Pulp bleaching around the Baltic Sea

April 2001

This report is an update of the situation of pulp bleaching and its environmental aspects around the Baltic Sea.
The report uses some technical descriptions used within the pulp and paper industry. Those are explained at the end of the report.

The report has been prepared by environmental consultant Rune Leithe-Eriksen, exclusively for Greenpeace International. The information in this document has been obtained from sources believed reliable and in good faith, but we make no representation or warranty to its completeness.

Gothenburg
April 2001

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SUMMARY

The pulp and paper industry is one of the largest industries in the Baltic region. Sweden and Finland combined produce 62% of the pulp in the EU. Around 50% is bleached chemical pulp. The proportion and concentration of this industry around a semi-closed sea, has a large impact on the environment. There are approximately 100 pulp mills located around the Baltic Sea drainage area. About 40 of them are producing around 14 million tons of bleached pulp each year. Around 10 million tons of the pulp are bleached with chlorinated compounds. The proportion and concentration of this industry around a semi-closed sea, has a large impact on the environment.

The pulp and paper industry has been responsible for major inputs of POPs, particularly dioxins, to the Baltic Sea. Pulp and paper effluents have had adverse impacts in fish populations living close to the discharges. Research has shown, however, that pollution impacts from the paper mills were not simply localised but also extended to regions of the Baltic Sea that are distant from the source of release.

In the past decade or so, pulp and paper mills have substantially reduced their demonstrable impacts by changing from the use of chlorine gas as a bleaching agent to the use of chlorine-dioxide. However, this bleaching technique does not completely eliminate POPs in pulp mill effluent since chlorine dioxide always contains free chlorine. To fully eradicate POPs from mill effluent and to fully eliminate environmental impacts necessitates a switch to Totally Chlorine Free (TCF) bleaching, a method already adopted by some pulp and paper mills in Scandinavia.

Using TCF bleaching processes allows mills to more readily move to zero-effluent operation. This “totally effluent free” operation avoids environmental impacts which are attributable to the discharge of naturally produced chemicals present in the wood (plant sterols). These chemicals pass unchanged through mill effluent treatment plants and cause disruption of the endocrine system in fish.

Although most of the pulp bleaching production has shifted to ECF/TCF technique and therefore discharges of chlorinated compounds have decreased, the discharge water from the pulp and paper industry contains a cocktail of toxic and oxygen demanding substances.

Over the last fifteen years, a rapid development and introduction of new and modified techniques for the production of bleached kraft pulp has occurred in the pulping industry. The main objectives of these developments have been to reduce the amount of residual lignin entering the bleach plant and to reduce and subsequently eliminate the use of chlorine in the bleaching process, thereby minimising the discharge of chlorinated organic matter. These developments will also facilitate the closure of the water system of the bleach plant. The combination of extended delignification in the cooking stage, oxygen delignification and ECF-bleaching is capable of bringing the discharge of AOX down to a level as low as 0.1 kg per ton pulp after secondary treatment. TCF-bleaching practically eliminates the discharge of chlorinated compounds. Thus the chlorine content of high molecular weight effluent

material from TCF-bleaching of softwood and hardwood kraft pulp is extremely low and fully comparable to the chlorine content found in naturally occurring humic materials.

The production capacity of TCF has stagnated for a couple of years, as there have been strong lobby activities from parts of the pulp industry and chlorine producing industry. At the same time pressure from society on the industry decreased because most NGOs have turned their focus more to the forestry aspect of pulp production than the production aspect itself.

In some cases TCF producers have switched back to ECF as the demand for TCF has decreased. Most companies have kept open the option of producing ECF in case the market should change back. Those companies that have not decided to switch over to TCF have turned their focus more to a closed-loop system which will stop the discharge of bleaching effluent. Several companies convinced that it is possible to stop effluent from being discharged from an ECF-bleaching plant but so far failed to do so because of technical problems.

TCF pulp can be produced with all required high quality brightness and strength. The development of new techniques and market competition has lowered the production price of TCF. Currently the profit margin of TCF produced paper is comparable to ECF. At most there was an extra bonus of 5-10% on the TCF pulp.

Today the market for TCF pulp has stabilised. The demand for TCF is still very low and has even decreased. Only a few key players on the market keep up the demand for TCF paper. The demand is based on a certain quality of the pulp or paper. Nowadays this could be either ECF or TCF pulp. There is no specific demand for TCF and the producers of ECF market the paper as environmentally friendly as TCF. ECF paper is even marketed as TCF-quality.

The Pulp and Paper Industry around the Baltic Sea

The pulp and paper industry is one of the most important industries in the Baltic region. Most of the plants are located in the northern part of the region, in Sweden and Finland. This is also where the largest forests are. Some of the largest pulp plants in the world are located in this area.

Intensive pulp and paper production has affected the biota of many coastal ecosystems in the Baltic Sea. High concentrations of organochlorines including highly toxic dioxins and furans are still found in the sediments of coastal areas near pulp and paper mills. This industry has been the largest source of pollution into the Baltic Sea for a long time. It still is a main contributor to sea pollution. Although most of the bleaching of pulp production has shifted to ECF/TCF technique and thereby the discharges of chlorinated compounds has decreased, the discharge water from the pulp and paper industry contains a cocktail of toxic- and oxygen-demanding substances. The chlorinated substances are only a part of them. Also one has to remember that the total production and discharge from this industry has increased substantially over the last 10 years. In 1999 alone all the countries surrounding the Baltic Sea together produced about 30 million tons of pulp. Most of it within the Baltic Sea drainage area.

For the last 10 years the total production of bleached chemical pulp has increased from 9 to 14 million tons per year in the Baltic Region. This also means that the total load of pollution has increased a lot.

Sweden and Finland combined produce 62% of the pulp in the EU. Around 50% is bleached chemical pulp. The proportion and concentration of this industry around a semi-closed sea, has a large impact on the environment. There are about 100 pulp mills located around the Baltic Sea drainage area. About 40 of them produce approximately 14 million tons of chemically bleached pulp each year. Around 10 million tons are bleached with chlorinated compounds.

Pulp mills in Sweden and Finland have during the last decade phased out bleaching with chlorine gas in favour of ECF (chlorine dioxide) or TCF. In former Eastern Europe most paper production was unbleached. In case it was chemical bleached pulp production the bleaching agent used was chlorine gas. Many pulp mills were small and used very old technology and therefore has been forced to close down as market economy has been introduced. In a few cases foreign companies has bought major part of the shares and invested in new technology. The Svetogorsk pulp mill outside St Petersburg and the Kwidzyn mill in Poland have both been bought by International Paper. The bleaching process in these mills has changed from chlorine gas to ECF. As far as this research has found there are still three pulp mills within the Baltic Sea drainage area using chlorine bleaching. All three are located in the Kaliningrad area (see table).

Only 23% of the total production of chemically bleached pulp in the Baltic area is TCF. According to several forest companies the demand for TCF is very low and many have switched over to only producing ECF pulp which makes the actual TCF production even lower than 23%. This is the case with StoraEnso, both in Sweden and Finland.

For the last 10 years the total production of pulp has increased from 9 to 13 million tons per year in the Baltic Region. This also means that the total load of pollution has substantially increased. From an environmental point of view this is not acceptable.

PULP PRODUCTION

Pulp mill

Trees provide the primary raw material for the paper and board industry. Wood is made from cellulose fibres that are bound together by a material called lignin. In a pulp mill, the fibres are separated from one another into a mass of individual fibres. After separation, the fibres are washed and screened to remove any remaining fibre bundles. The pulp may then be used directly to make unbleached papers, or bleached for white papers. Pulp may be fed directly to a paper machine in an integrated paper mill or dried and pressed into bales to be used as a raw material by paper mills worldwide.

The pulp-making process

Using chemical pulp is more expensive to produce paper than mechanical pulp or recovered paper, but it has better strength and brightness properties. Softwood kraft pulp is used to provide the required strength when producing light-weight publication papers. Fine papers (e.g. copy papers, writing papers, etc.) are an example of the type of paper produced mainly from hardwood pulp, which is reinforced by a minor amount of stronger and more expensive softwood kraft pulp. Pine and spruce provide the strongest pulp (e.g. softwood kraft), while hardwood kraft is produced from birch, eucalyptus, aspen, acacia and many other mixed tropical species.
Today, the fast growing species of tree (such as planted eucalyptus and acacia) are the most rapidly growing raw material for pulp.

Mechanical pulping

Woodpulp was first produced in the mid-19th century by grinding logs against a water-lubricated rotating stone-faced drum. The heat generated by grinding softens the lignin and the mechanised forces separate the fibres to form groundwood. This process is still used today, especially for newsprint. In the last two decades or so, newer mechanical techniques using "refiners" have been developed. In a refiner, woodchips are subjected to intensive shearing forces between a rotating steel disc and a fixed plate. In subsequent modifications to this process, the woodchips are pre-softened by heat (thermo-mechanical pulp (TMP)) to make the fibrillation more effective, or by heat and a mild chemical treatment with sodium sulphite (Chemi-thermo mechanical pulp (CTMP)). After grinding, the pulp is sorted by screening to suitable fractions. It can then be bleached with peroxide for use in higher value-added products.

Mechanical pulping provides a good yield from the pulpwood, because it uses all the log except for the bark, but the energy requirement for refining is high and can only be partly compensated by using the bark as fuel.

The investment costs for mechanical pulp mills are relatively low in comparison with other types of pulp mills.

Mechanical pulp is well suited for "bulk" grades of paper. Strong softwood (pine, spruce) fibres are abundantly available in Europe, and these fibres, mixed with recovered fibres, are good in the production of publication papers (e.g. newsprint, SC-paper, LWC-paper). Softwood kraft pulp is also used as a component in fine paper production.

However, mechanical pulp has lower strength characteristics than softwood chemical pulps and, because it retains most of the lignin, which reacts with ultra-violet light, can turn "yellow" when exposed to bright light.

Semi-chemical pulps

Semi-chemical: pulp produced in a similar way to TMP, but the wood particles are chemically treated before entering the refiner. This pulp has properties suited to tissue manufacture. Some CTMP pulp is used in printing and writing grades. CTMP pulp is classified under semi-chemical pulps in the Harmonised System of the Customs Cooperation Council. In the Food and Agricultural Organisation (FAO) of the United Nations, as well as other industry statistics, such Chemi-thermo mechanical pulps are grouped with mechanical pulp.

Chemical pulps

Sulphite pulp is produced by cooking wood chips in a pressure vessel in the presence of bi-sulphite liquor. End-uses range from newsprint, printing and writing papers, tissue and sanitary papers. Sulphite can be either bleached or unbleached. Modern mills mostly use non-chlorinated compounds as bleaching chemicals.

Sulphate (or kraft) pulp is produced by cooking wood chips in pressure vessels in the presence of sodium hydroxide (soda) liquor. The pulp may be unbleached or bleached. End-uses are widespread, with bleached pulp particularly used for graphic papers, tissue and carton board, wrappings, sack and bag papers, envelopes and other unbleached speciality papers.

Chemical pulping

In chemical pulping, the wood chips are cooked in a digester with chemicals. Cooking removes lignin, breaking up the wood into fibres. The process results in a slurry where fibres are loose but intact and have maintained their strength.

Most chemical pulp is made by the alkaline kraft or sulphate process which uses caustic soda and sodium sulphate to "cook" the woodchips. In the unbleached stage, a dark brown, but very strong pulp results which can be bleached to a high brightness if required. The cooking chemicals are recovered back to the process through evaporation and burning plants. Cooked pulp is washed and screened to achieve more uniform quality.

The alternative method is the sulphite pulping process. This method is based on an acid cooking liquor process, and it is best suited for speciality pulp. The sulphite mills produce easily bleached pulps, generally with hydrogen peroxide. These pulps fulfil today's demand for "chlorine free" products in the disposables sector and also in printing and writing papers.

Yield in both chemical processes is much lower than in the manufacture of groundwood, as the lignin is completely dissolved and separated from the fibres. However, the waste lignin from the sulphate and some sulphite processes, can be burnt as a fuel oil substitute. In modern mills, recovery boiler operations and the controlled burning of bark and other residues makes the chemical pulp mill a net energy producer which can often supply power to the grid, or steam to local domestic heating plants.

BLEACHING

Pre-bleaching

In response to environmental concerns as well as to government regulations on emission of chlorinated compounds the Nordic pulp and paper industry has in recent decades acted by developing and introducing a number of new processes and process modifications in order to minimise discharges of chlorinated compounds.

After cooking the kraft pulp has a very brown colour and the sulphite pulp has a grey-yellow colour. So the strategy has been to remove as much lignin as possible before the pulp enters the bleach plant by improving the cooking process. Also in recent years replacing chlorine by substitution with other bleaching agents (see below). Modified cooking (extended delignification), oxygen delignification and better brown stock washing can all be considered as pre-bleaching technologies. All three are parts of the closed process system in modern kraft mills. The organic material dissolved in the waste water from these processes (lignin, resin acids, fatty acids and other black liquor ”carry-over” components) is returned to the recovery furnace for incineration.

The process decreases the demand for bleaching chemicals and has thereby contributed to the reduction of chlorinated organic substances as well as other substances. Of course this also reduces the cost of chemicals used in the process.

The combination of modified cooking and oxygen delignification has further reduced the kappa number (measure for the amount of lignin remaining in pulp after cooking) of the softwood pulp entering the bleaching plant to around 10. It can be anticipated that this development will continue in the near future with improvements of cooking and pre-bleaching delignification processes, which may produce pulps with kappa numbers well below 10 before bleaching.

Today most modern craft mills producing softwood pulp uses oxygen delignification. Modifies cooking is also rather common and several mills are today producing softwood craft pulp with a kappa number about 10 after oxygen delignification. These process modifications, which have lead to a substantial reduction of residual lignin entering the bleaching plant, are also favourable from the point of view that they reduce the demand, and thereby the costs, for bleaching chemicals, which ease the burden on the environment.

Bleaching methods

Finally the pulp is bleached (in 4-7 stages). Quality papers require a pulp, which does not discolour during storage, or go yellow when exposed to sunlight, and which retains its strength. Bleaching achieves all three requirements, and has the additional advantage of improving absorption capacity, removing any small pieces of bark or wood left behind as well as giving a high level of purity.

In Europe, ECF-bleaching (elemental chlorine free) and TCF-bleaching (total chlorine free) methods are widely used. Even the rest of the world is now abandoning chlorine gas as a bleaching agent more and more. This is for environmental reasons. Modern pulp mills are constantly improving their effluent load and are tending towards totally effluent free plants.

Bleaching is used to achieve paper brightness. Chemicals are used that remove the lignin so the natural white colour of the fibre appears. The brightness is measured in ISO which shows the percentage of the total whiteness. Unbleached softwood kraft pulp has an ISO of app. 26 percent. Bleached pulp has an ISO of 70-90 ISO.

But bleaching also has another impact on the pulp. The pulp acquires other qualities. This can be biological and chemical cleanness, storage durability and exposure to sunlight.

Chlorine bleaching

Traditionally chlorine has been used as the bleaching chemical as it is cheap and effective. It became obvious that there were environmental impacts associated with the use of chlorine. The usage of chlorine reached its top level in the mid 1970s. The discharges of chlorinated compounds were then approximately 10 kg AOX per ton pulp on average in Scandinavia. During 1990s chlorine use for pulp bleaching was phased out in Sweden and Finland due to environmental reasons.

In the beginning of chlorine bleaching use the chlorine was used directly after the cooking stage. In the early 1970s oxygen delignification was introduced as a pre-bleaching stage. This decreased chlorine demand during the process and reduced the kappa number of the pulp entering the bleach plant. In 1990 extended cooking was introduced and the demand for chlorine decreased further.

Environmental aspects

The pulp making industry has for decades discharged large amount of chemicals, fibres and wood residues into the Baltic Sea. Large fibre banks, causing lack of oxygen, were formed along the coastlines. It was also discovered that the discharge water was toxic and harms fish and aquatic ecosystems. Pulp mill discharges - and organochlorines in particular- have been linked to physical deformities in fish, hormonal changes and reproductive impairment, liver disorders, disruption of cell function, changes in blood composition, damage to skin and gills, changes in shoaling behaviour and changes in the structure of fish populations.

The presence of dioxins and of chlorinated phenolic compounds in effluents from production of chlorine-bleached pulp has attracted much interest from an environmental point of view..

ECF Bleaching

ECF bleaching uses chlorine dioxide instead of elementary chlorine. By introducing oxygen bleaching it became possible to introduce chlorine dioxide as a bleaching agent, which also gives a lower AOX in the effluent. Later both oxygen and hydrogen peroxide were introduced which eased the burden on the pre-bleaching stage. After modified cooking was introduced, AOX discharges could be as low as 0,5 kg per ton pulp. Following these changes in the process COD-discharges decreased to 30-35 kg per ton. Before oxygen delignification was introduced these discharges could be as high as 100 kg per ton. By using aired lagoons and active sludge treatment of the effluent AOX can be lowered to 0,1 kg/t and COD to below 25 kg per ton. The strength and quality of the ECF pulp is favourably compared with chlorine bleaching.

Environmental aspects

Introduction of ECF-bleaching has had a major positive impact on the marine environment. The relatively few mill and laboratory studies on effluents from ECF-bleaching so far reported indicate that ECF-bleaching of softwood kraft pulp produces small quantities of chlorinated compounds. These compounds have not been eliminated, only reduced. Swedish research has shown measurable quantities of dioxins and furans, two very toxic compounds.

TCF bleaching

In the early 1990s the bleaching process Lignox was introduced. It means that the pulp is pre-treated with oxygen and a chelating agent (EDTA or DTPA), followed by an extraction process with hydrogen peroxide. The purpose of the chelating agent is to bind the metal ions from the pulp wood that would otherwise destroy the hydrogen peroxide. The Lignox method can be applied in an existing bleaching plant but it is best to introduce it when building a new plant. The TCF-bleaching technique has been improved and can now produce TCF-bleached softwood kraft pulp with brightness fully comparable to ECF pulp.

The next improvement was when ozone bleaching was introduced in the early 90s. Ozone is better than other bleaching chemicals in releasing lignin. But it also attacks the cellulose. By placing the ozone bleaching stage early in the process and technical adjustments this attack can be limited.

Kraft bleaching processes based on hydrogen peroxide or ozone or combinations of these bleaching agents (TCF-bleaching processes) have been introduced in full scale operation in several kraft mills world-wide with Swedish and Finnish mills acting as forerunners. Also other oxidative bleaching agents such as per-acetic acid are now used in mills as a complement to other bleaching alternatives.

By introducing hydrogen peroxide and ozone, bleaching without using chlorine dioxide or chlorine became possible. The main objective behind the introduction of TCF-bleaching was, in the short term, to minimise the discharge of chlorinated organic material to water recipients. More-over, the introduction of TCF-bleaching will more readily facilitate the closure of the water system in the bleaching plant into an effluent free plant (see next chapter).

The hydrogen peroxide is delivered dissolved in water and transported in tanks. Ozone is produced in the mill by an ozone generator.

Environmental aspects

TCF-bleaching practically eliminates the discharges of chlorinated compounds. Thus, the chlorine content of high molecular weight effluent materials from TCF-bleaching of softwood and hardwood kraft pulp is extremely low and fully comparable to the chlorine content found in naturally occurring humic materials.

The chelating agent EDTA has been discharged in the bleaching process by the mills using TCF-bleaching process mills. No major reduction of the EDTA load has been observed upon secondary treatment of the bleached kraft mill effluents (BKMEs) studied.

Metals originating from the pulp wood are found in the effluents from pulp industries. Chelating agents are used to bind metals that are a natural substance in the wood and that can cause the destruction of the ozone used to bleach the pulp. Metals can also complicate the bleaching process with hydrogen peroxide. After the treatment with chelating agents the metals are washed away and discharged with the effluent.

EDTA itself is regarded as being not a very toxic substance. This does not exclude that temporary larger discharges or often repeated smaller discharges can have a negative effect on the environment. Discharges of EDTA in amounts that could be toxic should be avoided. EDTA is not bioaccumulative in water but it can enhance the bio-availability and thus the uptake of metals and other chemicals by marine wildlife. The Swedish EPA has stated, in all new permits for discharges from bleaching plants, that the use of chelating agents must be limited.

Closing the bleaching process

To completely close the pulp plant is impossible. The same amount of the non organic substances that goes in has to go out and be processed or deposited in a good way. But one can close the system from an effluent point of view, so that no organic material leaves. This kind of plant is called TEF (Totally Effluent Free). Such a plant is of course more sensitive to disturbances than conventional plants. It will require more knowledge and technique.

The continuing development towards more environmentally friendly bleaching processes is mostly concentrated on decreasing the discharges of oxygen demanding organic substances measured as COD, BOD and BS_7 which are the last residues of the released wood substances. The more one delignifies at the cooking and oxygen bleaching stage the more the discharges decrease. Then there is only one more way left; to recover as much as possible of the bleaching discharges to the process of the plant. The alternative is to invest in external treatment systems. This is often an end-of-pipe solution that shifts the problem into another waste stream and does not give opportunities to decrease the consumption of chemicals. Besides it is also often very expensive.

There are always risks with closed systems. The organic substances that go into the system, have to exit sooner or later. If this is not in balance, high amounts of substances are accumulated in the system.

The bleaching plant process is an effective cleaning system for many of the substances and they are found in the effluent of the bleaching process. If the effluent is recovered the net intake of many of the substances will increase. This can have effects such as:
-bad bleaching
-coatings in the process machinery
-stoppages in the system
-corrosion
-increased heating costs

One way to solve this is to install internal treatment systems between the processes. These are called kidneys as their function is to remove harmful substances from the processes. A modern plant already has several kidneys within the system such as bark and soda boilers.

The future goal is to neutralise all organic substances from the effluent. No matter which method you use, recovering or external treatment, the effluent flow from the bleaching process has to decrease. With traditional bleaching processes the effluent flow could be as high as 100 cubic meter per ton pulp. By internal closed-loop procedures the flow can decrease to 20-30 cubic meter per ton pulp. With press washing instead of filters the effluent flow from the bleaching process can be lowered to less than 10 cubic meter per ton pulp. This is also necessary to be able to completely eliminate the organic substances from the effluent in an economical and energy efficient way.

Full closure of a bleaching process would imply washing the last bleaching stage with clean water. The filtrate is then returned counter-flow through the washing stage of the bleaching plant and then to the unbleached washing stage. From there the wood substance residues from the boiling and bleaching processes will go to evaporation and incineration or other disposal. For such a closure the kidneys of today are not enough. New kidneys and processes must be developed which are more adjusted to the new systems. These can be:

-membrane filters
-ion exchange
-precipitate
-biological
-evaporation and incineration

Using TCF bleaching processes allows mills to more readily move to zero-effluent operation. This “totally effluent free” operation avoids environmental impacts which are attributable to the discharge of naturally produced chemicals present in the wood (plant sterols). These chemicals pass unchanged through mill effluent treatment plants and cause disruption of the endocrine system in fish.

The Swedish Forest Company SCA has succeeded in closing the TCF bleaching plant process to 95% at their new TCF bleaching plant at their mill Östrand based on kraft pulp. The bleaching plant started in May 1995. It has been developed by Sunds and the American company Union Camp. The process uses peroxide, oxygen and ozone. This process lowers the cost as less peroxide is used. The strength and brightness is sufficient and the ISO is 90%. The process has lowered the effluent flow from 45 to 5 cubic meter per ton pulp. The bleaching process is now closed by 95%. AOX is zero and COD has decreased from 65 kg/t pulp to 40 kg/ton pulp. Production capacity is 370 000 ton kraftwood TCF pulp.

At their Domsjö mill based on sulphite pulp, Domsjöfabriker (former MoDo) has closed the TCF bleaching plant since1995. Theoretically it is closed to more than 90%. Before the closure the COD was 45 kg/t pulp and today it is down to 3 kg/t pulp. The effluent from the bleaching plant is sent back to the plant process. The total COD from the plant effluent is 47 kg/t pulp. The bleaching process is based on hydrogen peroxide and oxygen bleaching. ISO is 90-93%. Production is 210,000 tons of bleached sulphite softwood pulp.

At MoDo’s sulphate mill Husum, the birch line bleacher was closed to 100%, but only for periods of several weeks at a time. In the late 1990s this was a research mill for closing ECF bleaching effluent. A lot of money and time was invested. Today this research has been abandoned. There were to many problems that were impossible to solve.

It seems that although theoretically seems possible to close the effluent stream of an ECF bleach plant, it is much more complicated than estimated and the cost is very high. As chlorinated compounds are corrosive they have to be separated before closing the loop. This was one of the technical problems to solve. This will also leave the problem of disposing the separated chlorinated compounds.

Quality difference in TCF/ECF paper

TCF pulps have high brightness and are available at full brightness on the market, both softwood and hardwood. TCF pulps have high strength, full ”market strength”. There are no limitations in paper production with respect to strength.
The softwood pulp are at full brightness, >88% ISO.

Changing existing ECF system to TCF

Nowadays, the most common practice today is to change from chlorine bleaching to ECF and from ECF to ECF/TCF. As the market for TCF is rather unstable most mills have kept the option to switch back to ECF from TCF. Even mills aiming at a 100% TCF production have maintained the option to switch over to ECF if the market demand changes. This is primarily a financial issue, not a paper quality issue.

It is therefore a more difficult task to estimate the investment cost for rebuilding a ECF bleaching plant to a TFC plant. The following example can serve as a guideline:

In June 1994, the board of Södra Cell took a decision to invest in rebuilding the existing ECF bleaching plant at their Mörrum mill. It was rebuilt to a peroxide bleaching plant for TCF bleaching and included the possibility of closing the bleaching process as much as possible in the future. The investment cost for changing one bleaching line to TCF was 15 million USD. Production capacity is 375 000 ton and it is planned to increase to 460 000 tons per year.

According to Roland Lövblad, Environmental director of Södra, there are more or less no extra investments in changing from chlorine bleaching to ECF and small investment costs for changing from ECF to TCF. The investments increase when you want to increase the quality. But it all depends on what equipment you already have. If you already have modified cooking and oxygen bleaching there are no major extra costs in changing to TCF.

MoDo rebuilt their bleaching plant at the Domsjö mill in 1991. The bleaching plant is an old ECF plant and the investment cost for changing the process to TCF was around 1,5 million USD. Production capacity is 210 000 t/year of sulphite softwood pulp.

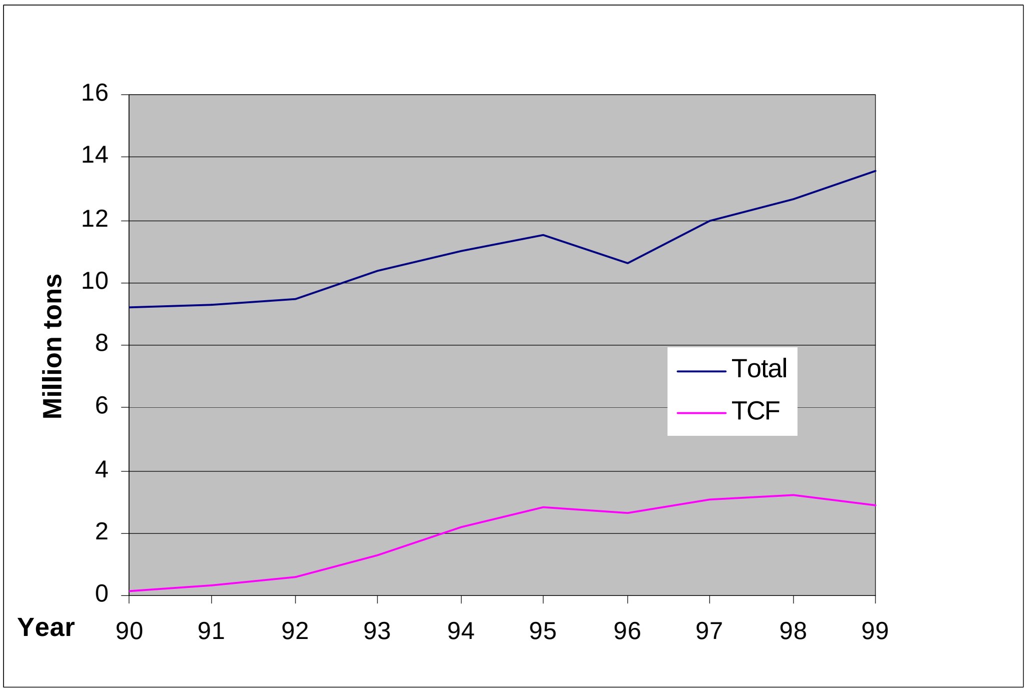
According to Lars Sjödin at Sunds Defibrator (pulp machinery manufacturer), investment costs differ a lot. Sometimes you have to build a new boiler before the bleaching plant and sometimes you have to rebuild parts of the bleaching line. If you can use the same building this also lowers the cost substantially. It all depends on what you have and what you want to achieve in quality.

As a conclusion one can say that everything from a couple of million to 40 millions USD can be invested in changing from ECF to TCF. But normally 10 to 30 million USD.

Tables

The following tables and numbers are based on research of available documents, personal contacts and phone calls. The figures are from 1999 and 2000. They can differ, depending an what source has been used. For some smaller mills numbers are missing and therefore left out. Only mills close to the coastline or large lakes within the drainage area are presented if not otherwise specified. In some cases total numbers are taken from statistical materials and might therefore differ from those taken from other sources.

Baltic Production of Bleached Chemical Pulp



Finnish chemical bleached pulp production

Company/mill	Production 1999 (tons)		
	TCF	ECF	TCF/ECF
StoraEnso Kemijärvi		216 000	
StoraEnso Imatra		580 000	
StoraEnso Oulu		370 000	
StoraEnso Veitsiluoto		495 000	
StoraEnso Enocell		605 000	
Sunila		330 000	
Mätse-Botnia Äänenkoski		452 000	
Mätse-Botnia Joutseno		381 856	
Mätse-Botnia Kaskinen	190 000	220 000	
Mätse-Botnia Kemi		350 000	
Mätse-Botnia Rauma	570 000		
UPM-Kymmene Kaukas		642 000	
UPM-Kymmene Kusaniemi		478 000	
UPM-Kymmene Pietasaari		597 000	
Total	**760000**	**5716856**	**6476856**

Swedish chemical bleached pulp production

Mill/Company	Production 1999/2000 (tons)		
	TCF	ECF	TCF/ECF
SCA Munksund	39 350		
SCA Östrand	365 000		
Assi Karlsborg		257 300	
Assi Frövi	80 700		
Assi Piteå	68 500		
Assi Skärblacka		143 300	
Korsnäs Gävle		380 000	
Domsjöfabriker	290000		
MoDo Husum		673 300	
Holmen Iggesund		253 000	
Holmen Wargön	131 000		
Munksjö Aspa	70000	80 000	
StoraEnso Gruvön		581 000	
StoraEnso Norrsundet		274 000	
StoraEnso Skoghall		529 000	
StoraEnso Skutskär		499 000	
Södra Mönsterås	529 000		
Södra Mörrum	124 000	267 000	
Södra Värö	313 000		
Rottneros Utansjö	71 200		
Rottneros Vallvik	50 000	105 200	
Petterson Säffle	37 500		
Totalt	**2 169 250**	**4 042 100**	**6 211 350**

Russian chemical bleached pulp production

Company/mill	1999 Production			
	TCF	ECF	Chlorine	All
Svetogorsk, St Petersburg		174 000		
Neman, Kaliningrad*			96 000	
Cypress, Kaliningrad			75 000	
Sovetsky, Kaliningrad*			62 000	
Total		**174 000**	**233 000**	**407 000**

*Operates only on market demand

Polish chemical bleached pulp production

Company/mill	Production 2000 (tons)	
	TCF	ECF
International Paper, Kwidzyn		300 000
Total		**300 000**

Baltic pulp production 1999

Country	Pulp (tons)	Bl Chem pulp (tons)
Finland	11 579 000	6 476 856
Sweden	10 694 000	6 211 350
Germany*	1 912 000	711 000
Denmark	65 000	0
Poland**	851 000	300 000
Lithuania	1 000	0
Latvia	0	0
Estonia	48 000	0
Russia***	4 750 000	1 917 000
Total	**29 900 000**	**15 666 206**

*   Includes mills outside the drainage area
**   Includes the whole country
*** Only European part

Key words

A

Activated sludge treatment
A biological method of cleaning waste waters in three stages. Stage I involves (anaerobic) equilibration. In stage II activated sludge containing micro-organisms is led into an aeration basin to speed up oxidation of organic matter and ammonia. In stage III the sludge is allowed to settle and the treated waste water is run off. Some sludge is removed and a portion is returned to the aeration basin.
Aerated lagoon
A biological waste water treatment method in which air (oxygen) fed into an aeration basin reduces the effluent load
AOX
Absorbable organic halogens. AOX is a sum parameter measuring total concentration of chlorine bound to organic compounds in waste water. AOX measures all chlorine compounds both harmful and harmless (a sum parameter)

B

Black liquor
Mixture of cooking chemicals and dissolved wood material remaining after sulphate cooking; recovered during pulp washing, concentrated by evaporation and burned in the recovery boiler to regenerate the cooking chemicals and generate energy
Board
Thick and stiff paper, often consisting of several plies; widely used for packaging purposes. Its grammage normally is higher than 150 g/m2.
Book paper
Woodfree or mechanical paper used for printing books.
Brightening
Addition of optical brighteners to the stock to make the pulp/paper appear whiter
Brightness
A measure of the whiteness of pulp and paper

C

Carbon dioxide (CO2)
Produced by burning coal and other carbon containing products. Burning fossil fuels or wood based products raises atmospheric carbon dioxide levels.
Cellulose
Structural material giving strength to wood cells
Chemical oxygen demand (COD)
The amount of oxygen consumed in complete chemical oxidation of matter present in waste water; indicates the content of slowly degradable organic matter present.
Chemicals recovery
In chemical pulping, the recovery, treatment and regeneration of cooking chemicals
Coated paper
The uniform application of a coating yields a more even and more closed surface of printing papers, which is suitable for the reproduction of fine screen artwork. The coating is applied in separate coaters or in the paper machine.
Coating
Process by which paper or board is coated with an agent to improve its brightness and/or printing properties
COD
See Chemical oxygen demand
Continuous cooking
A method used in chemical pulping in which raw material is fed continuously into the digester, while at the same time pulp and black liquor are removed (cf. batch cooking)

Cooking
A process for producing chemical pulp by treating wood with a cooking liquor at a certain temperature and pressure
Cooking liquor
Liquor made up of selected chemicals and used for cooking pulp
Copying paper
Copying paper is an uncoated paper in woodfree or mechanical grades, white or coloured in A4 and A3.

D

Delignification
The removal of lignin, the material that binds wood fibres together, during the chemical pulping process.
Direct cooking
Cooking in which heating is achieved by blowing steam into the cooking liquor
Document paper
Document paper is paper with a high ageing resistance. It is woodfree but may also contain rags or be fully made from rags and is used for documents that have to be preserved for a longer period.
Drawing paper
The range of drawing papers includes woodfree and mechanical grades with proper-ties that are tailored for specific drawing techniques. They have a low opacity and are erasure proof and often also wash-fast.
Dry coating
Coating method in which a binder is applied to the paper surface followed by dry coating pigment

E

Enzyme bleaching
Bleaching technique in which cooked and oxygen-delignified chemical pulp is treated with enzymes prior to final bleaching. Allows pulp to be bleached without chlorine chemicals
Evaporation plant
Unit used at pulp mills to concentrate spent liquor to make it suitable for burning and chemicals recovery
Extended cooking
Method of cooking pulp to low lignin content, thereby reducing the need for bleaching chemicals

F

Filler
Pigment, added to papermaking stock to improve properties such as opacity and smoothness, and often to reduce cost
Filter paper
Unsized paper made from chemical pulp, in some cases also with an admixture of rags, sometimes with a wet strength finish. Filtration rate and selectivity, which are both dependent on the number and the size of the pores, can be controlled by specific grinding of the pulps and creping.
Fine paper
High-quality printing, writing or copy paper produced from chemical pulp and usually containing less than 10% mechanical pulp
Flue gas scrubber
Equipment for removing impurities from flue gases by dissolving them in aqueous solution
Fully bleached pulp
Pulp that has been bleached to the highest brightness attainable (> 90 ISO)

G

Greaseproof paper
Greaseproofness is either achieved by grinding of the pulp and pore-free web formation or by special additives.

I

Integrated pulp

Integrated pulp is pulp that is produced for use as a raw material in the production of paper at the same mill, or for shipment by a producing mill to other mills, which it owns, controls or with which it is affiliated within the same country.

ISO brightness

The brightness of paper and board measured at a wavelength of 457 nanometres under standard conditions

K

Kappa number

Measure of the amount of lignin remaining in pulp after cooking

L

Lignin

Natural "adhesive" which binds wood fibres together in the tree and imparts rigidity. Pulp brightness depends on the amount of lignin remaining in the pulp. Paper containing high content will "yellow" in sunlight.

LWC paper

Light weight, two-side coated mechanical reel printing paper with a grammage of less than 72 gsm. It is used for magazines, mail-order catalogues etc. that are mostly produced in gravure or web offset printing (See "Coated paper").

M

Magazine paper

The selection of the magazine printing paper is mainly dependent on the print run and the demands on the print quality (image reproduction, outer appearance, advertising appeal). High runs are mostly produced in rotogravure, rotary offset printing or rotary letterpress printing on uncoated or coated reel printing papers (mainly SC and LWC. See "SC" and "LWC"). Magazines with medium or smaller circulation are generally produced in sheet-fed offset or sheet-fed letterpress printing.

Market pulp

Market pulp is pulp that is sold in open competition with that of other producers. All pulp exported from the producing country is considered to be market pulp.

Mechanical pulp

Stone Groundwood pulp is produced by grinding wood into relatively short fibres. This pulp is used mainly in newsprint and wood-containing papers, like LWC (light weight coated) and SC (super-calendered) papers.

Multi-stage cooking

Chemical pulping process in which the alkalinity of the cooking liquor is varied by charging the alkali in several stages

N

NCR paper

See "Carbonless copy paper"

Newsprint

Newsprint is a highly mechanical, machine-finished or calendered rotary printing paper (40 - 56 gsm) mainly made from mechanical and increasingly waste paper pulps. In line with its intended use as a short-lived information medium, the demands on newsprint in terms of optical properties or printability are lower than those on other, e.g. coated printing papers. Newsprint must have a very good runnability: today's state-of-the-art printing techniques require a paper with a good tear strength so that the uninterrupted production on high-speed rotary presses is ensured. Newsprint is used for dailies, weeklies and free journals produced in letterpress or offset printing.

Non-Wood Pulp

Pulp made from materials other than wood, for example straw, grasses, bogasse etc.

Nutrients

Generally refers to nitrogen and phosphorus compounds, which act as fertilisers in water systems

0

Offset paper
Collective term for printing papers with special properties for offset printing. For instance, the paper must not emit dust during processing and must be pick resistant. Offset paper may be woodfree or mechanical, coated (matt, glossy, embossed) or uncoated and is processed in sheets as well as in reels.
Optical characteristics
Characteristics of the appearance of paper or board. Most important are colour, brightness, opacity and gloss
Oxygen bleaching
A process in which pulp is initially treated with oxygen followed by 4-5 bleaching stages
Ozone bleaching
Pulp can be treated with ozone at the start of the bleaching sequence to lower its lignin content. Ozone allows bleaching to high brightness without chlorine chemicals

P

Packaging paper
Collective term for papers of different pulp composition and properties, sharing only the application. Selection and mixture of the pulps depend on the demands made on the paper. Important are tear strength, bursting strength, creaseproofness, abrasion resistance as well as elasticity and stiffness. Often also good printability is demanded (packaging as advertising medium). For special purposes packaging paper can be imparted wet strength or water repellent properties or made impermeable for aromas or water vapour. For these purposes either special additives are admixed to the pulp or the paper is coated, impregnated or combined with plastic and/or metal film.
Paperboard
Monolayer paperboard is basically thicker paper, frequently used in multilayers.
Peroxide bleaching
Method of bleaching pulp with hydrogen peroxide (H2O2) to remove lignin; reduces or avoids the need for chlorine dioxide in final bleaching
Printing paper
Printing paper is a collective term for all printable mechanical or woodfree papers that may serve as the medium for printed information. In addition to uniform and fast ink trapping and drying (printability) as well as dimensional stability, sufficient opacity (no show through of the back print) and smoothness, such papers require a certain degree of strength and stiffness, so that the paper may run through the printing ma-chine fast and without any problems (runnability). Many printing papers are coated to improve printability (See "Coated paper").
Ptp
Per ton of pulp.

R

Recycled fibre pulp
Pulp produced from recovered paper to be used in papermaking.
Recycling
Use of recovered waste paper and board by paper mills to produce paper and boards.
Refiner
A machine containing rotating disks between which wood chips are broken down into fibres for pulp making
Refiner mechanical pulp (RMP)
Mechanical pulp produced by passing wood chips between the plates of a refiner
Reject
Material removed and discarded during the cleaning of pulp/stock
Relative density Mass of a unit volume of a particular substance

S

Sanitary papers

The group of sanitary papers includes cellulose wadding, tissue and crepe paper, made from waste paper and/or chemical pulp - also with admixtures of mechanical pulp. As a consequence of the importance of tissue today, this name is now used internationally as a collective term for sanitary papers. These grades are used to make toilet paper and numerous other sanitary products such as handkerchiefs, kitchen wipes, towels and cosmetic tissues.

Sanitary tissue paper

Tissue is a sanitary paper made from chemical or waste paper pulp, sometimes with the admixture of mechanical pulp. It has a closed structure and is only slightly creped. It is so thin that it is hardly used in a single layer. Depending on the requirements the number of layers is multiplied. Creping is made at a dryness content of more than 90 %. The dry creping (unlike with sanitary crepe papers) and the low grammage of a single tissue layer result in a high softness of the tissue products. For consumer products it is normally combined in two or more layers. The flexible and highly absorbent product [is mainly produced from chemical pulp and/or DIP - sometimes also with admixture of groundwood pulp] can also be provided with wet strength. Applications: facial tissues, paper handkerchiefs, napkins, kitchen rolls, paper towels, toilet paper.

Sludge handling

Compaction and dewatering of sludge separated from treated effluent

Strength

Ability of paper or board to withstand mechanical stress

T

Thermal papers

One-side coated thermo-reactive papers used for printing text and illustrations on telefax machines, thermoplotters (e.g. for technical drawings) and thermoprinters (e.g. for labels, tickets, sales slips and other vouchers).

Three-layer paperboard

Paperboard consisting of three layers: front liner made from chemical pulp and/or waste paper pulp, middle made from waste paper pulp and back made from mechanical and/or chemical and/or waste paper pulp.

Thermo-mechanical pulp

Is produced in a thermo-mechanical process where wood particles are softened by steam before entering a pressurised refiner. TMP has mainly the same end-uses as Stone Groundwood pulp. Variants of the above two processes are pressurised Stone Groundwood pulp and Refiner Mechanical pulp.

Tissue paper

Collective term for papers of a grammage of less than 30 gsm that differ in application and composition but have the common feature of being thin. They are mainly used to wrap delicate items, as tissue for bottle wrapping, as fruit tissue wrappers for oranges or as wet strength flower tissue. They are also used as base paper for the carbon paper production, as lining tissue for envelopes and as lining paper (e.g. as a composite with aluminium foil in cigarette packaging). The extremely thin Japanese tissue papers are sometimes produced in grammages as small as 6 to 8 gsm.

Toilet papers

See "Sanitary tissue papers" and "Sanitary crepe papers".

Typewriter paper

Typewriterpaper (bank paper) is often woodfree, usually sized, erasure resistant and in rare cases coloured. It can be both with and without watermark and can also be embossed. Typewriterpaper (bank paper) is often woodfree, usually sized, erasure resistant and in rare cases coloured. It can be both with and without watermark and can also be embossed.

V

Viscose pulp

Dissolving pulp intended for the manufacture of viscose

W

Wall base paper

Collective term for papers that are suitable for wallpaper production. These papers may be monolayer or multilayer (simplex/duplex), woodfree or mechanical, uncoated or coated, and can also be laminated, pre-pasted or peelable.

Washing de-inking

De-inking in which solid particles are separated on the basis of their size by washing

Waste paper

Paper after it has been used. Most can be recycled into new paper products. Known also as recovered paper and secondary fibre.

Water colour paper

Woodfree (See "Woodfree paper") drawing paper with a rough or structured surface, sometimes also rag-containing or pure rag paper. Sizing is adapted to ensure that the water colours are well accepted by the paper but do not strike through. The paper must be erasure resistant. If they are hand-made, water colour papers have the additional advantage that they expand evenly in all directions when they are moistened.

Watermark

A localised modification of the formation and opacity of the sheet, so that a pattern or design can be seen

Wood pulp

Mechanical or chemical pulp made from wood (cf. Non-wood pulp)

Woodfree

Paper made using the chemical rather than the mechanical pulping process.

Woodfree paper

Paper consisting of chemical pulp fibres. It does not contain any mechanical pulp beyond a permissible content of 5% by mass.

Writing paper

Uncoated paper that is suitable for writing with ink on both sides. The writing must neither bleed nor strike through. Writing paper is always fully sized (See "Sized paper") and also suit-able for printing. It can be woodfree or mechanical, depending on the intended purpose. The admixture of fillers makes it less translucent.

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