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Paper industry and environmental issues

Development of Applications of Electricity and Marketing Study Committee

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FOREWORD

Environmental issues are today of major importance for the pulp and paper industry. The initiative to develop and install techniques that will reduce the environmental impact caused by the forest industry has to large extent been a matter for the industry, especially in the Scandinavian countries. New laws and regulations have been introduced that serve the purpose of bringing down the quantities of various outlets from the production of pulp and paper. Such requirements on the industry should to great extent be regarded in the perspective of greater public awareness of the need for protection of the environment and the consumers' demand for chlorine free paper and other similar requirements on the products and the production technology.

More severe environmental requirements have led to increased costs and need for new investments in many pulp and paper plants. In some cases old plants have been shut down, not being able to bear the capital costs associated with the investments needed to meet new environmental standards.

The structural changes in the pulp and paper industry can be regarded as a response to the demand for more environmental protection measures to be taken by the industry. The effect has been that the total number of plants has decreased as well as the number of industrial consortia.

Environmental restrictions will in many cases lead to an increase of the energy consumption and to the application of new technologies. It is therefore of interest to consider what kind of equipment that will be needed and what type of electro technologies that need to be developed and applied in the future pulp and paper mills. The increase of the electric energy consumption for production of thermo mechanical pulps is due to the increasing quality requirements on paper products

The survey given in this paper has been promoted by UNIPEDE (International Union of Electricity Producers and Distributors) and aims at a better knowledge of the paper sector to check how far its electrical technologies are implemented in a spirit of respect to the environment.

The analysis of the paper industry on both European and national levels was carried out to provide a complete scenario of the size of the paper sector through three main lines of presentation: the production of pulp, the production of paper and cardboard and the use of waste paper .

In the first part, after a short description of the production cycle of paper and pulp, the European technical economical data of the sector have been stressed (companies, production, consumption, import/export, etc.).

Then, the environmental problems of the sector have been illustrated relating them to the various types of wastes or pollutants produced (gaseous, liquid and solid ones).

To provide a view as wide as possible on the relationship existing between paper industry and environment, the regulation issued by the EEC with regard to the environment was presented: it highlights the new legislative approach taken by Europe especially through the well known IPPC (Integrated Prevention Pollution Control) directive on the integrated prevention and reduction of pollution deriving from industrial activities. National environmental regulations are also presented in this section of the document.

The analysis of the technologies implemented to reduce and control pollutants paid great attention to the electrical techniques used in the sector to eliminate them at the end of the production cycle as well as to reduce pollutants during the various phases of the cycle itself.

Finally, examples are presented of the electrical techniques used to treat pollutants in the pulp and paper industry.

Many thanks to M. Felippo GIUSTO (ITALY), who was responsible for this survey in the DEVIND group of experts.This report has been carried out with the valuable help of the members of the DEVIND group from Sweden, Finland and France.

SUMMARY

1. OVERVIEW

The average growth rate for paper products in Western Europe is estimated at about 2.5% per year, which means a consumption increase of about 1.9 million tonnes per year up to 2010. Thus, even if the growth rate is moderate, the volumetric growth is very large since the total consumption is as high as 70 millon tonnes per year. See figure 1.1. The electric power consumption will strongly depend on volume changes in the industry but also on process changes due to an increased use of recycled fibres and more stringent requirements on low emissions and effluents from industrial plants.

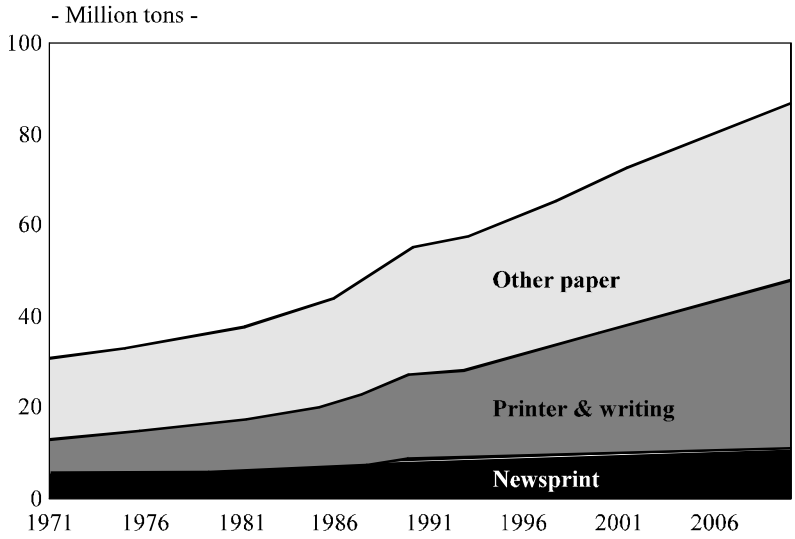


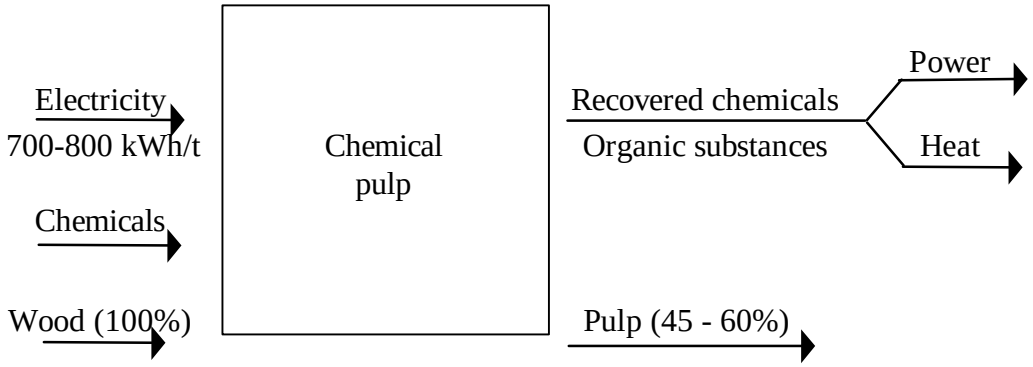
Fig. 1.1 : Consumption of paper in Western Europe 1971-2010

The pulp and paper industry is characterized by two types of products:

- *pulps*: fibrous materials for the production of final products (for newspapers, magazines, packing, wrapping, etc.);
- *papers*: sheets made of fibres (generally vegetal) united in their contact points by bonds between fibres (adhesive agents) and other matters such as fillings, pigments and colouring stuffs.

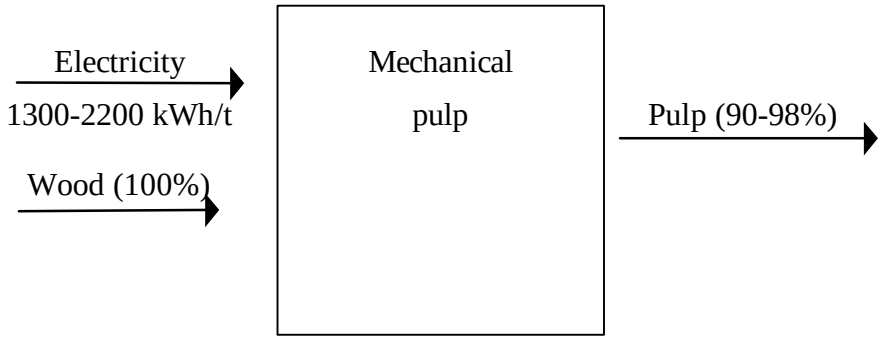
The production of paper can be based on different pulp grades depending on the type of paper in question. The fibre separation can either be carried out chemically, which means that the lignine is released, using chemicals at elevated temperatures, or mechanically, which means that the fibres are separated by a mechanical process. In the chemical process, about 50% of the wood content is transformed to pulp (yield = 50%), whereas for pure mechanical pulp the corresponding figure is almost 100%. In chemical pulp production, a liquor is produced that contains both chemicals and part of the wood substance.

As shown in the figure below, the yield is generally between 45 and 60% in chemical pulp production.



The recovery of chemicals is associated with energy production from combustion of the spent liquor in the soda boiler. This means that a modern chemical pulp plant produces steam and electricity (in back pressure turbines) to the extent needed for the entire plant. In many cases the pulp plant is integrated with a paper production plant and the excess steam from the pulp production is used for drying of paper.

For the production of mechanical pulps the need for chemicals is generally very low whereas the specific consumption of electric power is fairly high as shown in the figure below. The yield varies between 90 and 98% depending upon the type of process in question (stone groundwood, thermo-mechanical pulp, refiner mechanical pulp, chemi thermomechanical pulp).



The use of recycled fibres has increased very much during the last few years as a result of environmental concerns. Today, recycled fibres are not only used for the production of newspapers and tissue, but also for cardboard packing paper and partly for paper qualities like LWC (light weight coated), SC (super calendered) and fine papers. To make possible a more general use of recycled fibres it has become necessary to apply higher degrees of treatment of the recycled paper which has resulted in an increase of the consumption of electric energy from a previous level at about 150 kWh to the present 450 kWh/tonne.

The paper production can, however, never be based on recycled fibres only. New virgin fibres always need to be added in pace with the successive deterioration of fibres that have been recycled several times.

For the **paper production** it is essential that the pulp quality is well adapted to the required paper grade. For fine papers with good printing properties chemical pulps are required. For the production of newsprint paper or cardboard, mechanical pulps are generally used.

The pulp concentration is fairly low at the inlet of the paper machine. The paper web is heated by steam before pressing. Hot-pressing to remove as much water as possible can be carried through by a number of more or less energy efficient techniques (press drying, the Condebelt process, impulse drying etc.) which are all subject to further development. The more efficient the pressing techniques are, the less energy is needed for the paper drying that can be carried through in various ways like microwave

drying, induction heating of Yankee cylinders, infrared technology etc. At the end of the paper cycle the paper sheet needs to be treated in an adequate way to attain the surface and other properties required.

A continued development of the paper making process seems urgent, both with regard to the high energy consumption for fibre separation and the excessive use of water for the treatment of pulps. The drying section of the paper machine is still based on the same principles as when it was invented and the potential offered by new technologies has not yet been exploited.

Pulps

They are essentially vegetal and are classified according to the technological processes used to produce them. Raw materials are: wood, non ligneous plants, textile fibres and waste paper.

Wood pulps

a) They represent 95% of pulps made of virgin[1] fibres used in paper production and are subdivided in various types according to the production process. The processing common to all types of pulps is the preparing of wood: it implies trunk decortication (it consists of mechanical or hydraulic processes with water at very high pressure) and chipping (mechanical process) breaking wood down into scales of 3-4 mm both in the width and in length, and of 3-6 mm thickness.*Mechanical pulp*: it is produced from wood with purely mechanical processes obtaining a mass made of single fibres and fragments of fibres. Raw materials used are fir trees (stone groundwood produced of round wood crumbled through grinding procedures in presence of abundant water), chips of soft wood, wastes from wood processing, saw dust. After the mechanical processes, the pulp is assorted (by sifting) and dried. The pulp is mainly used for newsprint and wood type of papers such as LWC (light weight coated) and SC (super calendered).

b) Thermomechanical pulp

Wood is first steam preheated and then processed thermomechanically in the refiner. Raw materials are soft wood chips and wastes from wood processing. Then other assortment processes are performed. The pulp is mostly used for the same purposes as mechanical pulp.

c) Chemical sulphate pulp (Kraft)

Wood cooking with chemical reagents (Na_2S and NaOH) at 160 - 180° C in boilers (generally tower ones and with a continuous cycle). Chemical reagents dissolve lignin leaving cellulose intact. After the cooking, pulp is washed. Raw materials used are pine, birch, chestnut and beech woods. Bleached sulphate pulps are widely used to produce graphic paper, very thin paper and cardboard. Unbleached pulps are used to produce grooved cardboard, wrapping paper, bags, envelopes, etc.

d) Chemical sulphite pulp

It is a process similar to the previous one where the chemical reagent used is the disulphide acid of sodium. These pulps are used in many sectors: newsprint, printing paper, for sanitary uses and to produce very thin paper. They can be bleached.

e) Semichemical pulps

[1] The term “virgin” indicates the fibre obtained from cellulose; waste paper and recycled paper are called “secondary fibres”

After a cooking procedure which is the same as the one described before for chemical pulps, these products will be further mechanically crumbled. Semichemical pulps are mostly used to produce slightly craped paper and cardboard.

Pulps from non ligneous plants

They are obtained from agricultural residues (leaves, sugar cane), bamboo canes, straw, etc. through the mechanical processing (shredding) of raw materials and boiling with chemical reagents.

All the crude pulps mentioned before may be treated with bleaching (through chemical reagents) to eliminate colouring matters.

Pulps from waste paper (recovery fibres)

The pulp is obtained from mixed waste paper (corrugated, newspapers and magazines, etc.). Generally it is processed mechanically (mechanical kneading, paste removal, beating) also at very high temperature and with chemical additives according to the type of recovery paper being used.

In some cases, the removal of inking is also performed, which implies a washing process of the mixture with the addition of chemical reagents, both dispersing and flocculating, according to the kind of waste paper, to eliminate ink particles.

Paper

Paper is produced by the drying of an aqueous suspension of all the fibrous and non fibrous matters that will form the final sheet. The paper cycle consists of:

- *making up*: the pulp is laid on wire cloths to allow the removal of the water contained in the pulp
- *pressing*: it eliminates as much water as possible by means of mechanical pressing;
- *drying*: the residual water evaporates by means of heat.

Treatments of the final sheet

At the end of the cycle, the paper sheet may be treated in different ways for specific purposes:

- surface sizing: adhesive agents are applied (pressing) to modify paper characteristics (printability, sizing, colours, etc.)
- coating: sheets are treated with an aqueous dispersion of pigments and binding agents to improve the paper features, (printability, look, touch, etc.)

Equipping

They are the final operations for paper production that provide the produce with its final size and/or some peculiar features, among which the most well known are:

- calendering;

- coiling
- size cutting

Paper products are subdivided in : graphic papers, papers for domestic and sanitary usage, packing papers and other types.

Graphic papers include:

- newsprint: a type of paper essentially used to print newspapers and mostly obtained from mechanical pulp or waste paper pulp with or without limited amounts of additives. Weights go generally from 40 to 52 gr./m^2, but they can also reach 65 gr. The final product can be slightly calendered. It can be white as well as little coloured;
- uncoated mechanicals: a kind of paper convenient for topography or other graphic uses, where less than 90% of fibres comes from a chemical mixture. This type is also known as magazine papers;
- uncoated woodfree: a kind of paper convenient for printing and other graphic usage where at least 90% of fibres comes from a chemical mixture. This type of paper can be obtained from different matters with a variable amount of mineral additives as well as with a series of finishing procedures such as calendering, polishing, etc. It includes most of office papers;
- coated mechanicals and woodfree: it includes all the paper suitable for printing and for other graphic uses, it is coated on one side or on both with minerals such as calcium carbonate, kaolin, etc. Coating can be obtained in different ways during the continuos processing cycle or later on.

Papers for domestic and sanitary usage:

- they represent a large amount of very thin papers as well as other types of paper used for hygienic purpose in private houses and in commercial and industrial sites, such as toilet paper, diapers, paper tissues, napkins, kitchen paper and industrial paper, etc. It is obtained from a pulp of virgin fibres or waste paper or even a mixture of both.

Packing paper

- corrugated raw materials: linerboard and fluting essentially used for the production of craped paper. Such material is produced by an association of virgin fibres from newspaper. It can be bleached, unbleached and mottled;
- folding boxboard: it can be single or manifold, its surface is white, both coated and uncoated. It is produced by virgin fibres and/or recycled ones, it can be easily folded and it is also robust. It is mainly used in cardboards for consumption products such as frozen food and liquid containers;
- sack grades (more than 150 gr. per m2); papers mainly used for wrapping and packing are produced by an association of virgin fibres with recycled ones. They can be white or crude and can be treated with different finishing procedures. They include Kraft bags, various types of Kraft packing, waxed papers;

- other papers for packing: they include the most widely used papers and cardboards for packing that are different from the ones described above. Most of them are produced from recycled fibres.

Other types :

- other papers and cardboards for special and industrial purposes. They include cigarette paper, filter paper, special paper to wax, to asphalt and other peculiar uses and treatments.

2. DATA FOR THE EUROPEAN PULP AND PAPER INDUSTRY

In 1995 the European pulp and paper industry engaged, as a whole, 263,484 people that worked in more than 1,300 plants (see Table 2.1) .

Tab. 2.1 - Structure of the paper industry in Europe - 1995

Country	Number of people employed	Number of firms		Number of plants		Overall plants
		p	paper	pulp	paper	
Austria	10,324	7	26	11	28	39
Belgium	5,447	1	14	3	14	17
Denmar	710	0	1	2	3	5
Finland	37,540	10	25	43	44	87
France	26,650	5	115	20	141	161
German	47,493	1	170	26	201	227
Greece	500	0	13	2	25	27
Ireland	560	0	1	0	1	1
Italy	25,900	3	166	16	210	226
Holland	7,400	0	27	2	25	27
Portugal	7,100	5	60	7	65	72
Spain	19,000	6	116	17	130	147
Sweden	32,000	27	33	46	50	96
United	24,071	0	65	4	102	106
Total	**249,195**	**65**	**832**	**199**	**1,039**	**1,238**
Norway	9,000	8	15	19	17	36
Switzerl	5,289	4	27	4	27	31
Total	**263,484**	**77**	**874**	**222**	**1,083**	**1,305**

From CEPI (Confederation European Paper Industry)

The percentage of plants in Europe of different sizes is shown in figure 2.2 and the actual number of plants in each country is given in Table 2.2.

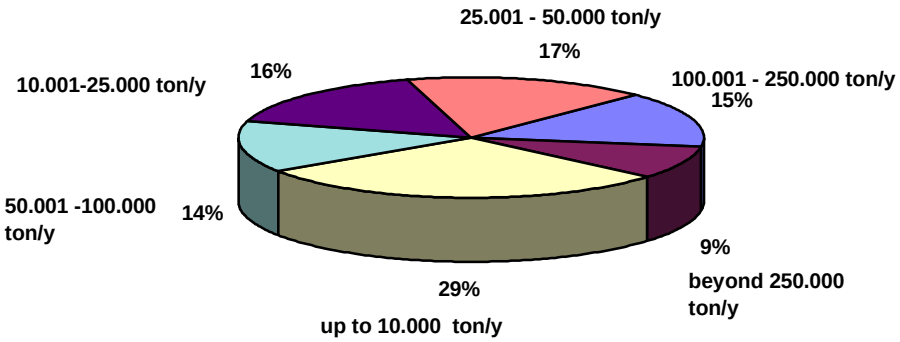


Fig. 2.2 Plants of paper industry distributed according to the amount of paper produced - Percentages

Tab. 2.2 - Plants of paper industry in Europe divided according to country and production type - 1995

Country	Up to 10,000 ton/y pulp+paper	From 10,001 to 25,000 ton/y pulp+paper	From 25,001 to 50,000 ton/y pulp+paper	From 50,001 to 100,000 ton/y pulp+paper	From 100,001 to 250,000 ton/y pulp+paper	Beyond 250,000 ton/y pulp+paper
Austria	6	5	3	7	12	6
Belgium	3	3	0	4	6	1
Denmark	0	0	1	2	2	0
Finland	2	6	6	14	26	33
France	31	27	35	32	27	9
Germany	72	32	36	39	33	15
Greece	9	9	6	3	0	0
Ireland	0	0	1	0	0	0
Italy	93	58	36	24	15	0
Holland	2	3	8	3	7	4
Portugal	56	2	1	4	5	4
Spain	53	32	34	12	13	3
Sweden	4	4	16	15	21	36
United Kingdom	29	18	20	19	17	3
Total EU	**360**	**199**	**203**	**178**	**184**	**114**
Norway	0	4	12	7	6	7
Switzerland	4	7	9	4	6	1
Total CEPI	**364**	**210**	**224**	**189**	**196**	**122**

From CEPI (Confederation of European Paper Industries)

As we have previously introduced, pulp represents both a produce of paper industry and a raw material together with waste paper. Table 2.3 illustrates the European distribution of raw materials used for paper production in 1995. The figures stress the weight of the use of recycled paper that represents on its own about 50% of the total of raw materials utilised (see fig. 2.3)

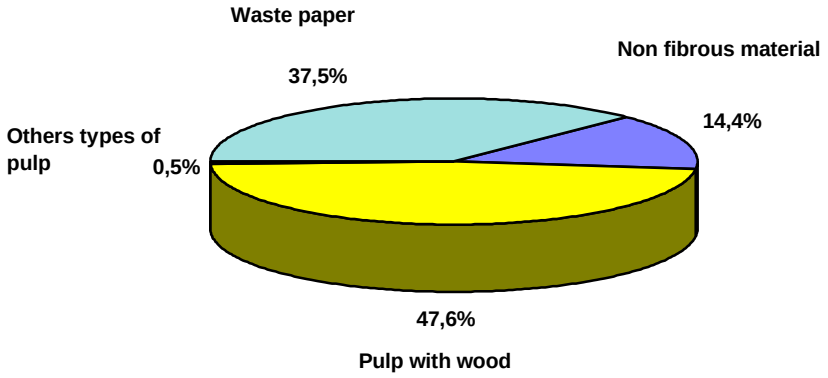


Fig. 2.3 - Percentages of raw materials used to produce paper in Europe - (1995 Data)

Tab. 2.3 - Consumption of raw materials for the paper production in Europe - 1995

Country	Pulp with wood 10^3 ton	Other types of pulp 10^3 ton	Waste paper 10^3 ton	Non fibrous material 10^3 ton	Total of raw materials 10^3 ton
Austria	1,7777.2	0.0	1,442.1	724.8	3,944.1
Belgium	771.9	0.4	313.3	326.4	1,382.0
Denmark	8.0	70.0	384.9	30.0	492.9
Finland	8,692.8	0.0	525.5	2,315.0	11,533.3
France	4,138.4	52.3	4,159.6	1,334.6	9,684.9
Germany	5,1670.0	47.0	8,598.6	2,962.0	16,767.6
Greece	134.7	8.7	166.6	56.0	366.0
Ireland	0.0	0.0	45.4	2.2	47.6
Italy	3,302.3	130.0	3,376.6	1,054.6	7,863.5
Holland	628.6	5.5	2,118.9	328.4	3,081.4
Portugal	631.0	20.0	300.0	126.0	1,077.0
Spain	1,210.3	25.6	2,689.5	571.0	4,496.4
Sweden	7,617.4	13.6	1,427.9	880.0	9,938.9
United Kingdom	2,305.8	27.6	3,997.3	608.4	6,939.1
Total EU	36,348.4	400.7	29,546.2	11,319.4	77,614.7
Total EU	46.8 %	0.5 %	38.1 %	14.6 %	100 %
Norway	1,995.2	0.0	246.1	200.0	2,441.3
Switzerland	582.6	3.0	874.6	236.0	1,696.2
Total CEPI	38,962.2	403.7	30,666.9	11,755.4	81,752.2

From CEPI (Confederation of European Paper Industries)

2.1 The pulp industry

Table 2.4 shows the 1995 European data for the various countries relating to pulp production, export, import, and apparent consumption (amount produced - amount exported + amount imported).

Tab. 2.4 - Synthesis of pulp industry of each European country - 1995

Country	Production 10^3 ton	Export 10^3 ton	Import 10^3 ton	Apparent Consumption 10^3 ton
Austria	1,466.1	221.8	528.3	1,772.6
Belgium	443.3	115.8	624.4	751.9
Denmark	75.0	71.0	54.3	58.3
Finland	10,088.1	1,324.8	88.0	8,851.3
France	2,817.6	399.5	1,837.8	4,255.9
Germany	1,950.2	257.1	3,565.8	5,258.9
Greece	28.0	0.0	144.8	172.8
Ireland	0.0	0.0	0.0	0.0
Italy	455.0	19.7	2,787.3	3,222.6
Holland	148.1	279.4	677.8	546.5
Portugal	1,617.0	950.0	76.0	743.0
Spain	1,576.6	665.5	319.6	1,230.7
Sweden	10,186.8	2,488.6	194.2	7,892.4
United Kingdom	638.5	56.2	1,668.1	2,250.4
Total EU	**31,490.3**	**6,849.4**	**12,366.4**	**37,007.3**
Norway	2,414.0	542.1	115.0	1,986.9
Switzerland	254.0	78.6	399.7	575.1
Total CEPI	**34,158.3**	**7,470.1**	**12,881.1**	**39,569.3**

From CEPI

The main European pulp producers (see figure 2.4) are Sweden, Finland, France, Norway, Iberian Peninsula (Portugal and Spain together), representing about 90% of the whole European production and 85% of the pulp exports.

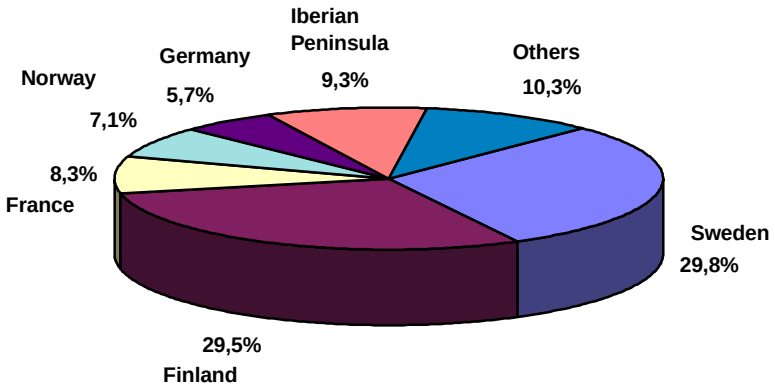


Fig. 2.4 - Main European countries producing pulp (1995 data)

2.2 The paper industry

Tab. 2.5 - Synthesis of paper industry for European countries - 1995

Country	Production 10^3 ton	Export 10^3 ton	Import 10^3 ton	Apparent consumption	Per capita consumption kilos
Austria	3,599.3	2,876.6	828.0	1,550.7	191
Belgium	1,314.6	863.1	2,143.1	2,594.6	236
Denmark	307.1	214.7	1,041.5	1,133.9	214
Finland	10,840.6	9,629.0	221.6	1,433.2	169
France	8,615.2	3,638.7	4,654.5	9,631.0	164
Germany	14,820.5	6,530.2	7,315.3	15,605.6	191
Greece	387.4	52.0	520.0	855.4	83
Ireland	37.5	27.5	363.2	373.2	104
Italy	6,801.6	2,059.5	3,334.4	8,076.5	142
Holland	2,967.2	2,084.0	2,236.7	3,119.9	201
Portugal	977.0	549.6	374.8	802.2	81
Spain	3,684.0	917.7	2,381.2	5,147.5	129
Sweden	9,168.7	7,730.6	417.8	1,855.9	211
United Kingdom	6,092.6	1,210.2	6,417.4	11,299.8	194
Total EU	**69,613**	**38,383**	**32,250**	**63,479**	**170**
Norway	2,263.0	1,958.2	451.2	756.0	175.8
Switzerland	1,433.4	779.0	872.5	1,526.9	215.1
Total CEPI	**73,310**	**41,121**	**33,573**	**65,762**	**171.0**

From CEPI (Confederation of European Paper Industries)

Table 2.5 illustrates the European data of 1995 of each country referring to paper production, export, import and consumption (amounts produced, exported and imported).

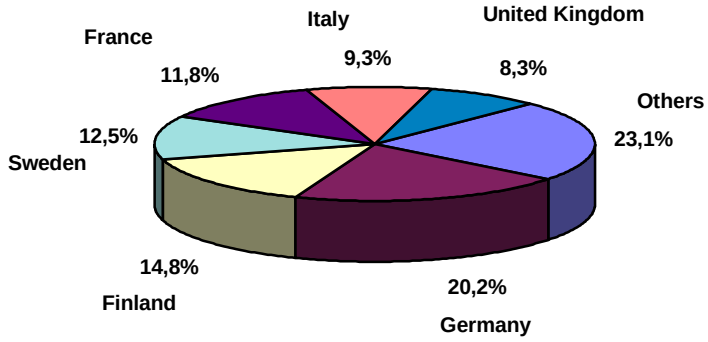


Fig. 2.5 - Main European paper producing countries.

The main European paper producing countries, as shown also in figure 2.5, are Germany, Finland, Sweden, France, Italy and the United Kingdom, while all the other countries represent 23.1% of the whole European production. As far as consumption is concerned, (see fig.2.6) Germany comes first, followed by UK, France, Italy, Spain and the Netherlands.

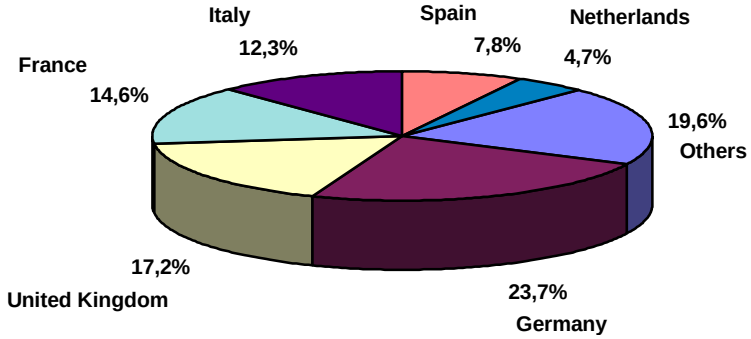


Fig. 2.6 - Main paper consuming countries in Europe.(1995 data)

In 1995 every type of paper had an impact on European total production as in figure 2.7.

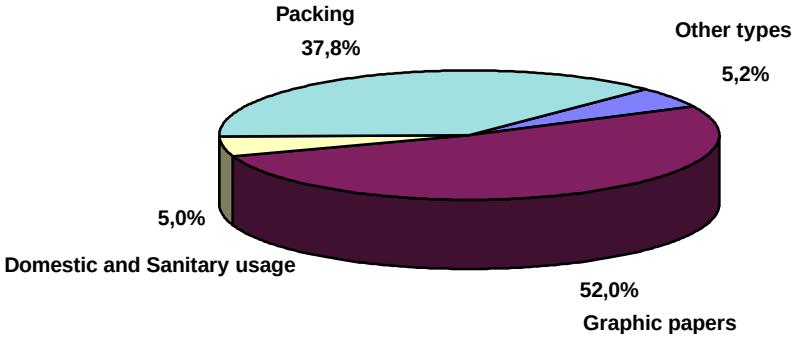


Fig. 2.7 - Weight percentagewise of every type of paper on the total production in Europe. (1995 data) (from CEPI)

The above mentioned data were further studied analyzing in detail the amounts produced by the various European countries for every type of paper. Table 2.6 illustrates the amounts produced by all European countries, the biggest producer of each type shown in bold figures.

Tab. 2.6 - Paper production in Europe according to types and countries - 1995

Country	Graphic papers 10^3 ton	Domestic and sanitary usage 10^3 ton	Packing 10^3 ton	Other kinds 10^3 ton	Total 10^3 ton
Austria	2,143.9	101.4	1,307.2	46.8	3,599.3
Belgium	986.8	not available*	142.8	not available*	1,314.6
Denmark	89.4	0	185.5	32.2	307.1
Finland	**7,881.3**	166.2	2,553.2	239.9	10,840.6
France	4,075.9	487.6	3,770.1	281.6	8,615.2
Germany	7,854.5	**877.3**	**4,543.8**	**1,544.9**	**14,820.5**
Greece	115.9	71.1	200.4	0	387.4
Ireland	0	0	37.5	0	37.5
Italy	2,778.5	553.6	2,899.4	570.1	6,801.6
Holland	1,176.4	160.9	1,626.7	3.2	2,967.2
Portugal	438.0	59	471.0	9.0	977.0
Spain	2,112.3	566.9	2,539.1	352.7	5,571.0 **)
Sweden	1,395.3	239.2	2,051.6	387.4	4,073.5 **)
United Kingdom	4,523.1	292.8	4,344.4	140.5	9,300.1 **)
Total EU	35,571.3	3,576.0	26,672.7	3,608.3	69,613.3
Norway	1,719.0	26.4	514.8	2.8	2,263.0
Switzerland	706.9	82.6	472.4	171.5	1,433.4
Total CEPI	37,997.2	3,685.0	27,659.9	3,782.6	73,309.7

*) The datum is not available

**) These data do not seem to be correct and are not in accordance with the figures in Table 2.5

From CEPI

More than 50% of European production was concentrated on graphic paper which, as stated previously, includes writing paper and paper for the press, coated paper (with or without wood) as well as uncoated paper (with or without wood).

2.3 Waste paper

Table 2.7 refers the data of the management of waste paper for each European country. It is worth considering that the data on the domestic collection are inferred: in fact, knowing the amounts of consumption, import and export, we defined the domestic amount collected within each country.

Tab. 2.7 - Synthesis of waste paper for each European country - 1995

Country	Domestic collection * 10^3 ton	Import 10^3 ton	Export 10^3 ton	Consumption 10^3 ton
Austria	1,012.1	510.0	80.0	1,442.1
Belgium	918.7	117.1	722.5	313.3
Denmark	534.6	116.9	266.6	384.9
Finland	500.5	55.4	30.4	525.5
France	3,702.0	1,244.9	787.3	4.158.6
Germany	10,530.8	1,053.6	2,985.8	8,598.6
Greece	166.3	12.0	11.7	166.6
Ireland	45.4	0	0	45.4
Italy	2,351.0	1,083.1	57.5	3,376.6
Holland	2,049.1	1,168.9	1,099.1	2,118
Portugal	298.0	39.0	37.0	300.0
Spain	2,117.6	607.4	35.5	2,689.5
Sweden	996.7	614.0	182.8	1,427.9
United Kingdom	3,964.8	295.2	262.7	3,997.3
Total EU	**29,187.6**	**6,917.5**	**6,558.9**	**29,546.2**
Norway	343.6	71.5	169	246.1
Switzerland	925.7	205.3	256.4	874.6
Total CEPI	**30,456.9**	**7,194.3**	**6,984.3**	**30,666.9**

* Domestic collection = consumption + export - import

From CEPI

Figure 2.8 shows the collection rate of every country, that is the weight, percentagewise, of the amount of recyclable paper collected versus the apparent consumption of paper (as said previously: amount produced + amount imported - amount exported).

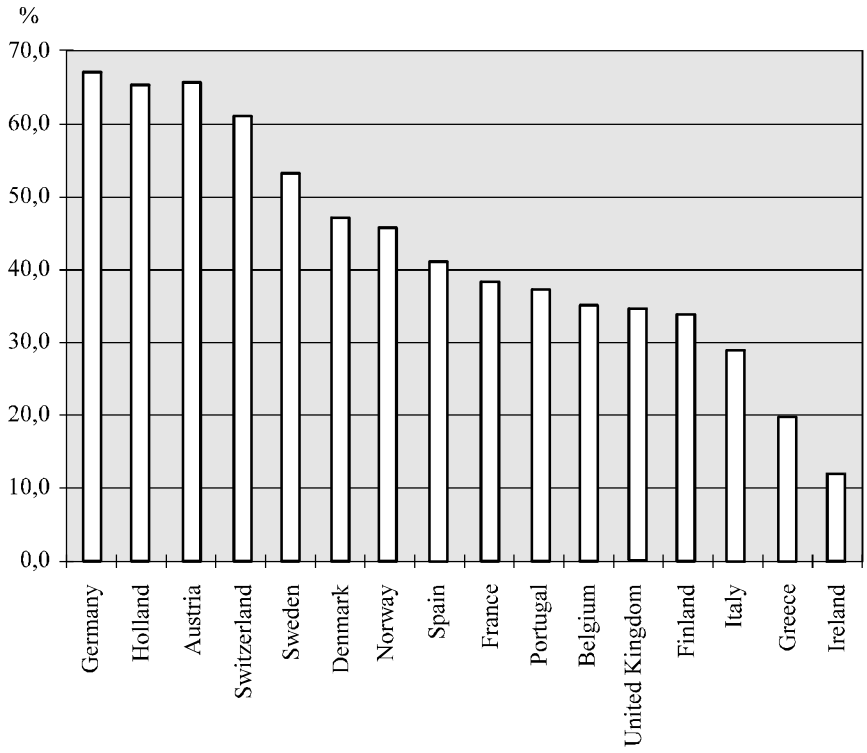


Fig. 2.8 - Collection rate of waste paper (1995 data) (from CEPI)

2.4 The pulp and paper industry in different countries

2.4.1 Belgium

The number of plants for pulp production in Belgium is 3 and the number of paper mills is 15 (1995 figures). The annual production of pulp was about 443 000 tonnes per year, 236 000 tonnes being mechanical pulp and 207 000 tonnes chemical pulp. The production of paper and paper board was 1 315 000 tonnes/year.

The total energy consumption in the pulp and paper industry in 1994 was estimated at 22.8 mill. GJ or about 6332 GWh/year. The electric power consumption was 3718 GWh whereas the natural gas consumption accounted for 978 GWh and other energy sources for 1636 GWh.

The electric power consumption for different steps in the production process was as follows:

Pulp production	64 %
Fibre preparation, refining, purification etc	22 %
Paper mill: heating, pressing, drying	8 %
Paper finishing: surface treatment, calendering	4 %
Treatment of water and effluents	2 %

Different methods of reducing the energy consumption for paper production are being developed and the production technology is being improved, e.g.

- increasing the dry content of paper by improved pressing technics will reduce the heat consumption for drying of paper
- new production technology for pulp production (”explosion pulping”) would reduce the electric energy consumption by 25%. No application is expected before year 2000.
- an increased use of recycled fibres will reduce the electric energy consumption
- increased automatization and improved production technology will increase the production capacity
- the water consumption will be reduced
- the speed of the paper machines will be increased

2.4.2 Finland

The pulp and paper industry in Finland is mainly an export industry. In 1995, Finland exported paper and board at a quantity of 9,7 million tonnes which is nearly 90 % of the total production. Only a small fraction was consumed in Finland. Finland is the sixth largest producer of paper and board in the world, producing 10,9 million tonnes of paper and board.

Production plants	number of mills	production million tons	export % of production
pulp mills - chemical pulp inc. semichemical - mechanical pulp	43	10.1 6.3 3.8	15
paper mills	29	8.6	91
board mills	16	2.3	84

In Finland there are 17 chemical pulp mills and four semichemical mills and 22 mills producing mechanical pulp. The chemical mills are generally big, producing 250 000 tonnes per year of bleached sulphate cellulose. This is the result of a versatile use of raw materials, environmental requirements, use of advanced technology and the market demand.

Crucial for the growth of mechanical pulp production has been the price of energy in Finland compared to competitors. Chemical pulp industry is energy self-sufficient. Chemical pulp industry produces all the energy it needs by burning bark and spent liquor from sulphate cooking processes.

The value of exported products of pulp and paper industry is FIM 39 900 millions. Export of paper corresponds to two thirds of that value and about 75 % of the value of paper export comes from printing and writing papergrades.

Pulp-, paper- and board mills employ directly about 38 000 employees.

Primary energy consumption in the forest industry, including mechanical forest industry, was 8,9 Mtoe including fuels and electricity. Consumption of electricity was 22,2 TWh. 40 % of the energy was obtained from wood, 16 % purchased electricity, 16 % nuclear power, 10 % from hydro power and 3 % of peat. Fossil fuels (oil and coal) accounted for only 6% and natural gas for 9 % of the energy used.

The consumption of electricity in the pulp and paper industry was 20,8 TWh (1994).

2.4.3 France

The paper and cardboard industry in France is divided into six sub-branches:

- Manufacture of pulps for paper
- Manufacture of papers and cardboards
- Manufacture of paper industry accessories
- Paper processing
- Manufacture of corrugated cardboard, and of corrugated cardboard products
- Manufacture of cardboard boxes

The upstream branches (pulps and paper manufacture) represent 35.8 % of the turnover and 28.7 % of the employees working for the cardboard papers industry. The downstream branches represent 64.2 % of the turnover and 71.3 % of the employees working in this area.

In general, this area is less integrated and is characterized by a stronger productivity than the manufacturing industries in general, especially this is valid for the upstream activities.

The pulp production and the manufacturing of paper have large shares of export (more than 40 % of the turnover in 1991) in contrast to the paper processing activities.

The upstream activities (pulps and paper manufacturing) are the largest energy consumers: 79.5 % of the energy consumption for only 36.7 % of the cardboard paper industry turnover. Among the downstream activities, the paper industry and the boxes have the lowest energy consumption. The distribution of pulp and paper companies according to size is displayed below.

Size of the firms	**from 10 to 19**	**from 20 to 49**	**from 50 to 99**	**from 100 to 199**	**from 200 to 499**	**> 500**	**total > 20**
Number of firms	238	358	140	97	103	34	732
Number of employees	3521	11641	10439	13373	31628	35867	102498
Turnover (MF)	2369	8373	9301	11716	31468	43875	107732

Growth of the pulp and paper industry

Between 1988 and 1991, the productivity of the cardboard industry increased on an average by 3 % per year in volume. The upstream activities (pulps and manufacturing) were even more dynamic. The apparent working productivity in the manufacturing has increased annually by 3.6 %, whereas it has decreased in the pulp production where the rates were reduced by 25 % in 3 years.

Within the downstream activities, the paper industry and the corrugated cardboard were the most dynamic sectors. Since 1988 the apparent productivity in this industry has increased to an annual value of + 2.1 %, more strongly in the corrugated cardboard sector (+ 4.9 %), and even with a decrease in the paper processing.

Size

There is a big difference in size between the pulp and paper plants. Firms with more than 500 employees generate 41 % of the turnover of the sector (to be compared with 57.7 % for the whole industry, except energy and food industry), but the upstream activities are more concentrated, in particular for the paper manufacture where the great units account for 2/3 of the turnover.

The downstream activities are less concentrated, in particular paper industry and paper processing where the large units respectively account for only 23 % and 34.8 % of the turnover.

Diversification

The cardboard paper industry is poorly diversified and the different branches account for 98 % of the turnover of the sector.

Among the downstream activities, the production of the plastic wrapping is the essential centre of diversification ; the corrugated cardboard and wrapping branches are least diversified.

Integration

The added value rate of this very energy intensive area is quite poor, especially in the pulp manufacturing area. The energy purchases of the cardboard paper industry indeed correspond to 3.4 % of the 1991 turnover (2.1 % of which is for electricity purchases) to compare with only 1.4 % for the whole industry including food industry but excluding the steel industry (0.8 % for the electricity purchases).

Geographic location of the activities in France

The cardboard paper industry is widely scattered over the whole territory, but the upstream activities are more concentrated around the highly forested regions : "Nord-Pas-de-Calais, Rhône-Alpes, Lorraine, PACA, Midi-Pyrénées".

Among the downstream activities, the "Nord-Pas-de-Calais, Rhône-Alpes, Ile-de-France, Alsace" regions include the main part of the employees of these sectors.

Foreign trade

This area meets an important competition from Scandinavia and Germany (especially they profit from competitive tax advantages and opportunities to make tax free funds or to achieve shorter payoff times), South East United States, as well as countries in the Southern Hemisphere that benefit from a weak dollar.

In particular, the pulp manufacture is the activity of this industry which is to highest degree subjected to competition and the penetration rate on the home market is about 80 % since 1986.

Except for processing, which benefits from the advantage of geographic closeness, downstream activities of the cardboard paper industry are poor exporters and with low competitiveness on their respective home markets.

Profitability

On the whole, the return of the sector is comparable with the remainder of the French industry (except energy and food industry) but it has decreased strongly since 1988 in the area of the pulp manufacturing because of an exceptionally strong boost of the investments. Thus, in 1991 the financial taxes were approximately 10 % of the turnover vs 5.2 % for the paper manufacture and 3.7 % for the whole cardboard paper industry, respectively.

In the paper and the paper processing industry, the financial charges in 1991were about 3 % of the turnover, which nevertheless remains less than the figure for the whole cardboard paper industry (3.7 %).

Investments

The investment rate in the pulp and paper industry is practically twice as high as in the entire French industry and has increased strongly since 1984, in particular for corrugated cardboard and in the paper processing. The rate of self financing is widely insufficient and even negative for the pulp manufacturing.

The investment for manufacturing (technical installations, industrial equipment and tools) represents 3/4 of the expenditure and 90 % is directed to pulp production.

The self-financing rate is rather satisfying in the downstream activities, except for processing.

The productive investments (technical installations, industrial equipment and tools) represents 2/3 of the expenditure for paper and corrugated cardboard paper industry.

Energy consumption

The energy consumption in 1990 in the whole pulp and paper industry as well as in the different sub-branches was as follows

1990	Electricity	Fuels	Electr.+fuels
Pulp and paper industry	GWh	kToe	GWh
Total consumption	9674	2516	38130
Pulp production	1042	624	6298
Paper and cardboard	6971	1702	26762
Paper accessories	99	9	204
Product from processing	933	147	2642
Corrugated cardboard &processing	558	171	2547
Cardboard boxes	270	98	712

2.4.4 Germany

In Germany 224 pulp plants and paper mills were in operation 1995 (19 pulp companies and 168 paper companies). The pulp production 1995 was 1 956 000 tonnes, 27% being chemical pulp and 63% mechanical pulp. The paper production was 14 457 000 tonnes.

After the positive sales balance in 1994, the paper market in Germany was very non-uniform during 1995. The inland-sales decreased by 4% in 1995. The per capita consumption was 194 kg (1994: 200 kg). The production of paper and cardboard increased by about 3% (1995: 14.8 mill. tonnes) as a result of the growing export. The export of paper and cardboard increased in 1995 by 8% up to 6.2 mill. tonnes. The export share of the production in Germany increased from 40% (1994) to 42% (1995).

The German pulp and paper industry imported 3.69 mill. tonnes of chemical pulp in 1995 (= 97% of the consumption of chemical pulp) The import rate of paper and cardboard was 45% of the consumption. The consumption of waste paper increased by about 5% (51.2%) and maintained its dominant part of the raw materials.

In 1995 there has been a rise in the turnover (20%) up to 20.6 bill. DM. This was possible due to the increased production and the increased paper price. The cash flow was 9.5% (1994: 6.8%) of the turnover but in the opinion of the pulp and paper industry this is still insufficient and the intention is to reach a level of 14%. The pulp and paper industry invested 1.2 bill. DM in 1995 (5.8% of the turnover, the figure for 1994 being 9.3%).

Since 1980, the energy consumption decreased from 4.625 kWh/tonne paper down to 3.259 kWh/tonne paper (old federal states). It is expected that this trend will continue for the next few years. The new federal states have a strongly increasing demand and are busy to build up efficient plants and production lines. Actually, the energy use is higher than in the old federal states.

The energy consumption during 1995 was as follows:

Electricity	13 858 GWh (end use of energy)
Coal	9 798 GWh (1 301 000. tonnes)
Oil	4 730 GWh (415 271 tonnes)
Gas	22 511 GWh (2 800 mill. m^3)

Others	6 507 GWh

2.4.5 Ireland

Smurfit Paper Mills at Clonskeagh, Dublin 6, is Ireland's only paper mill. The process which runs continuously involves 100% recycling of paper and is chemical-free. The company helps Ireland meet its environmental targets by recycling 45 000 tonnes per year of waste paper. If the paper mill closed, this material would have to be used as landfill or burned.

2.4.6 Italy

The Italian paper industry includes 166 companies with 210 plants and about 26,000 employed people (1995). The table below illustrates the trend of the paper industry in Italy during the last ten years.

Year	Companies*	Plants*	Personnel*	Variations %
1986	177	230	28,000	-1.1
1987	175	228	27,800	-0.7
1988	175	228	27,900	0.4
1989	176	227	27,900	0.0
1990	175	224	27,900	0.0
1991	175	222	27,900	0.0
1992	174	219	27,300	-2.2
1993	169	213	26,500	-2.9
1994	167	211	26,000	-1.9
1995	166	210	25,900	-0.4
* Companies and plants producing less than 1,000 tons are not included				

(2) "Paper industry" - Supplement to May-June 1996, No. 3 - Assocarta

The high number of paper plants must be linked with a typical feature of Italian paper industry: that is the outstanding role played by the many smaller production centers, highly keen on production of a particular value and quality universally appreciated.

The energy consumption of the paper sector, leaving out the self-production of electricity, amounts to 2,347,000 Toe according to the data of the energy national balance of 1994; it is subdivided as follows:

- natural gas 58%
- electricity 30%
- oil products 12%

In 1994 408,000 toe were self-produced: the use of natural gas for the self-production of energy is predominant, meeting more than 90% of the total requirement.

Italian paper industry represents one of the main industrial sectors with regard to the use of electricity, with its consumption of about 7 billions of kWh. Almost 60% of this energy is picked up from the ENEL network and more than 40% (more than 2.7 billions of kWh) comes from self-production.

With regard to the 80 cogeneration working plants, 15 are equipped with gas turbines with total power of more than 200 MW equaling almost 40% of the total installed power. Such technology is common mainly in the large paper companies, but a considerable development on a short time basis

among small and medium sized ones is envisaged. In the near future 15 additional plants with gas turbines will start working which would rise the power of present 200 MW to more than 300, i.e. to 50% of the power installed in the paper industry.

The development of the *pulp industry* in Italy is shown in the table below.

Year	Production	Import	Export	Apparent Consumpt.	Export on production	Import on app. cons.
	10^3 ton	10^3 ton	10^3 ton	10^3 ton	%	%
1986	646.1	1,821.7	51.7	2,416.1	8.0	75.4
1987	672.0	2,085.3	43.6	2,713.7	6.5	76.8
1988	702.7	2,230.4	58.4	2,874.7	8.3	77.6
1989	685.4	2,100.0	67.1	2,718.3	9.8	77.3
1990	596.4	2,049.8	70.0	2,576.2	11.7	79.6
1991	509.4	2,309.2	59.6	2,759.0	11.7	83.7
1992	442.1	2,451.1	12.4	2,880.8	2.8	85.1
1993	404.5	2,477.1	34.2	2,847.4	8.5	87.0
1994	426.4	2,669.0	26.4	3,069.0	6.2	87.0
1995	455.0	2,787.3	19.7	3,222.6	4.3	86.5

Assocarta estimates and CEPI data for 1995

The domestic production of paper pulp covers 13% of the total consumption (it is concentrated in the segment of mechanical pulp) and leaves the remaining 87% to the foreign market. As for chemical pulps, import is more than 98%.

The development of the *paper production* in Italy in figures is shown below

Year	Production 10^3 ton	Import 10^3 ton	Export 10^3 ton	Apparent Consumption 10^3 ton
1986	4,807.2	1,791.7	1,075.8	5,523.1
1987	5,107.9	2,123.7	1,162.6	6,069.0
1988	5,512.4	2,149.2	1,309.2	6,352.4
1989	5,735.1	2,491.6	1,373.1	6,853.6
1990	5,759.9	2,760.7	1,404.3	7,116.3
1991	5,932.2	2,846.0	1,511.0	7,267.2
1992	6,131.9	3,299.9	1,630.1	7,801.7
1993	6,188.2	3,264.3	1,946.4	7,506.1
1994	6,705.6	3,206.1	1,825.3	8,086.4
1995	6,801.6	3,334.4	2,059.5	8,076.5

Assocarta estimates and CEPI data for the year 1994 and 1995

2.4.7 Spain

The production of pulp and paper in Spain in 1990 has been described as shown below.

	Pulp, Cardboard	**Processing of paper and cardboard**	**Graphic arts**
No. of companies Total	**149**	**948**	**6 813**
< 20 workers	35	640	5 903
20 - 49 workers	40	170	632
50 - 99 workers	30	74	159
100 - 499 workers	41	64	111
> 500 workers	3		8
Employees	**16 311**	**25 500**	**90 000**
Energy consumption			
Electricity	3 000 GWh	450 GWh	600 GWh
Heavy oil	322 000 tonnes	55 000 tonnes	6 000 tonnes
Diesel oil		10 000 m^3	11 000 tonnes
Natural gas	350 mill. m^3	2.5 mill m^3	9 mill. m^3
Production			
	1 mill. tonnes Pulp	1.5 mill. tonnes Corrug. cardboard	
	1.2 mill. tonnes Paper for printing	0.1 mill. tonnes Packing paper	
	2 mill. tonnes Paper, cardboard	0.27 mill. tonnes Cardboard/packing	

The total production was over 14.2 mill. tonnes with the following distribution:

- Paper and cardboard manufacturers 43.2 %
- Paper and cardboard processing 15.3 %
- Graphic arts 41.5 %

Considerable increases in the consumption of natural gas are evident in addition to a notable reduction of in the consumption of heavy oil in favour of diesel oil. Electricity consumption provides a constant flat development with a slight upwards tendency.

2.4.8 Sweden

Considerable structural changes have occurred in the Swedish pulp and paper industry since about 1970. The number of plants for pulp production has decreased from 98 in the year 1970 to 46 in 1995 and the number of paper mills has decreased from 69 to 50 during the same period. The concentration of production plants was made in conjunction with an increase of the production from 8.9 to 10.2 million tonnes of pulp and from 4.8 to 9.2 million tonnes of paper per year. During the late 1980's the Swedish forest industry expanded considerably in Europe. The total amount of paper production in Swedish companies is about 16 million tonnes, 6.5 million of which are produced outside Sweden.

The structural changes in the Swedish pulp and paper industry will presumably continue for the next 15 years which means that the number of plants will continue to decrease whereas the production capacity will increase.

The total use of energy in the pulp and paper industry in Sweden is about 68 TWh per year. The use of electric energy is around 18 TWh, 15% of which is produced as backpressure power in the plants. The consumption of fuels is about 50 TWh, 80% of which can be attributed to wood fuels.

Around 60% of the electric energy is used for the operation of pumps, fans, agitators and a number of other machines. 10% is used for lighting and for electric boilers whereas the remaining 30% is used for the operation of chip refiners in the production of mechanical pulp. The specific use of electric energy in kWh per tonne has been fairly constant during the past 20 years and is, if regarded as an average, not expected to change very much in the time perspective up to the year 2010.

New emerging technologies may of course influence the use of electric energy in the pulp and paper industry. The major changes in the use of electric energy are, however, due to the development of the market for mechanical pulp. The present trend of increased recirculation of newsprint paper will probably reduce the need for thermomechanical pulp. The corresponding reduction of the use of electric power may be 1 - 2 TWh/year.

3. POLLUTANTS TO BE CONSIDERED IN THE PULP AND PAPER INDUSTRY

3.1 The forestry issue

Owing to the high amount of forest wood consumed, not to forget its water and energy requirements, the paper sector may have huge negative effects on the environment if not well integrated with forestry industry.

Since last century wood cellulose has represented the main raw material to make paper, which meant the extensive deforestration in every paper producing country of the world especially in the first half of last century.

In the last decades a new trend going in the opposite direction has taken place with a view to replace the old approach of wild deforestration with initiatives of maintenance or even of promotion of forestry, it being considered as a natural resource.

Nowadays most of the wood required for the production of paper cellulose comes from land cultivated according to planned production cycles. Furthermore, considering that 7 kg of clean timber are necessary - i.e. after having removed leaves, branches, corteces and roots - to yield 1 kilo cellulose, cellulose production is more and more directed towards the recycling of wood industry wastes. In fact, in some countries, (France, Portugal, Canada, Brazil, Argentina, etc.), where forestry areas increased, the same growth was recorded also for cellulose production.

Forestry resources of Northern Europe, USA and Canada are managed so as to provide the paper industry with future stocks consistent with the general interest of safeguarding natural as well as environmental resources (larger forests bind carbon dioxide thus lowering the greenhouse effects).

The more and more widely spread usage of waste and recycled paper has greately contributed to reduce the impact of raw materials on the environment.

Recycled paper implies environmental advantages as fewer trees are felled and some materials (waste paper), which otherwise would have increased the volume of wastes, are recycled.

The recycling of the same fibres cannot, however, proceed more than a limited number of times. Even if the collection of waste paper runs efficently there will be a remaining need for adding virgin fibres for the paper production.

3.2 Technologies

We will now describe the main pollutants of the paper industry together with their processing techniques according to the areas of pollution.

As waste waters represent the heaviest polluting factor of paper industry, the technology used to reduce their pollutants will be more deeply analyzed in paragraph 3.2.4 and in chapter 4 with particular regard to technologies using electricity. The technology for reduction of pollution caused by air emissions and solid wastes is not treated in this chapter.

3.2.1 Air emissions

a) Energy production system

Pollutants: NO_x, SO_x, CO

All production sites of the paper sector are endowed with a steam producing thermal power plant. Such thermal power plants in paper mills may be supplied with natural gas - whose combustion emissions have a low content of pollutants - and with a liquid fuel of low sulphur content. The positive achievements obtained with modern burners and fuels whose emissions are free from sulphur anhydrides, ashes, and heavy metals limit air pollution within legal constraints. Such provisions and the size of emissions do not require chimneys to be equipped with anti-pollution devices.

Furthermore, the type of energy consumption of a paper mill - high thermal and electrical consumption represents - the ideal situation to set up cogeneration plants: in Italy for instance, the paper sector through its self-production covers more than 4% of its electrical consumption, and such plants are generally supplied with natural gas. In Sweden, the self-production of electric power is above 15% of the total need.

b) Production plants

During the production phase there might be limited emissions of pollutants with steam outgoing after the drying phases of the produce, but it is a secondary problem.

3.2.2 Solid wastes

Solid wastes consists of sludge produced by substances present in suspension and in solution in processing water. Particles in suspension are generally cellulose fibres and ground materials, while particles in solution are starches and colloids of a natural origin present in cellulose, together with other elements added to enrich the final product with specific features. They are generally the outcome of the kneading procedure and they are very frequent in the industry using waste paper only (or in any case high amounts of such paper) for pulp kneading. Sludges from virgin fibres are recycled in the producion process while sludge from waste paper are dumped or burned (in fact they can be very well used as fuels in energy recovering incinerators).

3.2.3 Waste water

Paper industry requires a huge amount of water from its production cycle. The tariff limits and quality constraints imposed on the quality of waste waters (fines and punishments are enforced in case of enfringements) stress the importance of protecting water resources. The water requirement for paper production is measured in m^3 of water let out per one ton of produce, (the datum includes all the water used leaving out drinkable water and/or water for hygiene-health services and also cooling water).

Generally consumption is based on the type of products as well as on the possibility of recycling water and sludges.

There are no statistical data on paper mill average consumption, anyhow consumption generally goes from 100/150 m^3/ton of produce in small and medium mills up to 30/50 m^3/ton in very efficient ones.

In a paper mill water is used in three different ways:

a) processing water: it is the water used for technological processing and can be broken up as:

- water for manufacturing used to knead pulp;
- water for washing, used in softeners, on clothes, felts, etc.
- water for cooling and lubricating to make machines work.

b) water for general purposes: **it is used in the cooling systems placed outside the processing plant to supply and cool the thermal power plant, etc.**

c) drinkable water for hygiene-health purposes

The water exceeding the water types mentioned above make up the waste water that paper mills let out as follows:

- through softeners if the water has been used for manufacturing or cooling purposes
- in separate ad hoc installations if the water comes from thermal power plants, hygiene-health services and/or cantines;
- directly, if it is rain water or comes from a cooling system (of course, it must be free from pollutants in its flow).

Apart from the disposal of waste waters (we will illustrate the techniques implemented to control and limit their pollutants later on), it might be interesting at this point of the presentation to analyze the features that the water supplying a paper mill must have.

Water resources can be of two different types :

- surface waters - coming from rivers, basins, lakes, etc. that may contain different amounts of both organic and inorganic pollutants according to the seasons and soil through which they flow; pollutants are particles in solution or in suspension or of a colloidal type; bacteria may also be present and some surface waters may contain wastes from the civil or industrial sites;
- ground waters coming from wells with a high content of mineral salts (very hard ones) and a low rate of organic pollution.
- The most common forms of contamination of supplying waters are:
- torbidity, due to solid particles in suspension;
- colouring, due to organic materials in solution;
- hardness, due to magnesium and calcium salts;
- presence of silica causing harmful incrustations;
- presence of iron and manganese that may colour kneadings.

Categories supplied with well-waters generally need no further processing while those supplied with surface waters must reduce or limit pollutants to avoid later negative impacts both on equipments and final produce.

The main goal is to reduce the amount of particles in suspension and to this end the most common procedures implemented are :

- sedimentation
- filtration
- coagulation

With regard to waste waters from paper mills, the main pollutants are :

- BOD and COD

  Such parameters indicate the content of organic pollutants.

  BOD (Demand of biological oxygen) measures the content of biodegradable substances and COD (Demand of chemical oxygen) represents the total content of organic pollutant. The BOD/COD ratio, always less than one, represents the biodegradability level of the drained water. In paper mill waters COD is the result of particles in solution such as the derivatives from lignin, starches, adhesives, oxidizable inorganic salts, etc.

  Such substances are found mainly in paper mills either processing waste paper or using wood pulp.

- Chlorinated organic compounds

  They are essentially due to the bleaching processes of cellulose pulp to obtain a good content of white in final products (sanitary, graphic, coloured papers, etc.); they have a high molecular weight and are not volatile.

  Organic chloroderivatives are practically absent in the nature and they represent some features harmful to living organisms (limited biodegradability, liposobility and toxicity, some of them may also be cancerogenous).

  Ever since its discovery, chlorine underscored its bleaching capacities towards the colouring substances of vegetal fibres and therefore it is the most well known bleaching agent at first as a gas and then as a dioxide.

  The latest technological evolution detected alternative bleaching agents such as ozone and hydrogen peroxide. The detection of bleached celluloses without using both chlorine-gas (ETC) and also chlorine compounds (TCF) represents a sound improvement in the reduction of the impact carried out by paper industry on the environment and the forecast goes that by the year 2000 the use of chlorine for bleaching purposes will be further reduced by more than 70%. Up to ten years ago, the average level of the release of chlorine or its components was about 5-7 kg per pulp ton while, at present, a plant using the ECF bleaching process produces an amount of chlorine pollutants less than 1 kg per one produce ton (in the case of TCF even lower quantities may be produced but zero level can never be reached because chlorine is a compound widely present in the nature as well as in wood).

- colouring particles in suspension

  They are due to ligneous sulphonic compounds and titanium dioxide.

- sedimentable materials

They are made of fibres, minerals and sand; they can settle spontaneously or with a minimum addition of flocculating agents.

- colloidal materials in suspension

  they are particularly abundant when waste paper or wood pulp have been used for kneading.

- inorganic source

  They derive from the processing cycle of paper and consist in carbonates, chlorides, sulphates, etc.

- other pollutants

  In mills using large amount of waste paper, pollutants of various origins and types are present in solution.

  BOD and COD values and chlorine containing substances are drastically reduced through mechanical and biological processing installations, during the production phase of kneading and also with softening systems for water recycling (ultrafiltration, inverse osmosis, etc.).

3.2.4 Technologies for water treatment

Various types of technologies are used to soften the liquid wastes of the paper sector. The following paragraphs will leave out electrical techniques as they will all form the subject of the next chapter.

a) Primary chemical and physical treatments

The water used for production is collected in a basin where, in turbulent conditions, calcium and aluminium salts are added and sometimes also polyelectrolytes. If the pH is modified, flocculi are formed and they favour the aggregation of colloidal substances in suspension as well as the adsorbtion of organic substances in solution. The dirty mixture is then sent to a hot water clarifier where the separation of the precipitated takes place.

It is an easy process allowing to eliminate solids in suspension as well as some organic particles. Nevertheless COD is only partially reduced unless waste waters are still very rich of fibrous residues. Wherever possible, sludges obtained are recycled to produce paper and cardboard in the same mill or in other plants making produce of a lower quality. In other cases, these sludges are joined to those coming from biological plants and only afterwards they are disposed of. The cost of investments and of flocculating reagents are limited, instead the sludge disposal is very expensive. Anyhow, this treatment is almost always present in a production site of the paper sector.

b) Secondary treatments

The most widely used is the oxidation of pollutants obtained by active sludges. In aerobic conditions, the growth of bacteria species implies oxidation through the biological reaction of organic products as the source of the energy and the materials needed for cell synthesis. Such reactions are the same as those enabling the selfpurification in nature of the waters of rivers and lakes. Biomass has a large specific surface that destroys pollutants and furthermore acts as a flocculating agent adsorbing the various compounds not involved in biological processes.

The waste water coming from primary treatments flows into big basins where air is blown into and to which nutritional substances are eventually added to stimulate the growth of active sludges. An oxidation phase lasts on an average from 12 to 20 hours according to the type of plant and pollutants. In the following water clarifiers sludges are separated; some of them are recycled to keep the best possible balance between pollutants, the amount and age of sludges. Softened waters are then outlet or sent to tertiary treatments while sludges are first thickned in order to reduce their water content and then stabilised and finally dumped or burned.

Biological plants run non-stop and the speed of wastes in the various compartments of the plant determines reactions time. In such plants the organic substances are eliminated as well as the nitrogen compounds and phosphorous by adding some basins kept in aerobic and anaerobic conditions.

The setting up of the plants is standardized, still their running is very delicate as many factors must be kept under control, such as: the quantity of oxygen solved in the various parts of the plant to ensure a good airing of the procedure, the presence of substances that might endanger biomass, the average age of the sludges, the biomass composition. The plants have a good softening capacity depending on the features of the organic substances. Of course they also had some drawbacks: they need space; they produce gaseous unpleasantly odorous emissions; they bring out sludges that must be disposed of; they need staff skilled in running and analytical operations; they become easily useless if products harmful to the biomass are introduced into the waste waters. The running cost depends on energy consumption, staff and sludge disposal.

To reduce sludge volumes biological plants with filters or towers can be built or and air can be replaced by oxygen.

Active sludge equipments can be found in all medium sized plants to abate the organic substances present in waste water so as to outlet them into surface rivers or to comply with the less restrictive limits enforced by the managers of consortium plants.

3.3 Emissions and effluents in different countries

3.3.1 Finland

In 1995 the Finnish forest industry invested at total of FIM 700 millions in various projects promoting environmental protection. Water protection measures accounted for about 74% of environmental investments, air pollution control for a good 23% and other waste management for 3%. Most of the effluent treatment plants have been built during the last ten years.

In the pulp and paper industry a total of almost FIM 7 billion has been invested in environmental protection during the past ten years. Environmental protection accounts for 10 - 15 % of the total capital expenditure in the industry.

	Tonnes	Change 1994/95
Effluents to water		
biological oxygen demand BOD_7	29 415	- 18%
chemical oxygen demand COD	255 585	- 4%
total suspended solids	24 445	± 0%
organic chlorine compounds AOX	1 720	- 15%
phosphorus	320	- 5%
nitrogen	3 150	+ 2%
Emissions to air:		
sulphur dioxide SO_2	2 100(S)	- 21%
reduced sulphur compounds	2 820(S)	- 26%
nitrogen oxide NO_x	9 125(NO_2)	- 2.5%
particulate emissions	4 950	- 17%
Emissions arising from power generation in the paper industry :		
sulphur dioxide SO_2	4 680(S)	+ 5%
nitrogen oxide NO_x	12 215	- 10%
particulate emissions	2 835	- 18%

AOX emissions 0.34 kg/tonne of bleached pulp
Sulphur emissions 1.1 kg/tonne of chemical pulp (converted to S)

Water protection

The environmental pollution caused by pulp bleaching was reduced primarily by switching over to the use of oxygen-based chemicals. An oxygen bleaching phase was constructed at one mill, a second oxygen bleaching phase was added at three mills, the chlorine dioxide phase was modernized at one mill and the ozone phase improved at one mill. At present (1995), 13 pulp mills have oxygen bleaching phases, and at some mills a supplementary oxygen phase has been added to the bleaching sequence. Finnish pulp mills produce only ECF (elementary chlorine free) and TCF (totally chlorine free) pulp.

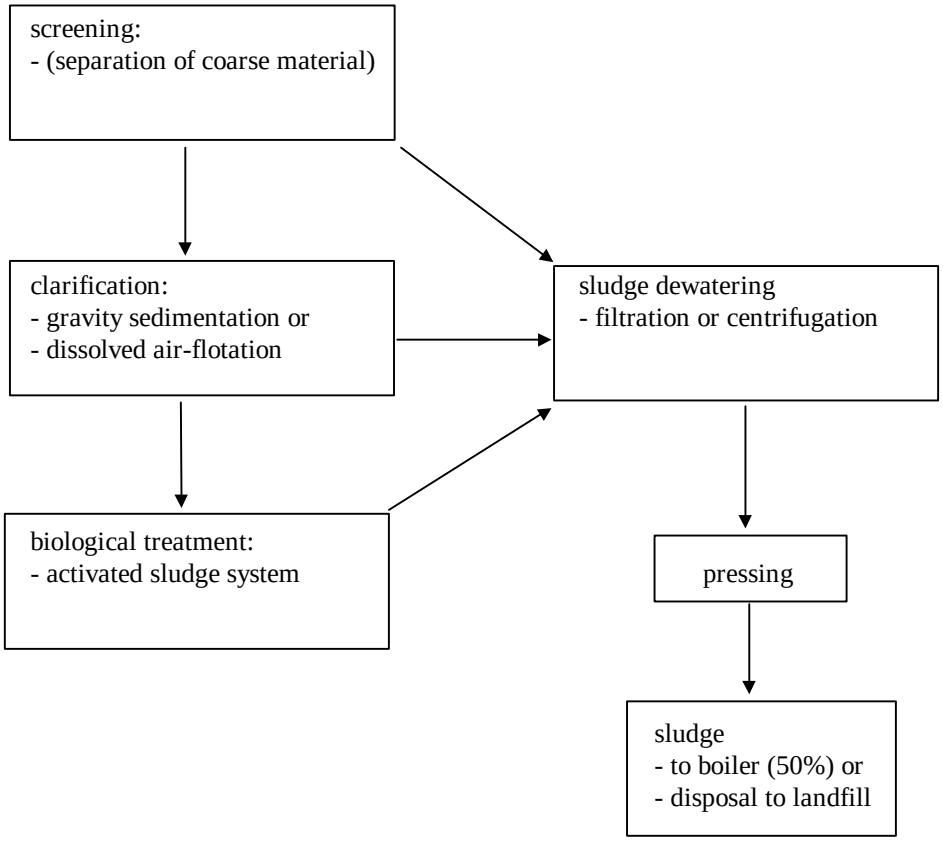
Paper mills targeted their investments at reducing coating and fibre residues and continued to build more closed water cycles in their production facilities.

Biological treatment of effluents is a characteristic feature of Finnish pulp and paper industry. Three new biological effluent treatment plants operating on the activated sludge principle were started in 1995. In addition, building of an activated sludge treatment plant started in one mill in 1995 to replace the present aerated lagoon effluent treatment system. With these investments all the pulp mills and nearly all the paper and board mills will now be treating their effluent by modern, efficient biological purification methods.

Treatment of effluents

Biological treatment of effluents is a characteristic feature of Finnish pulp and paper industry. At present, there are 31 biological effluent treatment plants in operation, cleaning the process water of 34 mills. In addition to these, three biological effluent treatment plants now under construction are to be brought into use during 1995. Most of the treatment plants use the activated sludge method, three have aerated lagoons and two are anaerobic plants with an additional aeration section. Chemical treatment of all effluents is made at five paper mills, and some of the effluents are treated at a further seven. At three mills effluents are treated by purely mechanical purification methods. Sanitary waters are usually led to local sewage treatment plants. As shown in the sketch

below the treatment is made in two steps: a first treatment to remove suspended solid material and after that biological treatment.



Activated sludge treatment, which represents 90% of the waste water treatment in Finland, produces 10-15 kg of sludge/ADt (ADt = air dry tonne). In 90% of the mills, sludge is incinerated in boilers. The real energy consumption of effluent treatment is 60-80 kWh/ADt including electricity and heat. The energy consumption for the biological treatment is as follows

	kWh/m^3	**kWh/ADt**
Wastewater treatment	0.7 - 2	7 - 20
Drying of sludge	0.1 - 0.2 (electricity)	1 - 2
Burning of sludge	0.5 - 1.5 (heat)	5 - 15
Water cooling	0.1 - 0.2 (electricity)	1 - 2

Solid waste

A characteristic feature of the forest industry is that the waste produced in one part of the process can be utilized in another phase. Waste of this kind includes bark from the debarking process and black liquor from the pulp digester, both of which are important fuels used in power generation. Chips from sawmills are used as a raw material in pulp production.

In 1995 the following amounts of waste ended up in the mills' own landfills: about 35.000 tonnes of wood residue, 45 000 tonnes of fibre and coating sludge and 200 000 tonnes of ash of various types from energy generation (35 %), from the combustion of other fuels (25 %) and from chemical pulp manufacture (40 %).

Some 150 000 tonnes (dry weight) of sludge from effluent treatment plants and some 45 000 tonnes of deinking sludge were taken to landfills.

Recovered paper and board amounted to 60 000 tonnes, most of it being recycled as a raw material for paper. The paper recovery rate was 43% of total paper and board consumption.

Some 2 850 tonnes of hazardous waste produced by the forest industry was either recycled or disposed of by hazardous waste treatment.

Air pollution control

In investments towards reducing airborne emissions, the main emphasis was laid on more effective treatment of malodorous gases and on reducing nitrogen oxide emissions. Flue gas scrubbers and electro-precipitators were aquired at three mills.

3.3.2 Sweden

Large investments have been made in the pulp and paper industry during the past 20 years to meet increasing environmental requirements. The emission of sulphur has decreased from 100 000 tonnes to less than 10 000 tonnes/year. For the bleaching of chemical pulp, the emissions of organochlorine compounds into water, expressed as AOX per tonne of bleached chemical pulp have been reduced from more than 5 kg/tonne to 0.2 kg/tonne or lower. The reason for this is that all Swedish pulp plants have eliminated the use of chlorine gas as bleaching agent. The only chlorine compound still being used is chlorine dioxide.

The emissions and effluents from the Swedish pulp and paper industry in 1994 were as follows:

Effluents to water:	Tonnes
chemical oxygen demand COD	340 000
organic chlorine compounds AOX	1 400
phosphorus	450
nitrogen	3 200
Emissions to air:	
sulphur	6 400
nitrogen oxide	14 700

In the future, the process technology will be further improved to achieve closed processes which means that the outlets from the plants will be minimized. The investment costs for such measures tend to be high which will affect the profitability of the pulp and paper industry.

Bleaching

During the past few years the bleaching techniques have been modified in all Swedish plants. Chlorine gas is no longer used and has been replaced by chlorine dioxide as the bleaching agent.

The energy consumption for the production of various bleaching agents is presented in the table below.

Agent	Chemical notation	Production techniques	Energy consumption [kWh/kg]
Oxygen	O_2	Distillation	0.5
Chlorine	Cl_2	Electrolysis	1.5
Chlorine dioxide	ClO_2	Reduction of chlorate	0.9
Ozone	O_3	Corona discharge	10 - 15
Hydroperoxide	H_2O_2	Anthraquinone process	0.9

A TCF (totally chlorine free) techniques for bleaching of pulp has successively been taken into use since around 1992. However, many mills are expected to continue to use chlorine dioxide as beaching chemical for at least the next five years.

The chemicals that are used in TCF bleaching are oxygen, hydroperoxide and ozone. For bleaching of pulp with hydroperoxide about 30 kg is needed per tonne. Bleaching with oxygen is estimated to require about 15 kg of oxygen per tonne of pulp.

Treatment of effluents

Most of the pulp and paper plants utilize biological treatment of effluents from their plants but there are still some plants that have not applied this technology. It is, however, anticipated that more severe environmental restrictions will force the companies concerned to install the equipment needed before the year 2000.

Biological treatment of effluents means in most cases application of aerobic methods. The end products at aerobic decomposition are carbon dioxide, water and sludge. Normal purification levels are 80 - 95% BOD reduction and 40 - 80% COD reduction. Electric power is needed for aeration, pumping and stirring, the major part of the consumption attributed to aeration. The treatment is normally carried through in aerated dams and in plants with active sludge.

The present power consumption for aerobic biological treatment in the Swedish pulp and paper industry is about 150 GWh/year. When all the remaining plants have applied this technology an additional 90 GWh/year will be required.

Totally Effluent Free Technology

Due to environmental concerns, the long term objective in the pulp and paper industry is to close the bleaching processes and to bring down the outlets from the processes to zero. The amount of water required for bleaching must be substantially reduced and the discharges from the bleacheries taken care of either by destruction or by evaporation and recovery of chemicals.

The technology for closing of bleaching processes has not yet been developed far enough to allow a full scale introduction. According to present estimates around 5 m^3 of water per tonne pulp will need to be evaporated. Using e.g. mechanical vapour recompressors, the electric energy needed will be of the order of 10 kWh per m^3 of destillate or 50 kWh per tonne of pulp. Simultaneously, the need for external purification will decrease, resulting in a reduction of the energy consumption by 10 kWh per tonne of pulp.

In 1992 the production of bleached chemical pulp was about 5.3 million tonnes. Using a totally effluent free technology would thus entail an increase of the use of electric energy by 0.2 - 0.3 TWh/year.

Recovery of Chemicals combined with Energy Production

An increase of the backpressure power production from the soda recovery boiler can be attained by different means. It is in principle possible to increase the steam pressure or to lower the bleed steam pressure or the back pressure. If all such possibilities were fully exploited in the pulp and paper industry, the power production would be increased by 6 TWh/year. About 20% of this potential is anticipated to be used up to year 2010.

Much effort has been devoted to the development of the technology for gasification of black liquor and using the purified gas in a gas turbine for production of electric energy. The potential for additional electric power production is considerable. According to estimates that have been made, about 5 - 7 TWh/year could theoretically be produced by the year 2010.

A pilot plant has been built in Sweden several years ago. More development steps need, however, to be taken to make the technology practically applicable. As heavy investments have already been made in soda houses, most of these will probably be used for one or two more decades until new technologies can be introduced. The introduction of plants for black liquor gasification will therefore be made at a fairly slow pace.

In summary, the power production in the Swedish pulp and paper industry is not expected to exceed 2 TWh per year by 2010.

4. EU AND NATIONAL REGULATIONS AND DIRECTIVES.

With regard to environmental protection in recent years, the EEC has issued two very important regulations and one directive - recently published on the Official Gazette of the European Communities (October 10, 1996) - substantially modifying the management of industrial companies with regard to their relationship with the environment.

The two regulations are:

- EEC regulation No. 880-92 regarding a community system for the allotment of an ecological quality label (ECOLABEL);
- EEC regulation No. 1836-93 on the voluntary participation by companies of the industrial sectors to a community system of ecomanagement and audit.

Directive No 96/61 dated September 24, 1996 concerns the prevention of pollution as well as its total abatement.

These provisions are in the framework of the “fifth environmental programme” approved by the Commission, whose title “Towards sustainability - A policy and a European action programme for the environment and the sustainable development) clearly indicates that one of the priority aims of community legislation is to achieve “Sustainable Development”.

In order to reach “Sustainable Development” the Commission deemed it necessary to modify the previous trends substantially by introducing into the legislation the principles of involving all the sectors of society and of making them responsible of their actions through an operational design less compelling than the previous one and also more inclined to reach the common goal through an enlarged participation.

The previous approach based on “order and control” was radically changed and the trend is now to influence directly the behaviour of companies involving them in a policy of prevention and

continuous improvement of environmental performance, on line with the will to use market forces to foster respect towards environmental.

4.1 Ecolabel regulations

ECOLABEL regulation dated March 23, 1992 aims at:

- enhancing the design, the production, the marketing and the use of products having a lower impact on the environment during the whole life cycle of the product;
- providing consumers with a better information on the impact of produce on the environment.

Through the assignment of a community label the provision intends to act on the market supporting the produce improving their environmental performances.

Consumers are adequately informed about the products of a given family of goods with a weaker impact on the environment: the favourable reception by the public rewards producers and spurs competition to improve the ecological level of produce, thus rising the environmental level of the whole sector.

The participation to ECOLABEL is free.

Ecological criteria for each group of produce are fixed according to a global method (from cradle to grave) based on the parameters of Table 4.1.

Tab. 4.1 - Scheme of criteria used to define ecological standards

Environmental aspects	Life cycle assessment				
	Pre-production	**Production**	**Distribution (incl packing)**	**Use**	**Disposal**
Waste amount					
Soil pollution and depletion					
Water Pollution					
Air Pollution					
Noise					
Energy consumption					
Consumption of natural resources					
Effects on ecosystems					

As far as the paper sector is concerned, the community has already approved the principles of granting ECOLABEL to the following groups of products:

- kitchen paper -Commission provision No 94/925 dated November 14, 1994
- toilet paper - Commission provision No 94/924 dated November 14, 1994
- copying paper - Commission provision No. 96/467 dated July 16, 1996.

Principles for "writing paper" are being elaborated.

Principles define :

1. fibrous raw materials used (all virgin wood)[2] must come from regions where rules and measures to ensure a sustainable management of forests are applied, according to the resolution adopted by the Ministry Conference of Helsinki[3] on forest protection in Europe;

2. the main features of waste waters (limits of chemical demand of COD oxygen and of the amount of AOX absorbable organic alogenates in dumps);

3. the features of emissions into the air (limits for sulphur emissions);

4. energy consumption (limits to the total energy consumption during the whole processing and to the energy acquired).

At present, each country applies its own ecological label; in the paper sector the main ones are the German blue angel and the Northern swan.

4.2 EMAS Regulation

EEC EMAS Regulation No 1836/93 dated June 29, 1993 fixes a community system of ecomanagement and audit - in which the companies of the industrial sector are free to participate - to assess and improve the environmental efficiency of industrial activities and to inform the public accordingly.

The aim of the system consists in promoting the continuous improvement of the company management and their production cycles from the environmental point of view.

The companies who envisage to participate in ecoaudit must comply with the environmental norms already in progress and commit to implement an environmental policy enabling them to improve their performances through a suitable programme of environmental management.

According to the regulation, companies should check their action programmes and management systems on regular basis through an audit programme.

Furthermore companies must draw up and announce an environmental declaration approved by a certified auditor. To foster the respect for the environment the market should be influenced also through a better knowledge of environmental problems by the public as well as through a gradual change of the demand becoming more and more concerned with environmental efficiency and more and more addressed towards environmental friendly produce.

The Regulation highlights the goals a company must set to keep on improving its environmental performances: in fact the constant rational improvement of environmental efficiency must get to the reduction of the impact of the environment never exceeding profitable results obtained by the best available technology (B.A.T.).

The concept of a better technology (or more precisely of the best technology) appears in many community and national regulations, but it is applied in more terms in community Directive 96/61 dated September 24, 1996.

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[2] Such restriction is not applied to 100% recycled paper or when fibrous materials used are not obtained from wood

[3] "General guidelines for the sustainable management of forest in Europe" - June, 1993

4.3 IPPC Directive No 96/61

The community Directive 96/61 known as IPPC Directive (Integrated Prevention Pollution Control) deals with the prevention and the integrated reduction of pollution to reach a high level of overall environmental protection.

It provides that plants of specific sectors must be certified by the competent Authority fixing emission threshold values that could be obtained with the best available technique; at the same time the Directive states that such emissions must not exceed the standard values of the environmental quality. Therefore, its primary objective is to reduce once for all water, air and soil pollution by enforcing the lowest emission levels obtainable through BAT and, if such limits do not concern the compliance with quality standard values, it will envisage additional measures.

Member states must abide by the Directive within three years starting from October 10, 1996, it being the date of its publication in the Official Gazette of the European Communities.

Only new plants complying with the directive will be authorized to start their activities.

For already existing plants member states must enforce the provisions of some articles starting from the official date of the norm and their time limit for the other articles will be 8 years at the maximum.

The directive provides that every three years an exchange of information between member states on the best available techniques should take place.

IPPC directive is highly innovative as far as its enforcement is concerned: companies must comply with it to be authorised to operate, and this is different from Ecolabel and Ecoaudit regulations which envisage a free participation.

The paper sector is concerned with this norm that on point 6 of annexed I takes into consideration industrial plants producing:

- pulp obtained from wood or other fibrous materials,
- papers and cardboards, with a production capacity exceeding 20 tons per day.

4.4 Regulations in different countries

4.4.1 Belgium

Due to the fact that Belgium is divided into different political Regions, the rules or norms that apply for the pulp and paper sector are not harmonized completely in the country. As an example, the following reject limitations are valid in the coast region "Vlanderen" for paper and cardboard plants that make

a) paper with less than 15% ash and b) paper with 15% ash or more

c) paper out of recycled paper

d) special paper and cardboard

	Discharge in surface water		**Discharge in sewer**
Lower limit pH	6.5 Sörensen	Lower limit pH	6.5 Sörensen
Upper limit pH	9.0 Sörensen	Upper limit pH	9.0 Sörensen
Temperature	30.0 °C	Temperature	45 °C

Floating matter	60.0 mg/l	Size of floating matter	10 mm
Sediment matter	not applicable	Floating matter	1000 mg/l
CCl_4 extractable matter	5 mg/l	Petroleum ether extractable matter	500 mg/l
Detergents	3 mg/l	Kjeldahl nitrogen	no trace
Oil and fat	no trace		
Ammonium nitrate	2.0 mg N/l		
BOD	50 mg/l		
COD	180 mg/l		
Total phosphorus	2 mg P/l		
Mercury below measurable threshold		Mercury below measurable threshold	

For e) pulp plants, the following values apply:

	Discharge in surface water
Lower limit pH	6.5 Sörensen
Upper limit pH	9.0 Sörensen
Temperature	30.0 °C
Floating matter	60.0 mg/l
Sediment matter	not applicable
CCl_4 extractable matter	5 mg/l
Detergents	3 mg/l
Ammonium nitrate	2 mg/l
BOD: - plants that do not work with calcium bisulphite - plants that work with calcium bisulphite	45 mg/l 250 mg/l
COD: - plants that do not work with calcium bisulphite - plants that work with calcium bisulphite	400 mg/l 600 mg/l
Sum of sulphide and mercaptans	1.0 mg S/l
Total phosphorus	2.0 mg P/l
Total mercury below measurable threshold	
Colouring measured with cobalt chloroplatinum scale (wavelength 465 nanom.)	700 mg/l
AOX : 1kg per ton of pulp dried in open air as average value per year. The formation of polychlorinated organic matter must be reduced by using a multiple of chlorine of less than 0.05. That is, by using less than 0.5 kg chlorine per ton of pulp, per number of kappa of the pulp that is used in the final bleaching	

For the discharge in sewer: this kind of waste water in the sewer is prohibited.

The emission limit values indicated in a), b), c), d), and e) apply for a specific reference volume of the effluent of :

for a) : 40 m^3 per ton of paper

for b) : 70 m^3 per ton of paper for plants with a prod. capacity < 40 000 tonnes/year

: 45 m^3 per ton of paper for plants with a prod. capacity > 40 000 tonnes/year

for c) : 50 m^3 per ton of paper

for d) : 70 m^3 per ton of paper for plants with a prod. capacity < 40 000 tonnes/year

: 50 m^3 per ton of paper for plants with a prod. capacity > 40 000 tonnes/year

for e) : 120 m^3 per ton pulp produced for plants that do not work with calcium bisulphite

270 m^3 per ton of pulp produced for plants that work with calcium bisulphite

4.4.2 Finland

In its programme of objectives regarding environmental protection by the forest industry to be reached by 1995, the government in Finland has set the following goals for the pulp and paper industry:

- Biological oxygen demand BOD_7 160 tonnes per day
- Phosphorus 1.5 tonnes per day

For the pulp industry:

- Organic chlorine compounds AOX 1.4 kg per tonne of pulp
- Chemical oxygen demand COD_{Cr} 65 kg per tonne of pulp
- Phosphorus 60 g per tonne of pulp

In 1987, under the Air Protection Act, the government imposed limits on the sulphur compound emissions of sulphate pulp mills as follows:

- New mills 4.0 kg per tonne of pulp
- Old mills 6.0 kg per tonne of pulp

The regulations for maximum emissions permissible in new mills came into force on July 1, 1987. The emissions of old mills may exceed the limit until the end of December 1997. Finland has decided to continue reducing sulphur emissions to about 80% of the 1980 level by the year 2000. The maximum permissible sulphur emission for the pulp industry will then be 2 kg per tonne of pulp.

The goals for water protection and air pollution control are valid for the whole Finnish industry. They also act as guidelines for the authorities issuing individual mill permits like waste water permits and air protection decisions.

4.4.3 France

Water pollution

Companies using water resources are subject to laws ensuing from three main origins :

- the law dated 1964 regarding water. It organizes for a region the implementation of the « *polluter - payer* » principle,
- law 92-3 dated January 3, 1992 regarding water ; it institutes a unified regulation of the waters and it organizes the water sharing out between the different users including industrials,
- law dated July 19, 1976 regarding classified installations ; it provides the possibility to impose to these installations standards concerning water wastes.

Control of the use of water

The 1992 law regarding water increases the governmental rights to the resource.

These rights are the same for public rivers, private rivers, surface waters, ground waters.

Co-ordination of the actions of legal authorities regarding water belonging to the State: the region Prefect « convenes and co-ordinates the State policy concerning the regulation and management of the water resources » and continues, at least on paper, to play an important role (or represented by the DIREN, DIrection Régionale de l'ENvironnement).

From now on, the control of the water use is foreseen to be carried out as follows :

- increasing the rights of the State by instituting a single water regulation, the aim of which is to ensure for everybody an access to this resource by mean of a well-balanced and planned management without impairing its quality,
- allocation to the *collectivités* (groups) the responsibility for the layout of the capabilities,
- restriction of the intervention area to the financial incentive of the Basin Agencies, from now called Water Agencies.

Administrative structures and water regulation

Water regulation

The law institutes a single and general regulation for the water quality control and the resource level control.

In principle, all samples or wastes have to be submitted to notification or authorization, the administrative control concerns from now all the interventions upon the water quantity and quality - whatever is the nature of the concerned aquatic environment (public or not).

Besides investigation, the water regulation rights, also affect the authorization requests :

- prohibition or regulation of products or devices potentially harmful for the aquatic environment,
- limitation or temporary adjournment of the use of water,
- requirements for control provision dependent on activities having an effect on the aquatic environment.

Temporary limitation of the use of water

This clause of the law came into force by a decree dated September 24, 1992. Except for the waste prohibition or sampling provisions, that can be decided on by the Prefect in case of emergency, the legal authority is in charge of defining the alert area.

Inside these areas, each user of an installation will have to state his actual and priority needs in order for the Prefect to organize the sharing of the resource when necessary.

Pollution hazards as indicated by the installation regulation

The criteria which will allow to define if an operation shall be submitted to an authorization or to a declaration will be its degree of danger and the seriousness of its effects upon the water resource and the aquatic ecosystems, according to a list established by a decree within the State Council.

When an authorization is required, it is delivered after a public enquiry (and impact study) and can only be delivered for a given period.

The withdrawal of the authorization will be possible in certain cases, e.g. the existence of a major risk for the aquatic environment.

Atmospheric pollution

Regulation: Specific Arrêté for the paper industry (dated 06/01/94 published to the Official Gazette dated 25/05/94)

The scope and the application terms are the same as for wastes in water. The waste limit values are given in mg/Nm^3 dry at 6 % of oxygen and are as follows:

Total dust :

Black liquor boiler	80 mg/Nm^3
Lime-kiln	100 mg/Nm^3
Other installations	50 mg/Nm^3
CO	Authorization stated by an arrêté from the Prefect
SO_x like SO_2	300 mg/Nm^3 if the waste exceeds 25 kg/h 500 mg/Nm^3 for bisulphate pulp
NO_x like NO_2	500 mg/Nm^3 if > 25 kg/h
HCl	50 mg/Nm^3 if > 1 kg/h
VOC (Volatile Organic Compounds) (except CH_4)	150 mg/Nm^3 if > 2 kg/h or 50 mg/Nm^3 if burning

Odour level : dilution factor (f) in order to be only smelt by 50 % of a sample of persons.

Odour flow rate : f x flow rate (eventually stated by the authorization arrêté from the Prefect).

The calculation method of the height of the chimney is described under the title regarding the waste conditions.

A study about dispersion is mandatory for wastes which exceed :

- 200 kg/h in sulphur oxides,
- 200 kg/h in nitrogen oxides,
- 150 kg/h in VOC,
- 50 kg/h in dust,
- 200 kg/h for inorganic gaseous compounds of chlorine,
- 1 kg/h for metals and metal compounds.

The supervision of wastes shall lead to continuous measurements of wastes exceeding the following values given in kg/h :

Pollutant	Continuous measurement in kg/h
Total dust	if > 50 kg/h : gravimetry if between 5 and 50 kg/h : opacimetry
SO_x	> 150
NO_x	> 150
CO	> 50
HCl	> 20
VOC (Volatile Organic Compounds)	> 20
Chlorine	> 2
H_2S	> 2
Ammonia	> 10
Cd + Hg	> 0.02 (per day)
As + Se + Te	> 0.1 (per day)
Sb + Cr + Co + Cu + V + Sn + Mn + Ni + Pb + Zn	> 0,5 (per day)

An annual assessment of gas emissions inducing a greenhouse effect over the whole site shall be carried out as soon as the emissions exceed the following values :

CO_2	10 000 t/year
CH_4	100 t/year
N_2O	20 t/year
CFC and HCFC	0.5 t/year

For CO_2 the figure corresponds to the burning of coal or heavy fuel of more than 3000 t/year. For the pulp plants, the non fossil carbon stored in the used wood (biomass) will be taken into account.

The control of the quality of the air or of the fallout (for dust) shall be carried out for installations which reject more than :

- 50 kg/h of dust,
- 200 kg/h of sulphur oxides,
- 200 kg/h of nitrogen oxides,
- 200 kg/h of inorganic gaseous compounds of chlorine,
- 150 kg/h of organic compounds.

<u>EEC Directive dated 24/11/1988</u>

The limit values of the European Directive dated 24/11/1988 are given in the table below versus the thermal power for the new installations (Nm^3 with 3 % O_2 for liquid and gaseous combustibles and 6 % for the solid combustibles).

Incineration plants. Limit values of emissions versus thermal power

Type of combustible	Power MW th.	Dust mg/Nm^3	SO_2 mg/Nm^3	NO_x (NO_2) mg/Nm^3
Solid	> 50 from 100 to 500 > 500	100 100 50	2 000 from 2 000 to 400 400	650 650 650
Liquid	50 to 300 from 300 to 500	50 50	1 700 from 1 700 to 400	450 450
Gaseous	> 50	5	35	350

For powers from 10 to 50 MW, the reject limit values of SO_2 are 2 800 mg/Nm^3 for solid combustibles, 3 400 mg/Nm^3 for liquid combustibles and 55 mg/Nm^3 for gazeous combustibles.

Non specific paper industry incineration plants are submitted to the Arêté dated 20/05/1975 and to the Arrêté dated 27/06/1990 regarding large plants.

Installations producing power and vapour in the frame of the non integrated paper industries have powers less than or about 50 MW.

Public institutions in France dealing with waste treatment:

Ministry of environment

- Direction de la Prévention des pollutions et des risques
- Direction de l'eau.

Agencies and public establishments under the Ministry of environment

- ADEME Agence de l'Environnement et de la Maîtrise de l'Energie
- IFEN Institut Français de l'Environnement
- INERIS Institut National de l'Environnement industriel et des risques

Other institutional actors:

- AFNOR Association Française de Normalisation
- ANVAR Agence Nationale pour la Valorisation de la Recherche

Regional institutional actors:

- Agence de l'eau
- DIREN Directions régionales de l'environnement
- DRIRE Directions Régionales de l'Industrie, de la Recherche et de l'Environnement

4.4.4 Germany

With respect to the single European market, the harmonization of legislative and quasi-legislative regulations is aspired to. The limitation of the pollution due to air emssions is given for

combustion systems by the "Bundes-Immisionsschutzgesetz" (BImSchG). The pollution due depends on the scale of the combustion system and the fuel. See tables 4.1 to 4.4.

The limits of the effluents to water are given by the "Wasserhaushaltsgesetz". This law regulates the prevention of water pollution, if the sewage is led to a public watercourse. All German pulp and paper plants have their own sewage plants (50%) or use common sewage plants. The consumption of water depends on the quality of paper (0 l/kg for recycled paper and up to 40 l/kg for high quality paper for technical use).

Table 4.1 The scope of validity of the 1st BImSchV(Federal Prevention of Pollution Ordinance), TA Luft (Technical Directive for the Prevention of Air Pollution and the 13th BImSchV (see preceding)

	Valid for heating	**effects [in MW]**	
Incineration plants for	plants not needing approval	plants with approval simple procedure	(4.BImSchV) official procedure
	1. BImSchV	TA Luft	13.BImSchV
traditional solid fuel	< 1	1...< 50	> 50
light fuel oil other fuel oils	< 5 [1)]	5...< 50 1 < 50	> 50 > 50
gazeous fuels	< 10	10...< 100[2)]	> 100
solid or fluid fuels	< 0.1[3)]		

[1)] Not allowed
[2)] Plants > 50 MW; official procedure
[3)] Only fuels like straw and similar vegetable sources

Table 4.2 Proposal for limitation of the emissions from medium-scale combustion systems; after a study in order of the EU BAT-Expert Group

Waste material - fuel	New plants 1...10 MW	New plants 10...50 MW	Old plants 1...10 MW	Old plants 10...50 MW
SO_2 (mg/m^3) [1)] - fuel oil - coal	 3400 or 2% S 2000 or 1% S	 3400 or 2% S 2000 or 1% S	 3400 or 2% S 2000 or 1% S	 3400 or 2% S 2000 or 1% S
NO_x (mg/m^3) [1)] - fuel oil - coal - gas	 - - 200	 450 650 200	 - - -	 - - -
Dust (mg/m^3) [1)] - fuel oil - coal	 100 150	 100 50	 - -	 - -

[1)] figures related to norm requirements
% S: % sulphur by weight - : no special requirements

Table 4.3 Limits for NO_x emissions specified in "TA Luft" (see above); finalized limits in general section, No. 3.1.6, for individual systems, Section No. 3.3

No. TA Luft	Type of plant	NO_x limit value (as NO_2) mg/m^3	Related O_2 content % by volume
3.1.6	General rule for all types of plants (in case no single rules apply to 3.3)	500	-
3.3.1.2.1/ 3.3.1.3.1	Stationary fluid beds > 20 MW_{th} and circulating fluid beds for solid fuels	300	7 (11 for wood and peat)
3.3.1.2.2	Incineration plants for light fuel oil	250	3
3.3.1.2.3	Incineration plants for gas fuels (except process gases)	200	3
3.3.1.4.1	Combustion engine plants (Otto engines) - four stroke engines - two stroke engines	 500 800	5
3.3.3.1.1	Iron ore sinter plants	400	-
3.3.4.1a.1	Production of nitric acid	450[1)]	-

[1)] Additional equipment for invisible discharge of waste gases

Table 4.4 Limits for NO_x emissions as specified in "TA Luft" (see above); clause on more specific definition for combustion systems (LAI resolutions dated May 30/June 1, 1988, and May 6 to 8, 1991)

Fuel / Type of plant	NO_x - Emission value
Solid fuels / solid combustibles (Nrn. 3.3.1.2.1 / 3.3.1.3.1)	
a) Grate plants - New plants - Old plants	 0.40 g/m^3 except for - single plants up to 10 MW fired with black coal: 0.50 g/m^3 0.50 g/m^3
b) Powder fired plants - New plants - Old plants	 0.40 g/m^3 except for - single plants up to 20 MW: 0.50 g/m^3 - plants for specific wood fuels: 0.50 g/m^3 0.50 g/m^3
c) Stationary fluid bed plants up to 20 MW - New plants - Old plants	 0.40 g/m^3 0.50 g/m^3
Fluid fuels(except light fuel oil)/fluid combustibles (No.3.3.1.2.2/3.3.1.3.2)	
- New plants - Old plants	Judgement in each case. target 0.30 g/m^3 0.45 g/m^3

4.4.5 Ireland

Environmental Protection Agency

The main standard which now applies to the paper industry is a licence arrangement which is operated by Ireland's Environmental Protection Agency (EPA). The Act establishing the Environmental Protection Agency, the EPA Act, was passed by the Irish government in 1992. The Agency was established in 1993. The EPA currently has a staff of approximately 150, of whom about 75% are technical specialists. The EPA has its own test laboratories.

The EPA is responsible for promoting environmental protection and protecting against environmental pollution in Ireland while also promoting sustainable development. It is empowered to issue integrated pollution control (IPC) licenses to industrial facilities in 13 industrial categories (including Paper and Pulp) which include 61 sub-categories. The IPC license contains a complete specification of company's interaction with the environment - chemicals, emissions, effluents, noise, traffic, groundwater, etc. and is based on EU Directives which are being applied to industrial plants of all member states.

BATNEEC

The EPA issues guidance notes to companies which are applying for licences under the EPA act. Companies are advised to follow these guidelines when applying for an IPC license. The licenses have no stated renewal period at present.

The technologies and associated emission limit values identified in the guidance notes represent "best availbale technology not entailing excessive costs" (BATNEEC). The technology in question should be **Best** at preventing pollution and **Available** in the sense that it is procurable by any company. **Technology** covers both techniques and their application (including training, operation, supervision, maintenance etc). **NEEC** addresses the balance between environmental benefit and financial expense recognising that reducing pollution represents a cost due to the need for on-line sensing, instrumentation, bunding etc. In essence the ICP license must balance the company's competitiveness and the environment.

The BATNEEC guidelines provide a list of technologies which the EPA will use to determine BATNEEC for a specified activity such as paper making. They stress pollution prevention techniques such as cleaner technologies and waste minimisation rather than end-of-pipe treatment.

The licence for the only paper mill in Ireland, the Smurfit Paper Mills at Clonskeagh, Dublin, was granted in March 1996. The company must maintain records and documentation and provide quarterly, annual reports to the EPA. EPA staff can take measurements or samples (emissions, noise etc) at any time to confirm that the company is complying with the terms of its IPC license.

4.4.6 Italy

Water[4]

Water is very important for paper production and therefore can be considered as its second raw material.

During the production process water is polluted by many chemical products and it is finally drained in the last phase of the cycle together with the water deriving from other treatments, such as the washing of machinery.

Therefore it is necessary to purify the waste waters so that they might need the concentration limits enforced by legislation for some pollutants present in effluents (in paper industry: COD, BOD, materials in suspension or sedimentable ones, chlorinated organic compounds, etc.). Furthermore the law states that waste waters comply with some given levels of pH and temperature.

Water disposal is ruled by law No. 319 dated May 10, 1996 entitled "Provisions for the protection of water resources" and by its following alterations and integrations (the last one in law No.172 dated May 17, 1995).

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[4] "Introduction to paper manufacturing" - Italian Technical Association for Cellulose and "ATICELCA" Paper

This law states the norms for the regulation of all water outlets, it provides the general principles and criteria to rationalize water resources and introduces a single discipline to be applied to the whole national territory.

The competent bodies are:

- Regions, that rule the control system of outlets, draw the regional programs to reclaim waters, coordinate and check the consistence of the programs designed by provinces and municipalities, integrate and implement the general norms also fixing intermediate limits of acceptability for all outlets;

- Provinces, that assess and control all the inlets into surface watercourses, verifying the quality of such courses within the regional estimation of resources, check the public sewage draining on the ground and under it.;

- Municipalities that manage public facilities such as waterworks, sewage, sludge depuration and disposal, control the outlets of production cycles as well as outlets on the ground and under it.

The law enforces first of all the compliance with some acceptability levels (mainly represented as maximum concentrations) of pollutants in the waste waters: such limits differ according to the site from which waste waters come (civil or industrial), and to the effluents destination (ground watercourses, public sewage systems, surface and subsurface).

Waste waters pollutants from production sites must conform with the limits fixed by the same law (tables A and C); when waste waters are drained into a public sewage system, they must instead conform with the limits fixed by public authorities as envisaged by municipalities and/or regions.

All the outlets of production sites must be authorized by controlling authorities (Municipalities, on an individual or associated bases, or mountain communities). The authorization is subject to the compliance with the acceptability limits. The application to be granted authorization must be renewed if and when qualitative and quantitative variations in the outlets take place.

Effluents must be measured before the very spot where they enter catcher.

All outlets must be easily accessible exactly where measurements are carried out so as to make the sampling for chemical and physical analyses easier.

The controlling authority is entitled to carry out all the checks they deem necessary to assess the conditions in which waste waters are produced, and this in all production sites.

The controlling authority can even compel the owners of outlets which might be hazardous to public health either to pay the installation of checking devises or to carry out some given pre-treatments of waste waters.

Sludges coming from the softening of waste waters must correctly be disposed of: they must be considered as particular wastes because of their chemical nature making them either toxic or noxious.

Paragraph dealing with wastes will analyze this topic in greater details.

Air

Italian legislation on air pollution essentially refers to D.P.R. (Presidential Decree) No. 203 dated May 24, 1988 enforcing some emissions limits defined by the Regions basing on norms and guidelines fixed by the State. The “crucial” life phases of the plants (building, running , essential changes and transfers), must meet some specific administrative requirements, as for instance, a

paramount one being the application for the construction of the plant. The application must be joined with the plan informing about the production cycle, the technologies envisaged to prevent pollution, the emission quality and quantity. Before granting the authorization the Region verifies that the tolerated emission limits are not exceeded. Furthermore the Region states how often companies must make the periodical measurement of polluting emissions and inform the Region about the results obtained.

Through the D.M. (Ministerial Decree) dated July 12, 1990, the State set the guidelines for the emissions of already working plants, while it has not yet set the norms for the new ones; in the meantime, Regions give new plants the necessary permits basing on the state and regional provisions on air quality.

In the D.P.R. dated July 25, 1991 some industrial activities are classified as "slightly air polluting" and others as" limitedly air polluting": the last ones include - annex 2.19 - "the production of paper, cardboard and alike using raw materials not exceeding 400 kg/day".

Slightly air polluting activities are the ones producing mass flows of pollutants - evaluated before enetering eventual plants of final abatement, lower than those envisaged by art. 3, paragraph 2, letter a) of D.P.R. No. 203.

Also activities carried in their production cycles with raw and auxiliary materials not exceeding the quantities and the requirements indicated in annex 2 are considered as reducibly air polluting ones.

In such cases competent Regions and authorities may issue specific procedures even with simplified applications of authorization, in which the quantity and quality of emissions stem from the indication of the amount of raw and auxiliary materials used in the cycles.

Of course, paper manufacturing activities not envisaged in annex 2 as well as those not covered by the quantitative limits mentioned in annex 2.29 are subject to authorization defined by D.P.R. No. 203/88 and by ensuing implementation norms.

Noise

Industry is a noise producer inside and outside its plants.

As to the noise produced inside, employers must protect workers health with the necessary measures, as to the outside noise they must comply with the requirements and maximum limits fixed for the very area where the plant is located. The workers protection against risks of noise exposure is fixed by Chapter IV of legislative decree No. 277 dated August 15, 1991: this provision has been applied in Italy to enforce many community directives on health and professional security.

Employers must abide by the following requirements:

a) the respect of threshold values in daily and weekly noise exposures of workers, values to be calculated through formulas mentioned in the decree;

b) the assessment of exposure risks which implies a series of recurring measures beyond the 80 DB.;

c) the use of individual devises of protection from the noise exceeding 85 DB.;

d) the display of appropriate signals and records of workers exposure in the cases of greater risks;

e) information to and training of workers as to the risks existing beyond certain levels for their hearing and how such risks could be prevented;

f) sanitary controls of workers more at risk;

g) the duty for new plants and equipments to be designed and built reducing noise exposure risks to the minimum, implementing the solutions brought about by recent technical developments and practically applicable; timely interventions should be encourage.

With the regard of the noise in the outside environment, the D.P.C.M. dated March 1, 1991 stated that a temporary regime should be applied up to the enactment of the law that would settle the problem of acoustic pollution once for all. The decree stated that municipalities should divide their territories in zones, according to their final usage, within which the sound level could not exceed certain limits. In the meantime, before the creation of such specific zones, which up to now has not been implemented by many municipalities, D.P.C.M. fixed the maximum limits of tolerability of continuous noises. The decree has also fixed a "differential limit" for non exclusively industrial zones: it consists in the difference between the "environmental" noise (taking into consideration all actual sound noises) and "residual" noise (represented by the noise level which would have been obtained had it been possible to exclude the specific disturbing source such as the production plant).

Companies had to comply with fixed limits, eventually presenting to the Region a "reclaiming" plan indicating the terms and the ways of adjustment.

At the end of 1995 the "Blue Print Law on acoustic noise" came into force (Law dated October 26, 1995, No. 447), confirming and strengthening the system introduced in a temporary way by the D.P.C.M. dated March 1, 1991.

Waiting for a decree that will fix the new values related to noise, (divided in "maximum emission values", "maximum inlet value", "alert values" and "quality values"), the law still enforces the values fixed by D.P.C.M. except for the differential limit which will be the object of specific norms, for the plants with a continuos production cycle.

Blue print law confirms the method of dividing the municipal territory into zones, still does not amend the action already carried by municipalities in this field as well as the acoustic reclamation interventions already implemented by companies. In any case, if such interventions might appear insufficient vis á vis the limits fixed by the splitting criterion companies are granted a period of time equal to the one necessary to achieve the depreciation program of adjustment interventions. Companies that have not yet presented their own reclamation program may choose whether they will do so within the six months following the splitting criterion indicating the final time within which they will be able to comply with the fixed limits, or to comply with the limits directly within the six month limit starting from the territory classification.

Wastes and residues

For the adequate disposal of special wastes the classification based on types fixed by the law must be followed:

Special wastes can be divided in:

a) industrial wastes treated as municipal wastes (RSA),

b) toxic and/or harmful wastes (RTL),

c) non toxic and/or harmless waste (RS).

Law No. 146/94 states that special wastes - mentioned on para. 1.1.1 let. a) of the Deliberation of the Interministerial Committee dated July 27, 1984 have to be treated as municipal wastes.

Such wastes even of industrial or handicraft origins must be given to the public service (as in the case of municipal wastes) basing on the so called municipal exclusive right) and the cost of their disposal is paid through the tax levied on municipal solid wastes.

Later on, D.L. (decree law) No. 274/95, one the reiterations of D.L. on the residues, introduced the threshold of 200 m^2 working surface beyond which limit the company was not compelled to assign the waste disposal to the municipality. In the reiteration of the provision the threshold has been left out so that the whole of special wastes that can be treated as the municipal ones fell again the municipal competence.

The system ruling wastes treated as municipal ones, is anyhow quite flexible; its norms keep on being the subject of legislative amendments owing to the different opinions on the bodies that should be responsible for the disposal services. On the contrary, special wastes that cannot treated as municipal ones can be disposed:

a) directly by the producer after been given authorization to act accordingly,

b) through third parties entitled,

c) through those who are responsible for managing the public service.

In its various phases, such as collection, sorting, transport, deposit, treatment and dumping, the disposal is subject both to technical norms (indicated in the Deliberation of the Interministerial Committee dated July 27, 1984), and to specific administrative requirements (application for authorization, book keeping collection and dumping, regular reports to authorities, etc.) that can vary according to the toxic and/or noxious nature of wastes. Therefore to identify correctly the administrative system and technical discipline to be implemented, it is necessary to assess whether the industrial wastes taken into consideration should be considered as toxic and/or harmful ones. The criteria to classify wastes toxic and/or harmful are to be found at point 1.2 of Deliberation of I.C. and are based on a certain amount of concentrated harmful substances or on their coming from specific processes, except for, in the last case, the counter-evidence given by the person or the body involved.

For the paper sector norms on waste paper are very important as it represents 50% of fibrous materials used in the production cycle.

The so called law decree on residues (Recycled Residues) - issued for the first time in November 1993 and reiterated many times (with some alterations) up to the present D.L. No.113 dated March 8, 1996 - considers paper secondary fibres as raw materials, leaving them out from the residues regime (and therefore also from the waste system).

Waste paper is one of the materials that, being endowed with specific market features, are quoted in the Stock Exchange - or in official lists of the Chambers of Commerce, Industry, Handicraft and Agriculture of the regional capitals - and traded as real ‘by-products” so that they may be reused in production cycles. Such materials are included in a list regularly up-dated by a interministerial decree.

Materials listed in the “waste paper” group also include both residues from paper industry and other products coming from other sources. However, they are all defined according to specific norms, selected, free from unsuitable materials which are forbidden and pollutants deriving from previous uses.

4.4.7 Spain

The current legislation in Spain concerning environmental impact caused by the paper industry covers the following areas.

- Spanish legislation concerning residues

- Basic law of toxic and dangerous residues
- Law on management of used oils
- Law on management of polychlorobiphenyls and polychloroterphenyls

- Spanish legislation concerning water collection and dumping

- General regulations on the dumping of dangerous substances from the land into
- the sea
- Dumping monitoring and regulation measures
- Law on Water Management

- Autonomous Government Legislation

- Organisation and Operation of the Sewage Management Board
- Regulation on sewage dumping

- Government legislation concerning sources of atmospheric pollution

- Law for the protection of the Atmospheric Environment
- Prevention and correction of industrial atmospheric pollution
- Implementation of equipment for measuring and recording atmospheric polluting emissions in power stations

4.4.8 Sweden

The Swedish Parliament passes laws and the Government issues directives. Various authorities publish instructions on how laws and directives are to be followed. It is also the task of the authorities to examine permit applications and carrry out inspections.

Protection of the external environment is regulated primarily by the Natural Resources Act and the Environmental Protection Act. Other acts of importance are the Working Environment Act and the Act relating to Chemical Products.

The *Natural Resources Act* (NRL) provides a common foundation for various laws when conflicts of interest appear on the use of land and water resources. The NRL serves as an umbrella for a number of different special laws as displayed below.

NRL		
Planning and Building Act	Water Rights Act	Environmental Protection Act
Nature Conservation Act	Peat Act	Roads and Highways Act
Electricity Act	Pipeline Act	Aviation Act
Minerals Act	Navigation Channels Act	Continental Shelf Act

The Act contains provisions concerning special permit assessments for large industrial plants, so-called localization examinations. The Environmental Protection Act aims at preventing detrimental effects on the surroundings as a result of air and water pollution as well as noise, vibration, light and other forms of influences that may be the result of an industrial activity.

The Swedish Environmental Protection Agency is the central executive department concerned with the external environment. Each of the 24 Swedish counties has an environmental department with the responsibility to investigate how the environmental regulations are pursued on a regional level.

According to the *Environmental Protection Act*, a formal permit is required to run an industrial activity. The permits are granted individually which means that each permit is unique and that the conditions defined in the permit are not necessarily equal to those defined for a similar activity at an other site.

Depending on the type and size of the industry in question, the environmental permits granted under the terms of the Environmental Protection Act are issued either by The National Franchise Board for Environmental Protection or by The Environmental Department of the County Council.

The *Working Environment Act* is the central enactment in the field of working environment. In this act a number of directives and instructions are specified.

Some of the special laws that need to be considered in this area are :

- The Act relating to Chemical Products
- The Victuals Act
- The Act relating to Public Health
- The Act relating to Explosives and Flammable Goods
- The Act relating to Transport of Dangerous Goods

The central executive department for the working environment is the National Board of Occupational Safety and Health.

5. ELECTRICAL TECHNIQUES IMPLEMENTED TO ABATE POLLUTANTS IN THE PAPER INDUSTRY

The following chapter deals with the electrical techniques that contribute to eliminate pollutants. Such techniques are applied during the treatment of waste waters and also - this is being the innovative conception - during the various phases of the production cycle.

5.1 Electrical techniques for water treatment

These techniques are generally used as tertiary treatments even if some of them, (i.e. steam mechanical recompression) are used as primary treatment and therefore before the others. Unlike the other treatments some of the techniques described in the following paragraphs allow processing water to be reused - and it is well known that huge amounts of such water are employed in paper industry - and therefore represent a real turning point in the technical and economical management of the sector industries.

The growth of consumption linked to the restless development of the human activities requiring high specific amounts of water contributes to make the “water resource” less and less available: hence in short - medium term a huge rise of water cost can be foreseen. The protection of the

environment also will become more and more important: legislative provisions tend to give greater place to the use of water for civil requirements and to enforce more and more severe restrictions as to the waste waters.

Paper industries therefore will be committed to adopt technologies aiming at reducing consumption and water spoilage as well as allowing water recycling.

Hence such treatments represent a decisive and desirable improvement of environmental and economic features of the paper sector.

5.1.1 Separation on membranes

The setting of ad hoc membranes and of integrated processes in the treatment cycle proved that up to 90% of water and 95% of chemical products can be recovered through these kinds of technologies.

This technique of water refinement consists in introducing, at a given pressure, some liquid into a container whose porous holes act as a membrane. According to the size of the membrane pores and to the pressure difference between the two sizes of the membrane there is a passage of solvent molecules through the membrane, while the solute remains in the most concentrated phase. The membrane filtration processes can be divided according to the size of the substances that are being separated as follows:

a) Microfiltration

It can separate, under the form of a concentrated fluid vein, solid substances in suspension, bacteria and colloidal materials going from 10 to 0.1 microns. This process is convenient as a pre-treatment for the following permeation of more selected membranes, and only in few cases, it may give way to an immediate recycling of the waste water having been treated.

b) Ultrafiltration

This technique uses pressures of 0.5 atm. and holds back particles of 0.002 - 0.1 microns. In this way organic substances of high molecular weight can be separated. It is ineffective versus inorganic pollutants and therefore produces a good quality of water, but rather polluting. The water produced can be recycled in many processes of paper industry and the concentrated waste water left can be sent back to primary and secondary treatment plants.

c) Nanofiltration

Nanofiltration allows the separation of substances of less than 0.002 microns, but it presents the lowest capacity of retention for inorganic substances. In spite of all this the water obtained is of a very high quality and therefore can be recycled.

d) Reverse osmosis

It is a technology widely applied in many fields such as in the sanitary and food industries. This is also used in the paper sector. It uses pressures from 20 to 80 atm. and it can separate substances whose sizes are less than 10 Angstrom and is therefore quite effective to separate both organic and inorganic substances. The quality of the water obtained is equal to the one of the normal supply or maybe even better.

A schematic illustration of the different techniques is given in figure 5.1.

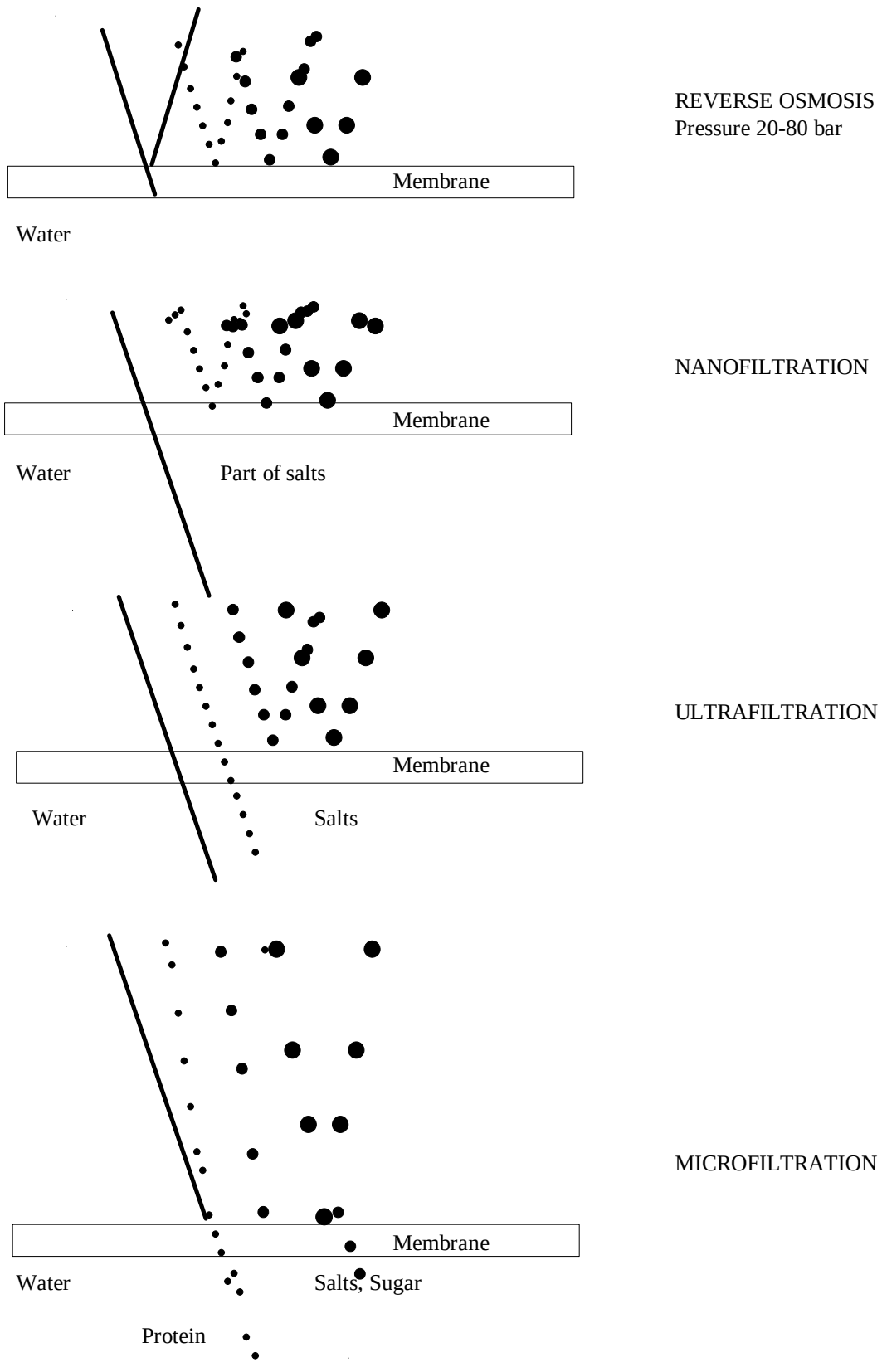

Fig. 5.1. Different filtration techniques

5.1.2 Ozone oxidation

In a specific device, an air flow or an oxygen flow pass through electrodes supplied with AC. The electric field gives way to the splitting of oxygen molecules and to the ozone formation (O_3). The air enriched with the ozone which is a strong oxidizer is scrubbed in the waste water in tight chambers to avoid ozone dispersion in the air as ozone is a gas toxic to mankind. The treatment is continuous and the amount of ozone supplied is measured through the intensity of the electrical field. At the end of the treatment the water, before being let out, passes through metallic grids that catalyse the decomposition of the amount of ozone that did not react. The ozonization reaction does not bring about secondary products and allows high levels of water softening to be reached. The ozonization plants are expensive and need diligent management. Air and oxygen must be carefully dried and cleaned from organic impurities and dust before being flowed into the ozonizers.

This technique is particularly convenient for the treatment of average amounts of waste waters (500-1000 m^3/day) coming from biological plants to further reduce pollutants in order to comply with legal constraints and also to boost the softening so as to recycle water for production purposes.

5.1.3 Mechanical Steam Recompression

This technology is used for the treatment of waste waters in various industrial sectors, including the paper one. It consists in increasing the pressure (and therefore also the temperature) of saturated steam by means of a mechanical compressor, thus obtaining the enhancement of its heat content and its reusability in the treatment. While in a traditional evaporator the steam of the liquid that must concentrated is produced through an exchanger, with this technique it is compressed, its temperature is increased and in the condensation phase it is used as source of thermal energy for the production of further steam. The great advantage of this technology consists in the outstanding energy saving (1 electrical kWh replacing 15 - 20 thermal kWh) in its being simply applied to already existing processes and in the reduction of the amount of steam produced (a reduced use of fuels i.e. improving the ecological side of the process).

5.1.4 Thickening of sludges from treatment installations of waste waters

Chemical, physical and biological treatment installations of the waste waters of paper industry produce sludges that, after their splitting in decanters present a maximum dry content of 4%. As the costs and the difficulties of the disposal of such sludges have increased, the paper sector industries are gradually adopting thickening installations to reduce the volume of sludges. The technologies implemented are: band filters, rotating drum filters under vacuum and press filters placed after the decanters. Before filtration some auxiliary substances are added to the sludge, such as fossil flour, lime, polyeletrolytes that facilitate the formation of a filterable panel. According to the technology used, the kind of sludge (which can come from either chemical, physical or from biological plants) and to the quality and quantity of the auxiliary agents, concentrations of dry substances around 20-25% can be reached with the band filters and the rotating drum ones, while with the press filters concentrations around 30-34% can be obtained. The cost of this filtration system has been estimated in Italy to be between 3 and 7 million Italian liras per m^3 per day of sludge according to the automation level of the filter and the technology used. There are many companies manufacturing such installations and there are also many plants adopting this technology that is now a well established one.

5.2 Electrical techniques implemented in the production cycle

As we have already said, we will now refer about some electrical technologies (both old and new ones) that, when introduced into a phase of the production cycle to replace some older ones, produce a reduced amount of pollutants in the paper industry.

5.2.1 Heat pump

This technology is now well established and is applied also in the paper industry for some operations that had been traditionally carried out by means of thermal installations (i.e. the drying of

the final product). In the total amount of pollutants produced by the paper companies, the implementation of the heat pump technique improves the impact on the environment.

5.2.2 Radiofrequency (RF)

RF technique is used for the drying process in many production activities and some tests are just being carried out in the paper sector.

The technology enables the heating of a body mass directly from its inside thanks to a mechanism transforming the energy of an electromagnetic field (having a typical frequency in the fields of radiofrequencies and microwaves) that can penetrate and occupy the whole body and be transformed into thermal energy if the chemical and physical structure of the material meets some given requirements. When some dielectrical material is subject to a magnetic field molecules are polarized: electrical dipoles range according the direction of the field itself. If the field polarity is periodically inverted dipoles oscillate with the same frequency as the one with which the field polarity is inverted. By means of radiofrequency field polarity is inverted millions of times per second and the fast oscillations of dipoles imply energy dissipation through heat production (some energy of the electromagnetic field is absorbed by molecules and transformed into heat).

The installation generally consists in the following equipments:

- An RF generator: it is a system that is supplied in its inlet by the network electrical energy and in its outlet generates the electromagnetic energy in radiofrequency that can be used and transmitted to the following applicator
- An applicator: it consists in a couple of electrodes (or more) between which the material to be treated is inserted. The electrode structure, the working frequencies and tensions as well as the power delivered all depend from the future application of the installation.

The application of radiofrequency technology provides many advantages:

- RF heating equipments give an average yield of 65-70% versus the 35% yield of conventional treatments using primary energy sources, thus being more and more efficient and cost-effective in terms of energy consumption; their high yield is mainly due to their peculiar “immediate” functioning as well as to the kind of heating process that can be defined as “endogenous” (the heating process begins as soon as the machine starts running and the energy consumption depends on the presence of the material to treat between the electrodes, and the environment around is not at all involved in the heating process);
- The lack of combustion processes contribute to limit the impact on the environment (emissions of fumes, ashes and dusts);
- the easy control and automation imply staff reduction in plants;
- the measurement and monitoring of supplied energy involve easier management;
- maintenance is simple;
- it allows an extremely fast heating of the substance to be dried contrary to conventional treatments: in fact, according to the mass and the conductivity of the material conventional treatments require much time running the risk of causing permanent alterations in the chemical, physical, mechanical and organoleptical properties in the case of natural substances;
- finally RF technology improves general heating versus traditional processes.

In paper manufacturing processes, RF technique is very expensive as it requires huge amounts of electricity considering the large amount of water to be removed.

It might be further used (and tests in progress are giving good results) to dry the glue applied on paper for different purposes as, for instance, to close envelopes, to shape corrugated cardboards, etc.: in such cases the amount of water to be removed is reduced and the power supplied for RF installations is within conventional values (some hundreds of kW). As to corrugated cardboard, many tests have been carried out: the RF application has undoubtly given results better than those obtained with traditional systems.

Generally, to obtain corrugated cardboard various levels of cardboards are joined making them slide on planes of cast iron steam heated up to 170 °C to obtain the gluing effect - by removing the water in the glue - and to stabilize the final moisture of the cardboard.

Heat starts flowing from the bottom and only from one side; its efficiency is very low owing to the limited thermal paper conductivity.

Finally, as the speed of lines is 200 m/min. and the standing time is short, the yield (the ratio between the transferred and installed power) is very low (20-30%).

RF technique produces heat exactly where there is water to be eliminated, thus encouraging the gluing effect and it limits to the utmost the warping of the final product by increasing the temperature of all the material homogeneously.

With the RF the yield reached 60-70%.

6. EXAMPLES OF NEW ELECTRICAL TECHNIQUES FOR THE TREATMENT OF POLLUTANTS

This chapter includes some examples of new electrical techniques - analyzed in the first part of the presentation - that have been applied in the pulp and paper industry.

Technical and economical data of the plants are presented very briefly. More information can be provided via the national Unipede representatives.

6.1 Finland

Membrane filtration

Process type:

A pilot plant has been built for membrane filtration of waste water in a paper mill.

Reason for installation:

To remove solids from the waste water.

Company:

ENSO GROUP in Kotka

Age of installation: 1995

Mechanical vapor recompression

Process type:

A pilot plant has been built for compression of saturated steam.

Reason for installation:

The steam is used for purification of waste water by evaporation.

Company:

ENSO GROUP in Kotka

Age of installation:

6.2 France

Ultrafiltration

Process type:

An ultrafiltration pilot plant has been installed with a filtration area of 53 m^2, installed power 100 kW, treatment capacity 100 m^3/day, concentration 10 g/l, concentration of concentrate 25%.

Reason for installation:

The purpose is to remove effluents from the paper coating process, like solved or suspended organic materials and mineral materials that result in opacity of the waste water and are harmful to the aquatic life. The effluents are also detrimental for the operation of the sewage treatment works of CASCADES BLENDECQUES. The installation of the ultrafiltration plant was made following a convention with the basin agency "Artois Picardie" on treatment of the coating waters.

Company:

CASCADES BLENDECQUES S.A., B.P. 6, 62575 BLENDECQUES

Age of installation:

The installation was ordered in January 1992 and started in July 1992

6.3 Italy

Ultrafiltration

Process type:

A pilot plant has been installed consisting of an equipment for reverse osmosis and an evaporator for water treatment. The plant has eight membranes and allows treatment of 4 m^3/h with an installed power of 50 kW.

Reason for installation:

For environmental reasons it was considered necessary to soften the effluent water from colouring materials, microorganisms, a considerable portion of organic materials in solution and a small part of salts, hence allowing the total recycling of treated waters in the whole production line. The results are that solids in suspension are removed before entering the reverse osmosis plant. A partial removal of COD and colours has been achieved.

Company:

Installation made by Cartiera Favini S.p.A., Via Cartiera, 21, 36028 Rossano Veneto - Vicenza

The building company is:

SEPAREM S.p.A., Via per Oropa, 118, 13051 BIELLA (VERCELLI)

Age of installation:

The plant was started by June, 1995

Reverse osmosis

Process type:

A pilot plant based on the principle of reverse osmosis for treatment of processed waters coming from an ultrafiltration plant.

Reason for installation:

To be able to reuse processed waters by removal of COD, colour and minerals

Company:

Installation made by Cartiera Favini S.p.A., Via Cartiera, 21, 36028 Rossano Veneto - Vicenza

The building company is:

SEPAREM S.p.A., Via per Oropa, 118, 13051 BIELLA (VERCELLI)

Age of installation:

The plant was started by June, 1995

Drying of sludges

Process type:

A press has been installed before a sludge dryer with band dual filters.

Reason for installation:

To reduce the volume of the sludge in a general effort to recycle sludges and use it in the production of special papers. The dry matter of sludges passes from 5 to 40%. The electrical power is 20 kW and the quantity of sludges yearly treated is about 200 tonnes.

Company:

The technology is used by Cartiera Favini S.p.A., Via Cartiera, 21, 36028 Rossano Veneto - Vicenza

The building company is:

SERNAGIOTTO S.p.A. Via Torino, 114, 27045 CASTEGGIO - PAVIA

Age of installation:

The plant was started in 1980.

Drying and post-drying of sludges

Process type:

Band press and screw press to treat sludges from paper mills containing 6% of solid wastes. The plant includes

- equipment for preparing and polyelectrolyte proportioning
- band press - type 1000 S4 P
- screw press - type TSP1

Reason for installation:

To dispose as rationally as possible the sludges recovered and to dry them to make their handling possible for being transported.

Company:

Cartiera Pigna S.p.A, Via D. Pesenti, 1, 24022 ALZANO LOMBARDO - BERGAMO

The building company is:

SERNAGIOTTO S.p.A. Via Torino, 114, 27045 CASTEGGIO - PAVIA

Age of installation:

The band press started working in 1989, the screw press started its activity in 1995.

Biological depuration through biodiscs

Process type:

A biological slowly rotating contactor or biodisc, partially immersed in tanks containing the sewage to be softened so that the surface of the discs composing the whole biological disc gets in touch with the liquid and the air alternately. The softening process is essentially performed by a film of active biological mass located on the disc surface and composed by micro-organisms.

Reason for installation:

To abate pollutants in the mass to be depurated. The results after treatment:

- COD = 160 mg/l
- BOD = 40 mg/l

Company:

Cariera dell'Adda S.p.A., Via Cavour, 63, 24032 CALOLZIOCORTE - LUCCA

The building company is:

SERNAGIOTTO S.p.A. Via Torino, 114, 27045 CASTEGGIO - PAVIA

Age of installation : The plant started working in January, 1996

6.4 Sweden

TCF bleaching of pulp

Process type:

Bleaching of pulp using oxygen, hydroperoxide and ozone (210 kg O_3/h)

Reason for installation:

To attain totally chlorine free bleaching of pulp is an increasingly strong requirement from the consumers and and a natural step to meet the environmental demands

Company:

Mönsterås Bruk, Södra Cell AB. The equipment was installed by Kvaerner Pulping AB and Karlstad Trailgaz

Age of installation:

The process was started in September 1992

Mechanical vapour recompression

Process type:

Compression of saturated steam to obtain overheated steam to be used in the plant or for distribution in a steam distribution system

Reason for installation:

Upgrading of steam for use in other parts of the plant

Company:

Papyrus Kopparfors AB

Age of installation: 1985

Infrared drying

Process type:

Infrared system for drying of cardboard in the final phase of the cardboard production system.

Reason for installation:

To achieve an adjustment of the moisture profile of the cardboard during the drying process and to improve the production capacity by a more effective drying system.

Company:

Fors Kartongfabrik (Fors Cardboard factory)

Age of installation : 1985

Treatment of sludges (large number of reference installations)

Examples:

1)

Process type:

Biological treatment plant for activated sludges from a pulp and paper industry

Reason for installation:

To reduce the BOD of the sludges. The capacity is 800 m^3/h,

Company:

Stora Hylte AB. Designed and built by PURAC AB.

Age of installation: 1978

2)

Process type:

Biological anaerobic digester for treatment of waste water from a pulp and paper industry.

Reason for installation:

To reduce the BOD of the waste water.

Company:

Stora Hylte AB. Designed by PURAC AB.

Age of installation: 1983

3)

Process type:

Sluge dewatering

Reason for installation:

To reduce the water content of the sludge.

Company:

Stora Fors AB. Design and installation by PURAC AB

Age of installation: 1997

6.5 Other countries

From **Belgium** the following examples were reported of electric technologies to reduce the environmental impact:

- Mechanic Vapor Compression (MVC) Systems used by "Cellulose des Ardennes"
- Electric Infrared Heating Systems by "Burgo"
- WKK (cogeneration cycle) not yet installed
- Millipore filtration of membranes technics

In **Germany**, electric filters are used to clean the pollution of combustion systems. Variable speed drives and electromechanical presses are used to reduce the water consumption and to reduce thereby the energy need of the tumble-dryer.

In **Spain**, infrared dryers are used in the paper production to improve the drying process. Also, the presses have been substantially improved to reduce the energy consumption for removing water. Internally steam heated roller presses with large diameters are used as a means of reducing the energy needs when the paper has already been produced.

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