2.H.1 - Pulp and Paper Industry

Short description

Category Code	Method					AD					EF				
2.H.1	T1					AS					CS				
	NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	Diox	PAH	HCB
Key Category:	-/-	-/-	-/-	-	-/-	-/-	-/-	-	-	-	-	-	-	-	-

T = key source by Trend **L** = key source by Level

Methods	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model

* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in the group specific chapters.

AD - Data Source for Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific data
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential

EF - Emission Factors	
D	Default (EMEP Guidebook)
C	Confidential
CS	Country Specific
PS	Plant Specific data
M	Model / Modelled

The fibre pulp for paper production is produced, via chemical or mechanical processes, either from fresh fibre or from processed recycled paper. A distinction is made between integrated and non-integrated pulp and paper mills. Non-integrated pulp mills solely produce pulp for sale on the open market.

On the other hand, integrated mills produce both pulp and paper, at integrated sites. A paper mill can either produce paper from fibre material produced at other locations or be integrated within complete pulping processes set up at one site.

Sulphate pulp mills normally operate in both integrated and non-integrated modes, whereas sulphite pulp mills are normally only integrated – i.e. part of paper-production chains. Mechanical pulping and recycled fibre processing is usually an integrated part of the papermaking but has become a stand alone activity in a few single cases.

Fibre production processes

In the chemical pulping process the fibres are liberated from the wood matrix as the lignin is removed by dissolving in the cooking chemical solution at high temperature.

Sulphate process

The sulphate or kraft process is the world's most common pulping process, since it yields higher pulp strengths and can be used with all types of wood. In the kraft pulp process the active cooking chemicals (white liquor) are sodium hydroxide (NaOH) and sodium sulphate (Na_2S). The term “sulphate” is derived from the make up chemical sodium sulphate which is added in the recovery cycle to compensate for chemical losses. As a result of the large amount of sodium hydroxide used, the pH value at the start of cooking is between 13 and 14 (alkaline pulping process). In the two German plants, carbonate is extracted from the circulation of liquor via bonding with calcium (causticising) and then, in a separate lime oven; the burnt lime is then reused for causticising.

This process produces atmospheric emissions in chemical recovery (boilers), in bark combustion, from lime kiln - from the combustion of strong and weak non-condensable gases (NCG) in dedicated burner, in wood-handling, in pulp cooking, in pulp washing, in bleaching, in bleaching-chemical processing, in evaporation, in processing of circulating water and in operation of various types of tanks. Such emissions include fugitive emissions that occur at various processing points – primarily in (liquor)-recovery boilers, lime kilns and auxiliary boilers. The main components of emissions include nitrogen oxides, sulphur-containing compounds, such as sulphur dioxide, and NCG which consists mainly out of total reduced sulphur (TRS), namely, methyl mercaptan (MM), dimethyl sulphide (DMS), dimethyl disulphide (DMDS), and hydrogen sulphide (H2S).

The two German sulphate-pulping plants are fitted with a system for post-incineration of NCG equipped with wet scrubbers for SO_x removal and with systems for NOx-reduced combustion in recovery boilers (>20 % NO_x reduction; figures of the German Pulp and Paper Association (VDP, September 2004). Because of the odours of reduced sulphur compounds, the two relevant plants are practically leak-proof and fitted with an advanced collection and odour abatement technique - otherwise they would not be permitted in Germany. All residues end up in (liquor)-recovery boilers and do not emit in reduced form.

Sulphite process

Sulphite pulp is produced in 4 of 6 installations in Germany. In such plants, pulping is based on the use of aqueous sulphur dioxide (SO_2) and a base - calcium, sodium, magnesium or ammonium. The four German mills use the acid bisulphite method. Acid processes are those in which the pH is 1 – 2.5. Sulphite pulping for papermaking derives its name from the use of a bisulphite solution as the delignifying medium. The cation used for papermaking pulp is magnesium (all 4 mills in Germany). The sulphate process and the sulphite process have numerous similarities, including similarities with regard to possibilities for using various internal and external measures to reduce emissions. From the standpoint of environmental protection, the main differences between the two pulp-production processes have to do with chemical aspects of the cooking process and the temperature in the recovery boiler, with aspects of preparation and post-processing of chemicals and with bleaching intensity – bleaching in sulphite plants is less intensive, since sulphite pulp is whiter than sulphate pulp. Atmospheric emissions occur especially in recovery (boilers) and in bark combustion. Waste-gas emissions with less concentrated SO_2 are released in washing and sorting processes, and they are released by ventilation shafts of evaporators and by various tanks. Such emission escape – in part, as fugitive emissions – at various points of the process. They consist primarily of sulphur dioxide, nitrogen oxides and dust.

All four sulphite pulping plants in Germany are operated with a collection system for concentrated and less concentrated sulphur dioxide-containing and odorous gases (organic acids) and they include multistage SO_2 scrubbers fitted downstream from recovery boilers (>98 % SO_2 reduction) and recirculation of the recovered chemicals (SO2 cycle). One plant is fitted with equipment for NO_x-reduced combustion in recovery and auxiliary boilers (total of >40 % NO_x reduction, loc. cit.). A number of measures are available for reducing consumption of fresh steam and electrical energy and for increasing plant-internal generation of steam and electricity. Sulphite pulp mills can generate their own heat and electricity by using the thermal energy in concentrated liquor, bark and waste wood. The recovery boiler acts as a power station where the concentrated spent sulphite liquor is burnt. Generated heat is utilised for the generation of high-pressure, superheated steam. Part of the energy content in the high-pressure steam is utilised for generating power in a back-pressure turbine. Medium-pressure steam extracted from the turbine and low-pressure exit steam are utilised for covering the heat energy demand in the pulp process. Integrated plants that operate a recovery boiler are nearly electricity self-sufficient and only need limited supply of fossil-fuel-based power. However; these additional amounts can be generated in either in on-site facilities or at off-site locations. Integrated sulphite pulp and paper mills consume 18 - 24 GJ of process heat, and 1.2 - 1.5 MWh of electrical energy, per tonne of pulp.

Explanation of the management of process related sulphur and ammonia emissions for pulping processes occurring in Germany Sulphur emission levels from sulphite mills and the potential for further reductions are highly dependent on the type of mill. Due to differences between different sulphite processes, the emission levels might show higher variations than in kraft (sulphate)pulp mills.: Many sulphite pulp mills (e.g. all mills in Austria and Germany) have installed a system for the collection of the vent gases from nearly all processes that may release diffuse SO2. The vast majority of these diffuse gases are captured by the weak gas collection system and used as combustion air in the recovery boiler. Well designed,

maintained and operated gas collection systems allow the recovery of almost all fugitive SO2 emissions of the mill so that no significant diffuse SO2 emissions are released to the environment. All SO2-containing gases are collected and treated and SO2 is recovered.

Emissions of odorous gases in sulphite pulping are normally limited compared to kraft (sulphate) pulping. However, emissions of furfural mercaptan and H2S might cause odour and emissions of gaseous sulphur may also cause annoyances. At many mills, emissions of odorous gases are collected and burnt in the recovery boiler (all German and Austrian mills). Another option is treatment in wet scrubbers. Exceptions with ammonia emissions are prohibited and actually excluded. Both circumstances are therefore not relevant for Germany.

Mechanical pulp

Mechanical pulp is produced in 8 plants in Germany. In mechanical pulping, wood fibres are separated from each other via mechanical energy applied to the wood matrix. This process is designed to conserve most of the lignin in the wood, in order to maximise yields while ensuring that the pulp has adequate strength and whiteness. In German mills two main processes are differentiated:

- the groundwood process (GW), in which pieces of wood are wettened and pressed against a rotating grinder

and

- the thermomechanical pulping process (TMP), in which wood chips are broken down into fibres in disk refiners.

Mechanical-pulp properties can be influenced by increasing the process temperature and, in the case of the refiner process, by chemical pre-treatment of the wood chips. The pulping process in which wood is chemically pre-softened and then broken down into fibres, under pressure, is known as chemical-thermal-mechanical pulping (CTMP).

In most cases, the waste-gas emissions consist of emissions from heat and energy generation in auxiliary boilers and of emissions of volatile organic carbon (VOC). VOC emissions occur in storage of wood chips, in removal of air from containers for washing wood chips, as well as from other containers. They also occur in connection with condensates that are produced in recovery of steam from refiners and contaminated with volatile wood components. Some of these emissions are released as fugitive emissions, from various parts of mills.

Paper and carton production

Paper is made from fibre materials, water and chemical additives. The entire paper-making process consumes large amounts of energy. Electricity is required primarily for operation of various motors and for grinding of fibres. Process heat is used primarily for heating water, other liquids and air, for evaporating water in the drying process of paper machines and for converting steam into electrical energy (with heat/power cogeneration). Large amounts of water are required as process water and for cooling. Various additives are used in the paper production process as process supplies and to enhance product properties (paper additives).

Most of the waste-gas emissions produced by non-integrated paper mills are produced by steam-production and energy-generation systems. The boilers used in such systems are standard boilers that do not differ from those of other combustion systems. It is assumed that such systems are operated in the same manner as other auxiliary boilers of the same capacity.

Overall, most product-specific waste-gas emissions are site-dependent (for example, they depend on the type of fuel used, the size and type of the relevant facility, whether the plant is integrated or non-integrated, whether it generates electricity). The auxiliary boilers used in Germany cover a wide spectrum of different sizes (from 10 to more than 200 MW). With smaller boilers, the only useful approach is to use low-sulphur fuels and the pertinent combustion technologies, while secondary reduction measures can also be effective with larger boilers.

Methods

Activity data

The figures are available from the base year 1990 onwards and are collected annually by the Association of German Paper Mills compiled in a so-called Performance Report [1)]. The separate AD of sulphat pulp and sulphit pulp may not be published,

but only in sum.

Emissions factors

Since 2005 real emission factors from German plants for pulp production are available (German contribution to revision of the Best Available Technique Reference Document (BREF) for the pulp and paper industry, 2007). For this reason, in many cases interpolations were carried out between default and country specific values for 1990 and the real, plant-based values (valid from 1995 up to now). In 2022 the national expert evaluated the used EFs with new figures of the producers [2)]. Some changes has been necessary with the following results:

Table 1: Overview of most recently applied emission factors, in kg/t

	EF sulphate pulp	EF sulphite pulp
CO	0.47	0.1
NO_x	1.07	1.7
NMVOC	C	NA
SO_2	0.02	1.5
TSP	0.09	0.14
PM10	0.07	0.11
PM2.5	0.05	0.07

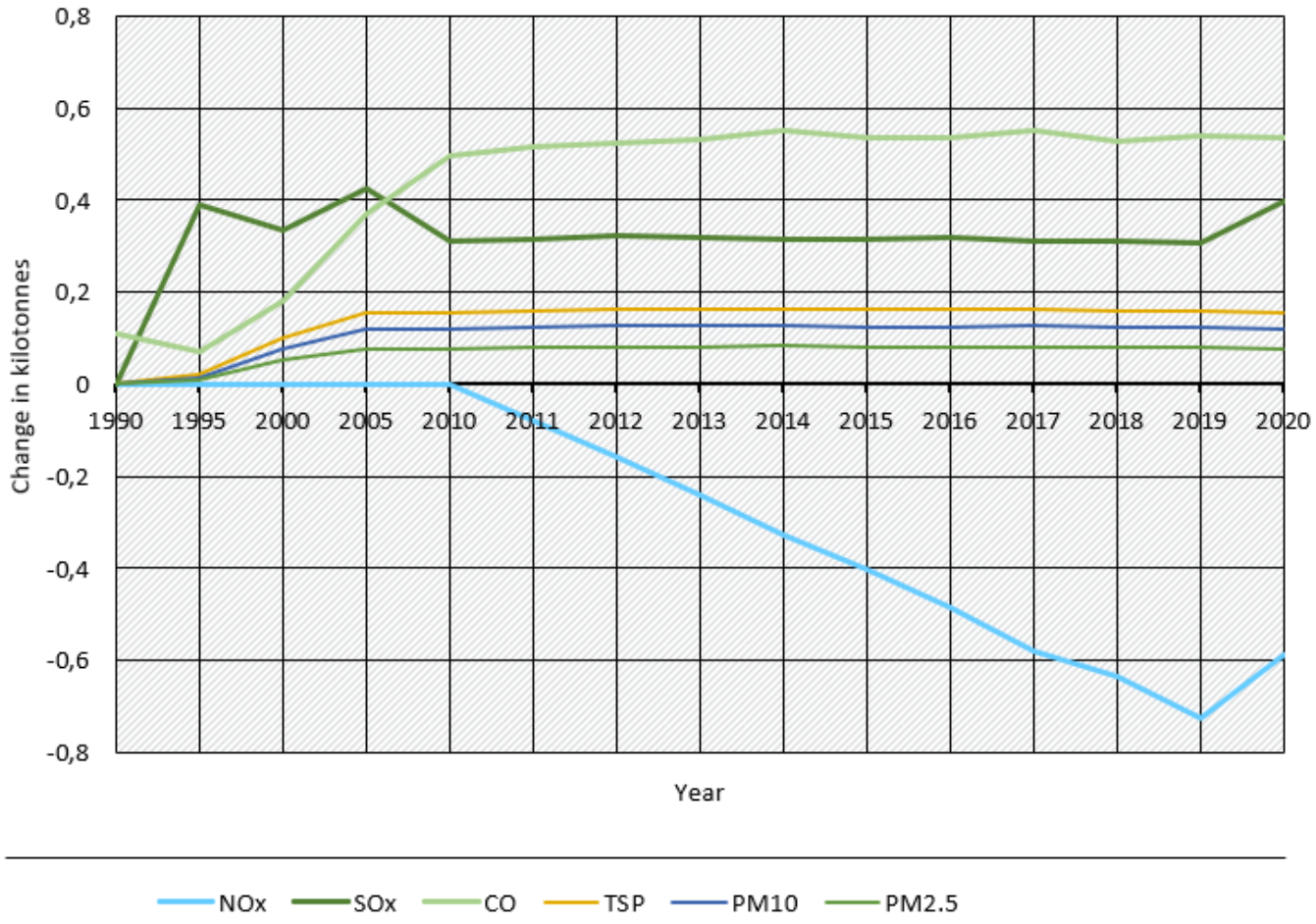
A range of measures in sulphite pulp production, carried out on a continual basis, led to reductions of SO_2 emissions. EF of NMVOC is confidential since the AD of sulphat pulp is confidential.

Recalculations

Recalculations were necessary due to corrected emission factors for many pollutants. The significant changes can be shown as an absolute difference over time as follows:

Emissions in Germany of pulp and paper industry

Absolute changes compared to last year's submission



Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2023)

Recalculations in NFR 2.H.1

For **pollutant-specific information on recalculated emission estimates for Base Year and 2020**, please see the pollutant specific recalculation tables following chapter 8.1 - Recalculations.

Planned improvements

At the moment, no improvements are planned.

[1)] and other short statistics: https://www.papierindustrie.de/papierindustrie/statistik

[2)] Figures of facilities: „Data of periodic monitoring“ made available by industry association, but not public available because of confidentiality issues