development could allow the effective landfill lifespan to match the life of plant of 40 years.

The guidelines that were used to design the landfill were drawn from the Technical Proposal on Regulations for the Management of Industrial and Agro-industrial Wastes and Services elaborated by the Uruguayan Environmental Protection Technical Evaluation Commission (COTAMA) in 2003. These guidelines include the installation of a waterproof base, a collection and treatment system for leachates, a collection system for gases and a daily operation and landfill cover plan. Directive 1999/31/CE that regulates the location and the construction of sanitary industrial landfills within the European Union as well as the IFC Environmental, Health and Safety Guidelines for Waste Management Facilities were also considered.

The dimensions of the waste disposal unit were determined according to design criteria for non-hazardous waste landfills established by the European Union, taking into account the types of wastes and any particular characteristics of the selected land:

- the base should be waterproof according to EU criteria and adapted to local conditions;
- the final cover should minimize inlet of rainwater;
- the landfill surface area should be minimized;
- the geometry should provide for easy operation and minimize the possible generation of leachates;
- the leachates should be evacuated by gravity; and
- affectations to the land's natural topography should be minimized.

The final disposal unit will consist of three chambers each to be filled in three stages or cells, separated by 1 m high berms. The berms will be used as a physical barrier for the retention of rainwater that drains upstream of the operation area before it is pumped to the peripheral rain canals. Leachate is collected from the landfill by a network of transversal drains and a central perforated pipe which conducts the leachate to the collection system. It will then be pumped to the effluent treatment plant. The final cover project will consist of a 30 cm layer of compacted waste (dregs with $K < 1x10^{-7}$ cm/s), a 15 cm mineral layer of compacted inert material from the site, 30 cm drainage and finally a 1 m layer of topsoil.

When looking at the general guidelines by IPPC-BAT (2001) and Tasmanian-AMT (2004) for management of residuals, the CIS project team concludes that Botnia-Orion will implement all of the recommended practices including innovative solids and sludge management strategies, for external utilization of residuals/waste as substitutes in forestry including returning the green liquor dregs to the plantations and composting.

A10.3.2 Management of Residuals at the ENCE-CMB Pulp Mill

Table A10.3-2 summarizes the management and disposal methods to be used for each solid waste category at the ENCE-CMB mill. It is important to underline the following to

Table A10.3-2: Management of and Disposal Methods for Solid Residuals at the ENCE-CMB Mill

Waste	Management – disposal
Non-hazardous solid waste	
Domestic/household waste	Sent to the municipal landfill
Primary sludge	Burned in the boiling fluidised bed biomass boiler
Biological sludge	Mixed with the intermediate black liquor, and then burned in the recovery boiler
Green liquor dregs	Sent to the on-site industrial landfill
Grits	Sent to the on-site industrial landfill
Lime mud	Sent to the on-site industrial landfill
Water treatment sludge	Burned in the boiling fluidized bed biomass boiler or composted
Boiler sand/ash	Sent to the on-site industrial landfill
Wood waste and bark from wood preparation	Burned in the boiling fluidized bed biomass boiler
Bark waste, sand and stones from woodhandling	Sent to the on-site industrial landfill
Rejects from fiberline	Will normally be sewered, but in the event of disturbances, it may need to be sent to the industrial landfill on site
Other	All waste not recycled or taken care of in other ways will be sent to the on-site industrial landfill
Hazardous solid waste	Will be recovered by an off-site approved third party

From this table, it can be seen that ENCE-CMB is committed to maximizing the recovery, recycle and reuse of its generated solid waste materials. At the ENCE-CMB facility, all non-hazardous organic waste will be incinerated in a state-of-the-art boiling fluidised bed (BFB) biomass boiler, except for secondary sludge which will be burned in the recovery boiler. Only inert, primarily inorganic waste will be landfilled while no liquid waste will be landfilled.

ENCE-CMB will also be looking at innovative solids and sludge management strategies to focus on the minimization of the generation of solid waste and their reuse. For example, part of the waste may be separated and could be valorized and used as fertilizer or as compost in blends with other organic material. This would further reduce landfill. ENCE has studied and had successful experiences in Spanish mills with sending back composted waste to forest plantations and it will be considered at ENCE-CMB.

The final disposal unit at ENCE-CMB's facility has a surface area of 42 000 m^2 and has a useful volume of 222 000 m^3. The mill proponent has designed for a landfill which has an effective use of 30 years on site, with the progressive construction of 8 cells of approximately 12 000 m^2 each. The arrangement of cells is shown in Figure A10.3.2-1. If additional landfill capacity is needed in the future to expand its life span, an area equivalent to four cells is reserved for that purpose. This could expand the life span to 40 years.

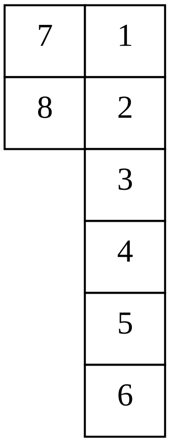

Figure A10.3-1: ENCE-CMB's Arrangement of Landfill Cells

The guidelines that were used to design the landfill were drawn from the Technical Proposal on Regulations for the Management of Industrial and Agro-industrial Wastes and Services elaborated by COTAMA. As mentioned above, these guidelines include the installation of a waterproof base, a collection and treatment system for leachates, a collection system for gases and a daily operation and landfill cover plan.

The drainage system will consist of one main and three secondary drainage channels in each cell. The outfall will carry the leachate by gravity to the emergency basin before entering the effluent treatment plant. Again the residuals to be landfilled are considered to be practically inert from a biological point of view and so a gas collection system has not been included. Four vents in each cell will be built even though the gases will not be collected and treated.

When looking at the general guidelines by IPPC-BAT (2001) and Tasmanian-AMT (2004) for management of residuals, ENCE-CMB will implement all of the recommended practices including innovative solids and sludge management strategies such as incineration of all non-hazardous organic waste and composting.

A11.0 COMPLIANCE MONITORING REQUIREMENTS

A monitoring and recording system is an essential element of BAT. An internal monitoring and control system of process parameters is necessary for good operation, management and performance as well as compliance with safety requirements. Additional monitoring and recording requirements are necessary for the compliance assessment with respect to the permit requirements, usually recorded in the environmental management system or EMS.

The IPPC-BREF document on Best Available Techniques in the Pulp and Paper Industry does not specifically refer to monitoring of emissions. IPPC has produced a separate document entitled “Reference Document on the General Principles of Monitoring” published in 2003 stating the following[1]:

- The responsibility for monitoring is generally divided between the competent authorities and the operators, although competent authorities usually rely to a large extent on “self monitoring” by the operator, and/or third party contractors. It is highly important that monitoring responsibilities are clearly assigned to all relevant parties (operators, authorities, third party contractors) so that they are all aware of how the work is divided and what their own duties and responsibilities are. It is also essential that all parties have appropriate quality requirements in place

- In principle, it is more straightforward, but not necessarily more accurate, to use a method involving direct measurements (specific quantitative determination of the emitted compounds at the source); however, in cases where this method is complex, costly and/or impractical other methods should be assessed to find the best option. Whenever direct measurements are not used the relationship between the method used and the parameter of interest should be demonstrated and well documented. The use of surrogate parameters or inferential measurements may be used as an alternative to direct measurements, may they be continuous or discontinuous. Advantages of using surrogate parameters include greater cost-effectiveness, reduced complexity, and continuous number of data. However, it may also lead to several disadvantages, including the need for calibration against direct measurements

In this section, end-of-stack compliance monitoring of emissions to the atmosphere and end-of-pipe compliance monitoring of emissions to the effluent are discussed. Monitoring of the receiving environments and reporting data to the community are discussed elsewhere in the CIS.

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[1] Reference Document on the General Principles of Monitoring, July 2003, European IPPC Bureau, Institute for Prospective Technology Studies, Seville, Spain, http://eippcb.jrc.es

A11.1 Compliance Monitoring Requirements for the Mill Proponents

DINAMA issued in August 2006 a preliminary compliance monitoring plan for the pulp mills in Fray Bentos. In this document, it is highlighted that there are three levels of monitoring:

1. Monitoring to be undertaken by the pulp mills for process control and environmental performance purposes, and which agrees with the Monitoring and Follow-up Plan to be presented to and approved by DINAMA,

2. Monitoring that can be undertaken by the follow-up commissions established in the respective Initial Environmental Authorizations (AAP),

3. Monitoring to be undertaken by the State of Uruguay through DINAMA with the objectives of industrial control and evaluation of the environmental quality. It is at this level that DINAMA defines the parameters to be monitored, the sampling stations, the frequency of sampling, operators and the analytic techniques and procedures.

The above-referenced preliminary plan was designed with industrial control and thus, follow-up activities, as overseen by DINAMA, comprise two different areas: the quantification of the parameters that characterize industrial emissions and environmental and ecosystemic quality (monitoring); and the audit of Management Plan implementation.

In 2004, the Argentinean and Uruguayan delegations to the Rio Uruguay Administrative Commission (CARU) adopted a joint monitoring plan of the impacts from the pulp mills to be carried out jointly by Argentina and Uruguay. This plan was initiated in November 2004 and continued until late 2005. CARU's intentions were to continue the monitoring plan for three years; however, it was unfortunately discontinued.

The Environmental Impact Assessments (EIA) submitted with the AAPs by each pulp mill contains a monitoring plan for environmental media in the impacted area. Additional monitoring requirements will be included in specific authorizations issued by the Ministry of Housing, Land Use Planning, and Environment (MVOTMA). A central part of the approval for both the AAPs and the Environmental Management Plan (PGA) for the Botnia and ENCE plants is the requirement of comprehensive monitoring of environmental impacts in different environmental media, including in the Rio Uruguay. Both companies are required to engage in extensive monitoring prior to operations of the plants – i.e. during the construction period – to establish a baseline condition of the Rio Uruguay. For instance, the Botnia AAP requires a full year of monitoring data before operations can begin. This monitoring plan should include superficial water (including sediments, fish and benthic fauna), air, soil and groundwater, terrestrial biota, noise and social aspects. Note that Botnia-Orion and ENCE-CMB have had operating meteorology stations since May 2006 and March 2005, respectively. Botnia-Orion also has an ambient air station operating since June 2006.

Extensive monitoring of discharges to the Rio Uruguay will be required when the plants become operational. The AAPs of both Botnia and ENCE set forth parameters with which their monitoring plans must comply. Further, through the PGA approval process and the Environmental Authorization to Operate (AAO) approval and renewal process, DINAMA has indicated that the monitoring requirements may be modified. Indeed, pursuant to the AAO procedure, DINAMA will review each plant's monitoring plans every three years and if necessary, will require additional monitoring to ensure the avoidance of negative environmental impacts. The monitoring data collected for the construction and operation PGAs will be submitted to and evaluated by DINAMA. If unacceptable impacts are observed, DINAMA will take appropriate action.

Neither of the two mill proponents has yet submitted their compliance monitoring program to be approved before being awarded the remaining PGAs and AAOs, even though they have produced preliminary versions of these plans and engaged in discussions with DINAMA to that respect. These preliminary plans for end-of-pipe and end-of-stack monitoring include parameters to be monitored, frequency and point of measurement and primary responsible. In the case of both mills, the design process of continuous monitoring will be based on the actual practice in European mills, with the addition of DINAMA's requirements.

While the process is still underway to determine the monitoring and reporting program at the mills, it appears that DINAMA is taking a systematic and thorough approach to addressing this important aspect in order to address technical pulp and paper sector issues. The Botnia-Orion and ENCE-CMB mills are actively pursuing the requirements set-out by DINAMA, in a cooperative manner.

The requirements for compliance monitoring are critical to ensure that the mill is well operated at all times. Establishing the compliance monitoring requirements is not a trivial task and is one that DINAMA and the two proposed mills are addressing incrementally and carefully. In particular, because of the 4h maxima requirements for effluent that DINAMA must enforce under Uruguayan law, these monitoring requirements are made even more complex. The compliance monitoring strategy must also be considered when establishing the reporting strategy which is dealt with elsewhere in the CIS. The permit requirements are not established at the time of this CIS writing and thus the compliance monitoring requirements cannot be explicitly stated. However, there are certain important principles that should be considered in establishing these compliance monitoring requirements:

1. DINAMA has indicated that they will establish loading-based requirements in addition to concentration-based requirements, which is less than ideal. Concentration-based requirements, while required by Decree 253/79, restrict the mills' ability to decrease flow and achieve energy efficiency, especially with regards to effluent contaminants such as metals. This should be recognized in the AAOs. The loading-based requirements should be considered the most pertinent and should include a more conventional time-averaging requirement, e.g. 24 hours.

2. Because DINAMA is responsible for requiring 4h maximum concentration values, continuous monitoring techniques should be used wherever possible for the effluent, including inferential techniques.

3. The variability in mill effluent discharge that needs to be accounted for between long term average discharge and various time maxima, e.g. 4h, daily or monthly maxima, is particular to every mill and depends on a number of complex factors. The variability that is considered in setting the loading-based permit requirements should consider mill proponent expertise and should be evaluated based on actual effluent data once production has stabilised.

4. Effluent flow limits should not be specified in permits and likewise, flow reduction targets should not be explicit in the Authorizations for Industrial Wastewater Discharge (ADI) and AAOs. Flow reduction is unlikely to result in measurable reduced environmental impacts, and it is essential that the mills have flexibility to target productivity factors such as production increase, energy efficiency, etc. without limitations from unduly low water usage requirements.

5. Air limit requirements should be specified on a source basis and not on a stack basis, e.g. for the recovery boiler, lime kiln, etc. in order that the data can be used to verify BAT.

6. DINAMA should not set specific in-process requirements unless the operating mills are proven to be out of compliance or to have an impact and that this can be clearly attributed to suboptimal in-process practices.

7. An allowance should be attributed in the permits during start-up and shutdown of certain major equipment items, e.g. boilers, and during an initial operating period for the mills.

8. DINAMA will include a requirement for AAO renewal every three years. It is recommended that in addition to this a re-permitting exercise be required should a production increase threshold be surpassed.

A12.0 DUE DILIGENCE PLANS

This section summarizes the key non-technology issues or due diligence plans related to BAT to be implemented at the proposed pulp mills and compares them with the general measures for best practice environmental management proposed by the IPPC and the Australian Government's Resource Planning and Development Commission (RDPC) report on recommended environmental emission limit guidelines for any new bleached eucalypt kraft pulp mill in Tasmania.

The implementation of the best available process and abatement technologies can lead to the reduction of emissions as well as to the improvement of economic performance at kraft pulp facilities, but it should be combined with the following general measures to achieve these goals in the most effective manner:

- *Training, education and motivation of staff and operators*. Pulp and paper mills are operated by people. Over time, training of staff can be a very cost-effective way of reducing discharges of harmful substances.
- *Process control optimization*. To be able to reduce different pollutants simultaneously and to maintain low emissions, improved process control is required
- To maintain the efficiency of the technical units of pulp mills and the associated abatement techniques at a high level, *sufficient maintenance* has to be ensured
- *Environmental management system* (EMS) which clearly defines the responsibilities for environmentally relevant aspects in a mill. It raises awareness and includes goals and measures, process and job instructions, check lists and other relevant documentation

A12.1 Training, Education and Motivation of Staff and Operators

Adequate training is a cost-effective way of ensuring optimum environmental performance at a pulp mill. Well-trained employees are also well motivated and their contribution to the success and environmental performance of the company is most likely to be improved. This section will treat the respective mills' staff training, education and motivation procedures.

A12.1.1 Training, Education and Motivation of Staff and Operators at the Botnia-Orion Facility

The project group for the Botnia-Orion pulp mill is composed of Finnish personnel along with key personnel from Uruguay. Key Finnish personnel at the managerial level are expatriated to Uruguay for a minimum of 1 to 3 years while Finnish internal trainers, start-up support staff and erection supervisors will be in Uruguay from 3 to 6 months. Key Uruguayan personnel at the managerial level or engineers are sent to Finland for technical training for 3 months up to 2 years depending on the required skills attached to the position, including practical training at existing Botnia mills. This process is still ongoing and these key personnel members, e.g. supervisors, will acquire good knowledge of pulp processes and the required skills to participate in the recruiting process as well as in the organization of on-site training. Their experience will also be used during the mill start-up.

Botnia-Orion’s technical operating personnel predominantly come from Uruguay and follow a training plan that is similar to Botnia’s Rauma mill in Finland, because of the similarities existing between the two mills: in both cases, most of the personnel hired did not initially have the skills or the experience in pulp making. Botnia's internal trainers and external partners first teach the basics in pulp and papermaking as well as Botnia's working philosophy. Each department then receives more in-depth training from the equipment suppliers who will also return during start-up and operation and will be joined by Botnia and UPM senior operating staff. The latter will assist the departments from erection through to fine-tuning of operations.

The operators are trained with the help of a mill-wide simulator and will go to other similar mills in South America to complete their training. The dynamic process simulator was developed by IDEAS Simulation Inc. and Andritz Oy Pulp Mill Operation, and covers process models of the pulp mill main process except for woodhandling. The simulator enhances the learning process by actively involving the operators and providing immediate feedback without any risk to production. Using the simulator, the operators will be able to learn about the process at their own pace and at any time. Not only can the simulator help Botnia operators gain familiarity with the control system, but it could eventually train other operators and new employees without the need of a specialized training company. Botnia operators will train on the same interface that will be used at the actual pulp mill. Operators can also train for start-up and shutdown of the processes before the actual mill start-up or shutdown, particularly for the NCG system. Finally, training time can significantly be reduced with the use of simulator. Similar simulation systems have been used successfully at the Aracruz C-Line and Veracel mills in Brazil.

Maintenance personnel are trained independently according to the Andritz training plan which sets up specific training programs (see Section A12.3.1 for more details on maintenance).

A12.1.2 Training, Education and Motivation of Staff and Operators at the ENCE-CMB Facility

At ENCE-CMB’s facility, key technical personnel will predominantly come from Uruguay’s engineering faculties. The program which has been already been prepared includes after induction, a 2 year training period in Spanish mills for key positions (supervisors, shift supervisors, technicians, etc.) as well as a twelve to eighteen month training program in the same mills for the key operators.

Shift supervisors receive basic training and then travel to Spain where they participate in a 2 year on-the-job training program that alternates between each of ENCE's mills. The rest of the engineers hired for key technical positions will go through an incremental training program that starts with theoretical background on pulp making processes [with the Pulp and Paper Technology Centre of the National Industrial Learning Service (SENAI) in Porto Alegre, Brazil and with the Industrial Engineering School of Terrassa within the Universidad Politécnica de Cataluña]. Finally, meetings were held with the Employment Secretaries of the Andalucía and Galicia Assemblies in Spain to explore the possibility of sending pulp technology instructors to Uruguay for the training of engineers. This theoretical program is estimated to take 5 months.

After having had their level of competency evaluated, the group of engineers will spend a 6 months theoretical and practical training period working in ENCE's facilities in Spain, focusing on the area that they were hired to work in. Upon their return from Spain, they will further be trained to participate in the development of courses for the theoretical training of laboratory technicians for a period of 5 months in Uruguay. The latter will then move on to practical training for 6 months in Spain. The same general process will be followed by the field operators, namely a 5 months theoretical program followed by practical training for a month in Spanish, Brazilian or Chilean mills.

ENCE-CMB has also made a sizeable investment in acquiring a state-of-the-art plant simulator which will not only be used in basic operation training, but also permit refresher courses as well as cross-section apprenticeship at all levels.

Maintenance personnel will also follow courses designed by the Uruguayan engineers on the pulping processes and more specifically on equipment and maintenance techniques, for a period of 6 months. They will also participate in practical training activities in mills in Spain, Brazil and Chile.

Motivation, another key factor in maintaining a successfully operational mill, is assured by an adequate induction program, which aims at obtaining from the staff and personnel a strong identification with corporate values. Continuous education, an adequate remunerative policy with benefits and a bonus or an incentive system rewarding productivity coupled with quality (which includes emission control) round off a very comprehensive motivational formula. The general features of these systems, with the exception of the mill simulator, are in place in ENCE's mills in Spain and have proven to be successful.

Uruguay has recognised engineering expertise in its University system. Botnia-Orion and ENCE-CMB will represent the most modern and largest industrial facilities in Uruguay, and are expected to be employers of choice for top Uruguayan professionals and technicians.

A12.2 Process Control Optimization

Adequate process control is key to minimizing process variability, which in turn translates into significant environmental benefits. This section will discuss the respective mills' process control optimization strategies and give examples of some key control issues to be considered at the facilities.

A12.2.1 Process Control Optimization at the Botnia-Orion Facility

Advanced process control applications for quality and production shall be implemented at the Botnia-Orion pulp mill to reach high and stable quality, and to decrease the environmental impacts and maximize savings on raw materials. The following are a few examples of some of the advanced control strategies to be addressed at the Botnia-Orion pulp mill:

- The lime kiln was designed to be able to optimize the burning conditions at the firing end:
  - Control of fuels: the lime kiln uses three different fuel compounds (crude oil as main fuel with hydrogen and methanol). The control program calculates the fuel composition at all times so that the amount of energy and temperature at the burning zone is kept as stable as possible. The investment to use hydrogen from the chemical plant is to minimize emissions from oil burning. Hydrogen is a by-product from the chemical plant and methanol is separated from liquor in the evaporation system
  - The air controls are also engineered to keep the burning zone stable and the kiln in safe conditions with the controls of oxygen and CO levels
  - The burner and kiln design are state-of-the-art
  - The processes at the pulp mill have been designed to operate at moderately low sulphidity levels and with very good washing capacity/efficiency using state-of-the-art lime mud disc filter technology and a water optimization system, to minimize the SO_2 emissions

- Recovery boiler upper level control system:
  - Firing air to the recovery boiler furnace is controlled by control curves. The system calculates the needed amount of air based on fuel flows. Computer-based fine tuning is done by using emission measurements, especially oxygen measurements
  - The recovery boiler has six separate air levels, which allow for the minimization of NO_x emissions
  - Because the firing liquor dry solids content is over 75%, SO_2 emissions are minimal. Dry solids are measured by on-line refractometres
  - The recovery boiler includes all standard general and emergency controls

- Digester
    - In the digester area, on-line analyzers are used to provide consistent brownstock pulp quality. On-line kappa analyzers are used for the brownstock area while alkali analyzers are used for the digester area.
    - The on-line measured temperatures, kappa number values, white liquor strength to cooking, black liquor residual alkali strengths and digester level measurements give feedback to control for even kappa number and delignification rate in order to produce high quality pulp out of the digester. This further ensures a low consumption of chemicals in the oxygen delignification and bleaching processes
- Bleaching
    - In the bleaching area, combined kappa and brightness analyzers are used to control the bleaching chemical dosage in order to secure high end-product quality and optimum bleach chemical use. This further ensures minimal discharges from the bleaching process to the effluent

A dynamic process simulator will be used to assist in the Distributed Control System (DCS) staging (or verification of control programs) and operator training at the Botnia-Orion facility (see Section A12.1.1). The process simulator covers process models of the pulp mill main processes and provides feedback to the DCS. The DCS controls will be tested in a "Virtual Mill" simulation environment to minimize errors during the mill start-up. Once the controls are corrected and verified, the dynamic process model will be used for operator training. During the mill operation phase, the process simulator shall be used for testing the process changes as well as a process development tool.

The implementation of control logic is a difficult task since the performance of the pulp mill is not only dependent on mechanical and electrical components, but also on the control logic and the design concept used to control these components. A process simulator system will allow Botnia-Orion to be involved in the control system staging process. Using dynamic process models, Botnia-Orion can test control strategies for interactions prior to implementation within the DCS system, thereby reducing the risk of having to troubleshoot the logic in the field during start-up. DCS verification will reduce costly logic design errors that normally would delay the start-up. If the DCS logic cannot start the simulation, it will not be able to start the real equipment.

One example of the dynamic models included in the mill-wide simulation system is the model developed for the Non Condensable Gases (NCG) system. Because the NCG combustion and collection systems cover several process areas, it creates a substantial challenge from an operations point of view. With the NCG system simulator, operators can check and verify the smooth operation of the entire NCG collection system which comprises the concentrated odorous gas boiler and scrubbers, the diluted odorous gases boiler and the NCG collection system. The simulator will also be used for fine-tuning of the NCG combustion process.

A12.2.2 Process Control Optimization at the ENCE-CMB Facility

Good process control is vital in assuring process efficiency as well as minimizing process variability. A well run process with low variability also allows for adequate control of environmental parameters. ENCE-CMB has chosen the well proven Distributed Control System (DCS) for process control and has given specific attention to design in critical areas such as the bleach plant, the evaporator plant and the recovery boiler.

ENCE-CMB will also use a dynamic simulator to assist DCS staging and operator training. The simulator will ensure that process operators are capable of operating the mill according to environmental requirements. Simulator process models will provide feedback to the DCS so that the process logic can be tested, resulting in fewer errors during start-up. Once the DCS logic is corrected and verified, the simulator will be use for training.

A12.3 Maintenance

This section underlines the maintenance activities and strategies to be implemented at the proposed pulp mills.

A12.3.1 Maintenance at the Botnia-Orion Facility

Botnia has chosen to outsource maintenance at the Orion pulp mill to the equipment supplier Andritz who specializes in this area. The main tasks are to keep the mill's equipment in good condition, to meet equipment performance targets and to follow and execute the asset management plan agreed to with mill management.

Maintenance tasks and activities will vary during the different phases of the greenfield mill project, namely the project implementation phase, the start-up and warranty phase and the operational phase.

In the project implementation phase, Andritz will set up specific training programs and assign some of the maintenance staff to the erection site area teams, in order to train the key resources in maintenance. This staff will be transferred to the final maintenance organization later during the commissioning of respective areas.

During the commissioning and start-up as well as during the first year of operation, the fixed mill maintenance staff will be supported by Andritz process machinery experts. During the warranty period, Andritz will provide all maintenance services needed for the normal operation of the mill, to bring the plant to nominal performance and to eliminate possible weak points or malfunctions. The measurement, calculation and reporting of Key Performance Indicators (KPIs) will be implemented during the warranty phase.

During the operational phase, Botnia-Orion and Andritz will work together to reach the mill's targeted production level and maintenance costs. After the mill is running at the planned production, maintenance will be performed by the fixed maintenance staff with an additional 2 year support period by an Andritz team for maintenance outside normal working hours. After this period of time, the need for this team will be reviewed.

A12.3.2 Maintenance at the ENCE-CMB Facility

ENCE's commitment to efficiently run mills with a stringent emission tolerance policy has produced excellent results in Huelva, where the mill incidents and complaints are at an all time low and compare favourably to other pulp mills in Europe. A basic pillar to uphold this effort is the maintenance policy applied at that mill and common to all ENCE mills. Adequate preventive and predictive maintenance programs, as those in force in all company mills, ensure a minimum of unwarranted shutdowns (thus reducing emission values) and an efficient yearly mill shutdown.

At the ENCE-CMB facility, maintenance procedures and programs will be developed based on existing company documentation and equipment supplier's recommendations. All maintenance personnel will be trained by equipment suppliers in both predictive and preventive maintenance, as well as during the start-up period. Equipment and engineering suppliers will participate in the development of maintenance procedures as well as in their implementation. Finally, during the annual maintenance period, estimated to last a maximum of ten days, additional specialized personnel and suppliers will be subcontracted.

A12.4 Environmental Management System

Pulp mills need a formalized structure to deal with environmental issues, namely the Environmental Management System (EMS). This EMS contains details on the means used by a company to achieve its objectives relative to the environmental aspects of its operations, products and services as well as on how the company may monitor the achievement of these objectives.

Besides concurring with the IPPC on the main EMS role of raising awareness of issues, the RPDC guidelines further suggest the following general points to be part of an EMS:

- The EMS needs to be independently audited to an international standard and to include environmental monitoring and a response mechanism
- The reporting framework of the EMS needs to be open and transparent
- Community consultation is recommended to ensure interested communities are informed and involved in any new kraft mill development and its impact on them
- Development of an incident/emergency response plan to ensure appropriate response measures in relation to non-compliance events

While both mill proponents have not yet fully designed their EMS, this section will introduce some general features that will be included in their respective systems such as procedures for internal and external communications, standard operating procedures (SOPs) and emergency preparedness procedures.

A12.4.1 Environmental Management System at the Botnia-Orion Facility

The target of the Botnia-Orion environmental management plan is to be aware of the important emissions from an environmental point of view, of the emission sources and impacts on the environment, and of the techniques to mitigate these emissions. The management plan defines the action plan, means and schedule to achieve the targets based on the environmental goals. It also produces data on both the process and environmental impacts in order to regularly crosscheck with the established environmental goals.

According to the principles of continuous improvement, Botnia-Orion is committed to improve all sections of environmental protection and develops the knowledge level of its personnel with respect to environmental protection and mitigation of the emissions and discharges.

Botnia-Orion has also established a preliminary emergency response plan that covers expected emergency events and impacts on the pulp mill and on the surrounding communities. This plan includes for instance spills prevention measures. The revised chapter 7 of Botnia-Orion’s EIA has more detailed information with respect to this plan and to the environmental management plan.

A12.4.1.1 Communication

The target of the communication plan is to give real-time information to the citizens and other stakeholders about issues related to the environmental protection as well as swift responses to environmental enquiries. Botnia-Orion’s communication plan and commitment to community and stakeholders outreach can be summarized by the following points:

Internal communication

- Environmental questions and complaints received will be discussed in the morning meetings and documented in the minutes of the morning meetings

Communication through environmental and annual reports

- The environmental development of the company and the mills will be tracked monthly, and an environmental report published as an annex to the annual report
- The main environmental indicators of the mill will be published annually in the company’s environmental balance sheet. These indicators will cover pulp production and energy generation, emissions to air, water and the solid waste. The reporting follows the general guidelines of environmental reporting in auditing

Communication with the regulators

- The environmental authorities and the regional fire brigade will be informed of the environmentally abnormal situations creating abnormal discharges or emissions, either beforehand or as soon as possible after the abnormal situation has been detected
- Botnia-Orion will participate in a follow-up commission to be organized by DINAMA, as indicated in the environmental authorization (RM 63/2005) granted to Botnia-Orion on February 2005. This commission will be integrated by stakeholders and community representatives, including the Municipality of Rio Negro, the Ministry of Foreign Affairs, and the Departmental Council of Rio Negro. It is foreseen that the follow-up commission will be active before the end of 2006.
- Furthermore, the follow-up commission can suggest any additional information to be reported and the means to make it available to the public.

Communication with the public/community

- Botnia-Orion will render available to the public, on the Internet, indicators of environmental performance such as the quality of air in Botnia-Orion's monitoring station and quality of the Rio Uruguay at the sampling stations.
- The local press is informed of the planned investments and their environmental impacts at the time of the decisions and implementations. The press releases distributed by the mill are available on both the Intranet and the Internet
- Visitor groups are received for mill visits. The environmental training of the mill guides belongs to the personnel training program

Environmental enquiries

As in other Botnia mills, the Orion mill will have a 24-hour telephone line to receive questions and comments from citizens. The production manager will keep a record of the environmental enquiries. He/she will reply to the enquiries during office hours while, outside office hours, the mill operators write down the contact information of the enquirer which will be contacted later on by the production manager. During the weekend, the person on duty replies to the enquiries.

Botnia participates in local and international technical organisations. It hosts visits to its existing mills from the general pubic, regulators, technical professionals from other mills and nations and educational groups (from primary (elementary), secondary and tertiary (university) groups). It has many mill and corporate communication avenues and generally operates in an environmentally transparent manner.

A12.4.2 Environmental Management System at the ENCE-CMB Facility

The ENCE Group management's guiding principles for the development of its strategic plans are care of the environment, the quality of its products, the health prevention and occupational safety of its employees and workers and the company's responsibility before the society with whom it interacts. The general management policies are framed by these principles and developed within the Integrated Management System (IMS) which consists of the EMS, the Quality Management System, the Security and Occupational Health Management System and the Social Responsibility Management System. ENCE-CMB will establish, will document, and will support an IMS and is committed to constantly improving its efficiency in accordance with the requirements of the following standards to be implemented:

- *ISO 9001/2000, Quality Management Systems*
- *ISO 14001/ 2004, Environmental Management Systems*
- *OHSAS 18001/1999, Occupational Health and Safety Assessment System*

As per the requirements of the above standards, different stages are established namely planning, implementation, control and critical analysis stages.

Of particular interest to this section, it is during the implementation stage that the mechanisms for communication and public consultation are established to insure that the interested parties and collaborators are informed and that they take part in the development of the activities of the company. This mechanism provides a system for the employees and the community to manifest their concerns and questions about security and environment. On the other hand, the opening of external communication channels guarantees transparency in the activities of the company and reaffirms its commitment to society. It is also during the implementation stage that SOPs related to the company's environmental performance are developed. Experience at ENCE's (i.e. in Huelva) demonstrates that the establishment of operational criteria created by the workers coupled with advice from specialists of the Coordination Unit ensures controlled operations and design operative conditions. SOPs developed at the Huelva mill cover, for example, control and maintenance of the wastewater treatment plant, control of gas emissions from the lime kiln stack and manipulation and storage of dangerous products. Two examples of SOPs implemented at the Huelva mill are listed here:

- SOP for the control of environmental impacts in pulp drying:
    - oil residues are collected and by the cleaning personnel and disposed of in containers exclusively used for that purpose
- SOP for the control of environmental impacts in cooking, washing and bleaching:
    - in the event of a liquid spill of cooling water or possible general cleaning water, the liquid flow will be directed to the washing channel and further reintegrated to the washing process;

  - in the event of a spill of hot contaminated water, the flow will be directed to the evaporator plant. When it is not collected, it is directed to the effluent treatment plant via the cooking/washing/bleaching collector.

It is to be noted that the SOPs at the ENCE-CMB facility will be designed based on experience at other ENCE mills to ensure proper environmental performance.

Also of particular interest for this section, is the establishment of the procedures for the recording and notification of environmental accidents, during the control phase.

The design and implementation of the emergency response and hazardous waste management plans will also be based on the actual practice at the ENCE Huelva mill in Spain, with the addition of the demands of DINAMA, IFC and experts recommendations.

Mr. Gleadow from the CIS project team visited the Huelva and Pontevedra mills as part of the CIS development process. Both mills use and certify the EMAS system. The Environmental Management Systems are well documented, and mill personnel are aware and responsive to environmental parameters. Based on the review team's experience (primarily in North American mills), the implementation of these systems by ENCE was leading and is at a very high standard. ENCE indicated that they will apply similar systems at ENCE-CMB. This would satisfy the requirements of IPPC-BAT (2001) for EMS.

A12.4.2.1 Communication

The general objectives of the communication plan are to ensure the availability of information relative to the company's activities in Uruguay to the stakeholders, as well as to guarantee each one of them the opportunity to express his opinions and concerns.

ENCE-CMB's communication plan and commitment to community and stakeholders outreach can be summarized by the following points:

Public opinion in general

- Periodic qualitative and quantitative studies will be performed by external firms to investigate on ENCE's public image in Uruguay, particularly with regards to its ENCE-CMB pulp mill. These studies will include the monitoring of stakeholders information needs and demands, in particular the communication means to satisfy them in real time
- Through the ENCE in Uruguay Website, global information on the ENCE Group will be diffused and the company will seek interactions with social groups and organizations. ENCE-CMB will participate in, for example, conferences and other meetings with organizations such as DERES (business organization for the development of social responsibility), ACDE (Christian Association of Business Managers), SPF (Forest Products Society) and ADM (Association of Marketing Managers)

Citizens living in the zone of influence

- ENCE will maintain an office open to the public in Fray Bentos, for information on the project and equipped with a scale model of the ENCE-CMB pulp mill. This office will serve as the reference point for contacts with other institutions or public and private companies in the area. An ENCE-CMB employee from the department of communication will be available for discussions with the principal social actors such as the IMNR, the Fray Bentos hospital, elementary schools, professional associations, artists, churches, sport clubs, etc.

Authorities and universities

- A great deal of information will be available to the authorities in the form of folders, bulletins, etc.
- Periodic direct contacts will be made following a pre-established agenda and will entail presentations, details on technical controls, etc.
- Visits will be facilitated for national and departmental authorities, university delegations to the M´Bopicuá installations (TLM, ZFMB, ENCE-CMB and conservations area)
- It is planned to organize technical seminars on, for example, monitoring at pulp mills for which an expert from the Government of Huelva would share his experience with the industrial facility at Huelva

Media

- ENCE-CMB will ensure a periodic presence in the media, informing the public about its production activities and accomplishments through its communication and press agency in Uruguay and its corresponding agency in Argentina. Contacts have already been made with the national press as well as with the principal daily and weekly newspapers in the departments of Río Negro, Soriano and Paysandú. Agreements were also in place with radio and television stations in Río Negro, Soriano y Paysandú
- ENCE-CMB will organize training sessions for journalists in the subjects of pulp making, especially the process used at ENCE-CMB's facility in Uruguay

Teachers, artists

- Visits to the M'Bopicuá conservation area will be continued
- Periodic information will be distributed to teachers about the environment, wood and forestry. Visits and seminars will be organized
- ENCE-CMB will also send questionnaires to these stakeholders asking them for feedback on their activities
- ENCE-CMB will also organize, with local institutions, competitions for artists using wood as raw material

Internal

- Employees will be informed through the Intranet as well as through memoranda distributed by different departments
- A tri-monthly bulletin will inform the employees of the company activities and projects in Uruguay

Suppliers

- Suppliers will be informed about the company's policies, plans and activities through e-mail communications and printed bulletins

While both companies are at different levels in engineering and in the project, the CIS project team has reviewed available information and concludes that they have thoroughly considered non-technology measures for ensuring good environmental performance as suggested by the IPPC-BREF document on the pulp and paper industry, particularly with regards to training, process control and maintenance.

Regarding EMS, neither Botnia-Orion nor ENCE-CMB have fully completed their EMS in particular regarding SOPs, but will draw from similar experiences at their respective European mills. Detailed communication plans with different stakeholders have been elaborated as well as emergency response plans at both proposed mills.

European mills of both Botnia and ENCE have established, successful standard operating procedures, and communicate well with local communities, regulators and stakeholders. Both companies have stated that they will use this experience in guiding the general and many specific procedures for Botnia-Orion and ENCE-CMB, and include these mills in the corporate environmental, social and sustainability reporting, in the same manner as their European mills. This provides a high level of assurance for these projects, in this area, and in many areas that the mill will go beyond regulatory or BAT levels. The level of reporting on the ENCE and Botnia European mills, and which is planned on at the Botnia-Orion and ENCE-CMB facilities is better than that provided in North American, some Asian and some (generally older) South American mills.

A13.0 SUMMARY OF BAT EVALUATION

In order to assess BAT for the Botnia-Orion and ENCE-CMB mills, a careful methodology was presented in Section A1 and systematically executed for the purposes of this CIS. The methodology and results can be summarized as follows:

1. *Assessment of the mill's compliance with the emission levels achievable with the use of BAT:* Based on emission levels from the IPPC-BAT (2001) and Tasmanian-AMT (2004) standards, it was found that the mills are implementing BAT. Furthermore, a comparison was made between the proposed mill emission rates and other mills including state-of-the-art BEKP mills in Brazil, as well as other well-operated Botnia and ENCE mills. It was found that the proposed emission rates for the new pulp mills were generally in the same order or better than these mills.

2. *Assessment of whether the environmental regulating body in Uruguay, DINAMA, has a comprehensive plan to ensure the BAT standard will be met through their permitting process and requirements:* DINAMA is employing a staged process to issue management plans for each of the two pulp mills as engineering and construction activities progress, which should eventually lead to the AAO or operating permit for the mills. Both concentration-based and loading-based discharge requirements are expected for the effluent, and well-defined atmospheric emission limits. The mill proponents and DINAMA are currently discussing monitoring and reporting requirements, which will be used as the basis for the operating permit renewal required every 3 years.

3. *Assessment of whether BAT has been included in the mill equipment design:* The summary of IPPC-BAT (2001), Tasmanian-AMT and certain USEPA Cluster Rule (2000) requirements has been summarized in Tables A13-1 and A13-2, and targeted issues have been discussed in greater detail in earlier sections of this Annex. Both mills will employ state-of-the-art process technology.

4. *Assessment of BAT operating requirements:* The Botnia-Orion and ENCE-CMB mills were evaluated regarding their plans for solid waste management practices, monitoring plans including those implemented in other operating mills, training and motivation of mill personnel, process control, equipment maintenance, environmental management systems (EMS), and plans for communication with the community. Expectations for state-of-the-art practices in regards to these issues are in place for both mills.

Table A13-1: Summary of BAT Analysis for the Botnia-Orion Pulp Mill

IPPC Requirements Related to Emissions to Water	
Dry debarking of wood	Logs will be dry-debarked at the plantations, therefore debarking drums at the mill will remove only the remaining bark and impurities such as soil and sand. Water used in washing of the logs will be recycled, with only a minimum purge going to the effluent treatment plant, in order to avoid accumulation of impurities. The water consumption at the mill is expected to be below the definition for dry debarking, i.e. 0-5-2.5 m^3/ADt.
Modified cooking either in batch or continuous system	Cooking will be done in a Downflow Lo-Solids® continuous digester.
Highly efficient brown stock washing and closed cycle brown stock screening	Brown stock will be washed first in the digester, then in high-efficiency drum displacement washers (DD-Washers®, E10=23); three in parallel before oxygen delignification, and two in parallel before bleaching. Brown stock screening will be done in a three-stage closed cycle.
Oxygen delignification	Before bleaching, pulp will be delignified in a two-stage oxygen delignification process. Final kappa number will be under 11.
ECF or TCF final bleaching and some, mainly alkaline, process water recycling in the bleach plant	ECF bleaching with the sequence A/D-E_{OP}-D-P; DD-washers® will be used in the intermediate washing stages. Botnia will install the necessary equipment to recycle the alkaline filtrate from the bleaching plant, however Botnia has stated that the implementation of this option requires that the mill is running for at least two years.
Purification and reuse of condensates	Segregation of condensates will be as follows: o primary (clean): returned to the feed water tank of the recovery boiler o secondary, type A: used in the fiberline o secondary, type B: used in the white liquor plant o foul: stripped to be returned to the process. TRS and methanol removal efficiency in stripping: >98%.
Effective spill monitoring, containment, and recovery system	Spills will be collected and returned to the process. The floor channels and sumps will be monitored with sensors (pH or conductivity).
Sufficient black liquor evaporation plant and recovery boiler to cope with the additional liquor and dry solids loads due to collection of spills, bleach plant effluents etc.	Evaporation plant and recovery boiler have been designed with adequate additional capacity. Evaporation capacity: 20% above normal operation. Recovery boiler: 27% above design capacity for peaks (9% for continuous operation).
Collection and reuse of clean cooling waters	Contaminated cooling water will be directed to the effluent treatment plant.
Provision of sufficiently large buffer tanks for storage of spilled cooking and recovery liquors and dirty condensates to prevent sudden peaks of loading and occasional upsets in the external effluent treatment plant	Spills will be collected and returned to the process. However, if an unexpected load goes into the effluent sewers, it will be contained in the equalization and safety basins (3 basins, 25,000 m^3 each). No effluent will be sent from these basins to the biological treatment without being checked by an operator.

Primary treatment of wastewater	Fiber-containing effluents from the process will go to a primary clarifier before being sent to the equalization basins.
External biological wastewater treatment	Activated sludge treatment, with two parallel lines (two aeration basins + two secondary clarifiers). Total volume of biological treatment: 150,000 m^3.

USEPA Cluster Rule Requirements Related to Emissions to Water	
Adequate chip thickness control	The selected chippers (HHQ-Chipper) will produce chip size distribution sufficiently even to be classified by flat screens used only for cooking of eucalyptus pulp.
Use of dioxin- and furan-free defoamers (i.e. water-based defoamers or defoamers made with precursor-free oils)	Only dioxin- and furan-free defoamers will be used.
Oxygen- and hydrogen peroxide-enhanced extraction (which allows elimination of hypochlorite and/or use of a lower kappa factor in the first bleaching stage)	Oxygen and hydrogen peroxide enhanced extraction is in use.
Use of strategies to minimize kappa factor and dioxin & furan precursors in brown stock pulp	The eucalyptus is delignified in Lo-Solids cooking system and two stage oxygen delignification system. Efficient washing with E10=23 will be used to minimize the organic solids content in front of bleaching. Hexenuronic acids are removed by acidic hydrolysis (A-stage) in front of the final bleaching.
High shear mixing during bleaching to ensure adequate mixing of pulp and bleaching chemicals	Ahlmix high share chemical mixers are used in all bleaching stages.

IPPC Requirements Related to Emissions to Air	
Collection and incineration of concentrated malodorous gases from the fibre line, cooking plant, evaporation plant, condensate stripper, and control of the resulting SO2. The strong gases can be burnt in the recovery boiler, the lime kiln or a separate, low NOx fournace. The flue gases of the latter have a high concentration of SO2 that is recovered in a scrubber.	The concentrated odorous gases are collected from the cooking and evaporation plant and condensate stripper. The gases are primarily fired in the recovery boiler, and as a back-up only in an odorous gas boiler equipped with a scrubber for bisulphite production.
Collection and incineration of diluted malodorous gases from e.g. the fibre line, various sources as tanks, chip bins, smelt dissolver etc. The weak malodorous gases can be burnt in e.g. the recovery boiler mixed with combustion air or in an auxiliary boiler depending on the volume.	The diluted odorous gases are collected in the brown stock fibreline, oxygen delignification, evaporation and recausticizing. The gases are burnt as the secondary air in the recovery boiler, and as a back-up only in an odorous gas boiler for weak gases.

Mitigation of the TRS emissions of the recovery boiler by computerized combustion control and CO measurement and in the case of the lime kiln by controlling the excess oxygen, by using low S-fuel, and by controlling the residual soluble sodium from the lime mud fed to the kiln.	The TRS emissions of the recovery boiler are mitigated by computerized combustion control and CO measurement. No odorous gases are fired in the lime kiln, mitigating the TRS emissions. The residual soluble sodium to the lime kiln is minimized.
Control of SO2 emissions from the recovery boilers by firing high dry solids concentration black liquor in the recovery boiler to mitigate SO2 formation and/or by using a flue gas scrubber.	The black liquor will be concentrated close to 80 % dry solids to mitigate SO2 formation.
Control of NOx emissions from the recovery boilers and lime kiln by controlling the firing conditions and by ensuring proper mixing and division of air in the boiler, and for new or altered installations also by appropriate design;	- Low NOx burner will be installed. - Firing conditions will be controlled. - Vertical four level air distribution.
Control of NOx emissions from auxiliary boilers by controlling firing conditions and for new or altered installations also by appropriate design.	N/A
Reducing SO2 emissions from auxiliary boilers by using bark, gas, low sulphur oil and coal or controlling S emissions with a scrubber (n/a in the case of Botnia).	N/A
Cleaning of the recovery boilers, auxiliary boilers (in which other biofuels and/or fossil fuels are incinerated) and lime kiln flue gases with efficient electrostatic precipitators to mitigate dust emissions.	The recovery boiler and lime kiln flue gases are cleaned with high efficient (99,9%) electrostatic precipitators.

USEPA Cluster Rule Requirements Related to Emissions to Air	
Bleach plant vent control and collection. The control device shall reduce the total chlorinated HAP mass with 99 wt-% or more, achieve an outlet concentration of 10 ppmv or less; or achieve an outlet mass emission rate of 1 g/ODt.	All bleaching vents are collected to the bleaching scrubber.
Collection and treatment of CNCG should include digester, turpentine system, evaporation and stripper system. For DNCG the identified sources are at least; knotting/screening, oxygen delignification, pulp washing and weak black liquor storage. Reducing the total HAP emissions using a boiler, lime kiln or recovery furnace by introducing the HAP emission stream with the primary fuel or in the flame zone is an available option.	CNCG are collected from cooking, evaporation and stripper system and fired primarily in the recovery boiler and as a back-up in the strong odorous gas boiler equipped with a scrubber. DNCG are collected in the brown stock fibreline, oxygen delignification, evaporation and recausticizing. DNCG are fired primarily in the recovery boiler secondary air and as a back-up in a separate weak odorous gas boiler for mild gases.

Foul condensates from digesters, evaporators and NCG collection systems. Different options are mentioned for treatment. For stripper systems the reduction of total HAP should be at least 92- wt%.	Foul condensates are collected from cooking, evaporation and NCG collection systems. The foul condensates are purified in a stripper. The system includes also methanol segregation. (The gases from the system are led to the CNCG collection system and fired.)
For new sources electrostatic precipitators are considered for recovery boilers and lime kilns, and for smelt dissolving tanks wet scrubbers. This to reduce particulate hazardous air pollutants (PMHAP).	Efficient electrostatic precipitators are used for both the recovery boiler and lime kiln. The gases from the smelt dissolving tank are fired in the recovery boiler.

Table A13-2: Summary of BAT Analysis for the ENCE-CMB Pulp Mill

IPPC Requirements Related to Emissions to Water	
Dry debarking of wood and chip storage	Logs will be de-barked in two parallel debarking lines of high efficiency, Rotabarker system. Design includes noise mitigation, low energy consumption and closed water circuit except for purge within the limits required by BREF for dry debarking (0.5 to 2.5 m^3/ADt). Air particles entrainment and emissions of VOC to the atmosphere are mitigated by designing of chips storage in metallic closed silos.
Increased delignification by extended or modified cooking	Pulping includes continuous COMPACT COOKING™ G2. High wood impregnation, very low steam consumption, high flexibility extended cooking, and preservation of the pulp characteristics.
Highly efficient brown stock washing and closed cycle brown stock screening	Washing design in the fiberline consists of the following: o One counter current washing section zone in the bottom part of the digester, and o Four COMPACT PRESS™ models 1557/1535 The counter current washing in the digester is an efficient washing stage (E_{10} value 5). The COMPACT PRESS is specifically designed for the following: o high washing efficiency, o even pulp distribution, o even wash liquor distribution, o wash liquor addition at high consistency. The addition of all E_{10} values before bleach plant, gives an overall efficiency E_{10} value of 25. Closed brown stock screening location is located before washing in a four stage cascade closed system with knots recovery. The objective of this design is to prevent shives in the pulp, and to minimize further chemical consumption.

Increased delignification before bleaching plant by additional oxygen stage	Oxygen delignification is designed in two-stages. Location of the screening system before the stage lowers shives and pulp impurities, and improves efficiency. Final kappa number will be under 10
Elemental chlorine free ECF with low AOX or TCF bleaching	Bleaching is designed to achieve the following: o low chlorine dioxide consumption (less than 10 kg ClO2/ADt) and o low AOX emission (less than 0,2 kg/ADt from bleaching plant The AOX emission after the secondary treatment will be less than 0,1 kg/ADt) Bleaching sequence: D_{HOT}- PO- D Sequence description: o Leaching stage in HDT o D_{HOT} 120-min flexible reactor (80-90ºC) o Pressurized peroxide stage 60-min retention time at over 100ºC, and > 4 bar o D-stage 120-min retention time
Recycling of some, mainly alkaline, process water from the bleach plant	Design features include: o COMPACT PRESS with 2 separate wash zones, o Leaching system to purge chlorides and potassium from the recovery circuit High degree of the alkaline filtrate recovery by using it as wash liquor on post oxygen washing (50 % of the filtrate added to the secondary condensate washing circuit). The alkaline recirculation is expected to be approximately 20%. Recirculation is limited by the following: o chemical consumption limits o increase in AOX emissions o scaling rate and operating problems o cleaning frequency
Stripping and reuse of condensates from the evaporator plant	Stripping, segregation and reuse of condensates: o primary (pure): returned to the feed water tank of the boilers o secondary: o fraction A: from 4th effect (to washing) o fraction B: from 6th effect (to causticizing and to fiberline) o fraction C: from Condensers (to be stripped and, after purified, to fraction B) The TRS efficiency in stripping tower is more than 98%.
Effective spill monitoring, containment, and recovery system	Sewer collection with gravity sumps are designed for each plant area, to detect and collect the spills from the sewers, and return to process. The sumps will be instrumented with pH or conductivity monitors, and linked to millwide control

Sufficient black liquor evaporation plant and recovery boiler to cope with the additional liquor and dry solids loads due to collection of spills, bleach plant effluents etc.	The recovery boiler capacity is 20% over the normal continuous operation of the mill. The evaporation plant has been designed with adequate allowance to accommodate the following: o maintain solids fuel rate to the boiler o to handle recovery spill peaks. The resulting capacity is 15% over the continuous operation of the mill.
Collection and reuse of clean cooling waters	Cooling towers (turboalternator condenser, indirect condenser evaporator, indirect effluent heat exchanger, etc) are designed to collect and reuse clean water.
Provision of sufficiently large buffer tanks for storage of spilled cooking and recovery liquors and dirty condensates to prevent sudden peaks of loading and occasional upsets in the external effluent treatment plant	In addition of the specific tank dyking and individual sewers designed for each plant area to collect and control spills, large buffer tanks have been designed (tank farm to contain volumes during shut-downs, evaporator washing, etc.) For events of sudden large disturbances to treatment, the flow would be conveyed to one of the equalization and safety basins (two basins, 25 000 m^3 each). From the basins, the effluent will be metered to the treatment plant.
Primary treatment and secondary biological wastewater treatment	Primary treatment has been designed to clarify the effluent, and to separate suspended solids before being equalized and biologically treated Biological activated sludge treatment plant includes two equalizers, one high load reactor, two chlorate removal stages, one selector, an aerated basin, and two secondary clarifiers. The specific biological treatment option is now under study.
USEPA Requirements related to water	
Adequate chip thickness control	Chipper horizontal design is type FED HHQ- model XL for narrow distribution curve and quality of chipping.
Use of dioxin- and furan-free defoamers (i.e. water-based defoamers or defoamers made with precursor-free oils	Defoamers will be totally free of dioxin and furans
Oxygen- and hydrogen peroxide-enhanced extraction (which allows elimination of hypochlorite and/or use of a lower kappa factor in the first bleaching stage	The bleach plant has been designed with oxygen and hydrogen peroxide enhanced extraction.
Use of strategies to minimize kappa factor and dioxin & furan precursors in brown stock pulp	Delignification in the Compact Cooking system assures effective chip impregnation prior to cooking. Screening system before oxygen assures effective delignification in the two stage oxygen reaction system. Washing design with E10=25 minimizes the carry-over solids to bleaching. The innovative design of first stage acidic reaction Dhot reduces lignin and hexeneuronic acids.
High shear mixing during bleaching to ensure adequate mixing of pulp and bleaching chemicals	High shear chemical mixers of high efficiency are designed for all mixing stages.

IPPC Requirements Related to Emissions to Air	
Collection and incineration of concentrated malodorous gases from the fibre line, cooking plant, evaporation plant, condensate stripper, and control of the resulting SO2. The strong gases can be burnt in the recovery boiler, the lime kiln or a separate, low NOx furnace.	The LVHC NCGs from the fiberline, cooking, evaporating, stripper and recovery line are collected, conveyed and incinerated in the recovery boiler. The dissolving tank and mixing tank vents are eliminated by their introduction in the recovery boiler system. The vents from the dissolving and mixing tank are scrubbed and sent to the secondary combustion air system. As a back-up system, a “hot” flare (permanently ignited) will be available.
Collection and incineration of diluted malodorous gases from e.g. the fibre line and various sources	HVLC odorous gases are collected from the vents of the fiberline, evaporation and causticizing. HVLC gases are mixed with the secondary air in the recovery boiler. As back up, the HVLC gases are mixed with the feed air to the bark boiler.
Mitigation of TRS emissions by controlling the efficiency of the recovery boiler	Computerized combustion control including bed temperature to maintain low TRS/SO2 emissions is a key design feature of the recovery boiler.
Control of SO2 emissions from the recovery boilers by firing high dry solids concentration black liquor in the recovery boiler to mitigate SO2 formation and/or by using a flue gas scrubber.	The evaporators plant is designed to feed the recovery boiler with black liquor at steady high solids concentration (about 75% solids), in order to better control and to mitigate SO2 formation.
Control of NOx emissions from the boilers, ensuring proper mixing and division of air in the boiler, and for new or altered installations also by appropriate design	Low fluidized bed temperature in the biomass boiler is maintained to allow control of NO emissions, and injection of NH3 in the upper part of the bark boiler further decreases NOx emissions.
NOx emissions reduction from aux boiler by controlled fuel oil firing or substituting by renewable fuels	Bark boiler fluidized bed design requires no fuel oil consumption during normal operation.
Efficient electrostatic filters to mitigate dust from the combustion gases stacks	Electrostatic precipitators of high efficiency (more than 99,8%) have been designed for all combustion sources. In the lime kiln, in addition to the ESP, a scrubber is designed to further mitigate SO2 and dust emissions.
Use of renewable fuels such as wood waste and application of cogeneration	The ENCE-CMB mill will require minimum fuel oil, and will otherwise satisfy its energy and power needs through black liquor and wood waste.
Stripping condensates and heat reuses	Foul condensates will be stripped and burned.

USEPA Requirements Related to Emissions to Air	
Bleach plant vent control and collection. The control device shall reduce the total chlorinated HAP mass with 99 wt-% or more	The scrubber of the required efficiency is designed to treat all the collected bleaching vents.
Collection and treatment of CNCG should include digester, turpentine system, evaporation and stripper system. For DNCG the identified sources are at least; knotting/screening, oxygen delignification, pulp washing and weak black liquor storage. Reducing the total HAP emissions using a boiler, lime kiln or recovery furnace by introducing the HAP emission stream with the primary fuel or in the flame zone is an available option.	The CNCG system collects all cooking, evaporation and stripper system CNCG streams, which are fed to the recovery boiler, and as a back-up, to the hot flare. DNCGs are similarly collected and fed to the recovery boiler as secondary air. The bark boiler is the back-up disposal point.
Foul condensates from digesters, evaporators and NCG collection systems. Different options are mentioned for treatment. For stripper systems the reduction of total HAP should be at least 92- wt%.	Foul condensates collected from cooking, evaporation and NCG systems will be stripped. The gases are conveyed to the CNCG collection system and incinerated.
For new sources electrostatic precipitators are considered for recovery boilers and lime kilns, and for smelt dissolving tanks wet scrubbers. This to reduce particulate hazardous air pollutants (PMHAP).	Efficient electrostatic precipitators are used for both the recovery boiler and lime kiln. The gases from the smelt dissolving tank are eliminated by firing these in the recovery boiler.