ANNEX to submission in PFAS public consultation filed by Bioeconomy Task Force
Socio-economic analysis

Q1 What would be the economic impact? (e.g., shutdown of manufacturing lines, production plants, cost of replacement of the material)

Based on the longish reply presented in question Q5 on the cause-effect relation to PFAS containing components or parts to production line performance, the team of experts at Valmet has suggested two production scenarios to happen on case of a sudden PFAS ban. With the build in hypothesis that all PFAS affected components

Scenario 1: doubling the planned and unplanned shutdown amount on EU pulp and paper mills
Scenario 2: quadrupling the planned and unplanned shutdown amount on EU pulp and paper mills

Scenario 3: worst case scenario where operating the mill is not possible technically or financially and the mill is shut down. Not calculated here, as it will result in 100% capacity closure for technological and economic viability reasons.

In case too sudden ban of PFAS, the likelihood of scenarios 1,2 and 3 can be estimated on following ways

1) Technological analysis of increased shutdown impact
2) Technological analysis of production design capacity and current PFAS containing critical components
3) Economic viability due to increased shutdowns

Current planned and unplanned shutdown in pulp and paper industry

Valmet has been collecting yearly production statistics on paper and board mills for the last 20 years. Based on 2022 statistics the planned and unplanned amounts in paper and board mills are shown in table Q1/1**.**

Table Q1/1. planned and unplanned amount in pulp and paper industry in Europe. Source 2022 Valmet customer production statistics.

	Planned shuts, (%) of time	**Unplanned shuts**, (%) of time	**Total production shutdown without market shutdowns**, (%) of time
Cartonboard	2,6	6,0	8,6
Containerboard	2,6	4,2	6,8
Paper	2,1	5,4	7,5

Technological analysis of increased shutdowns due to sudden PFAS ban

Scenario 1 with doubling production line shutdown would lead modest technological loss of production capacity leading to increased exports to Europe. Calculated in table Q1/2

Scenario 2 with quadrupling would lead to large and meaningful production loss in Europe’s pulp and paper production loss leading to heavily increased exports to Europe. Calculated in table Q1/2

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Table Q1/2. Technical production capability, Scenarios 1 and 2. Source: AFRYSmart database & Valmet analysis.

	2021 Europe production (M/a)	2021 Europe Demand (Mt/a)	2021 Europe Capacity (Mt/a)	Scenario 1 production capacity (Mt/a)	Scenario 2 production capacity (Mt/a)	Europe under capacity, Scenario 1 (Mt/a)	Europe under capacity, Scenario 2 (Mt/a)
Cartonboard	13,6	11,5	16,0	12,4	10,1	0,9	-1,4
Containerboard	41,5	38,3	46,0	38,6	33,0	0,3	-5,3
Paper	28,3	26,6	33,0	30,5	21,7	4,0	-4,8
Tissue	8,9	9,1	11,0	10,2	7,2	1,1	-1,9
TOTAL	92,3	85,5	106,0	81,5	64,8	5,2	-11,6

From table Q1/2 it can be seen that in scenario 1 there is no under capacity in any grade. When the capacity decreases in scenarios, the gap between capacity and demand decreases and eventually turns negative illustrating under capacity. Under capacity is calculated: scenario x production capacity minus 2021 Europe demand. In scenario 2 there is under capacity in each grade because there is less production capacity than demand in Europe.

Technological analysis of production design capacity and current PFAS containing critical components

The capacity development of pulp and paper production machines and processes is based heavily on global, long term material development. For paper, board and tissue machines this realizes in increased machine speed, as with of the machines cannot be easily widen. The current high capacity and high-speed machines is a direct derivate of long-term material property development including heavily PFAS materials.

To demonstrate the age of EU paper, board and tissue machines the industry uses a “technical or technological age” -indicator. This indicator takes into account all modernizations made to the asset and expresses well the age when the machine and its prerequisites for materials used is done. I.e., design criteria and design age. This is shown in table Q1/3.

Table Q1/3 Technical/Technological age of European paper, board and tissue machines. Source: AFRY Smart database & Valmet analysis

	Average Technical/Technological age, (a)
Cartonboard	32
Containerboard	28
Paper	25
Tissue	26
TOTAL	28

One cannot start using non PFAS components on production critical components without totally compromising the functionality and production capacity of the machines and safety to humans and nature. See Figure Q5/1.

Economic viability due to increased shutdowns due to sudden PFAS ban

The viability of pulp and paper production in Europe is traced and estimated through scenarios 1 and 2. Viability is taking into account production and distributions costs of manufacturing versus the market price level of the product produced. The chance of shutdown as discussed in the two production scenarios relating to the sudden PFAS ban is estimated to have the following impact to production viability.

In scenario 1, approximately 50 % of the capacity will be closed due to economic reasons and respectively approximately 90% in scenario 2. The outcome to production capacity is shown in table Q1/4.

Table Q1/ 4. Viable production capability now and on scenarios 1 and 2. Source: AFRYSmart database & Valmet analysis.

	2021 Europe production (M/a)	2021 Europe Demand (Mt/a)	2021 Europe Capacity (Mt/a)	Scenario 1 viable production capacity (Mt/a)	Scenario 2 viable production capacity (Mt/a)	Europe under capacity, Scenario 1 (Mt/a)	Europe under capacity, Scenario 2 (Mt/a)
Cartonboard	13,6	11,5	16,0	6,8	1,4	-4,7	-10,1
Containerboard	41,5	38,3	46,0	20,7	4,1	-17,6	-34,2
Paper	28,3	26,6	33,0	14,0	2,8	-12,5	-23,8
Tissue	8,9	9,1	11,0	4,7	0,9	-4,4	-8,2
Total	92,3	85,5	106,0	46,2	9,2	-34,8	-68,1

In Table Q1/4 above under capacity is calculated similarly to Table Q1/2. From the table it can be seen that the decrease in viable production would lead to significant under capacity in Europe in both scenarios. The under capacity would be 35 % in scenario 1 and in 70 % in scenario 2

Q2 What would be the social impact? (e.g., job losses resulting from the above economic difficulties)

On the question Q13, paper industry direct workforce is established to be app. 180 000 people only in CEPI countries. Respectively on Q13 there is an approximation on **indirect effect to be 3 x direct.** The number of mill sites is analyzed through AFRYSmart database (Q10). Based on Q1 and economically viable sites to survive thinking, the impact of sudden PFAS ban for **job losses** is following:

Scenario 1; 950 mill sites x 760-man years (190 direct + 570 indirect persons) * 0,5=
361 000 (50% of mills shut down)

Scenario 2; 950 mill sites x 760-man years (190 direct + 570 indirect persons) * 0,9=
650 000 (90 % of mills shut down)

This analysis is based on Q1 likelihood analysis of viable production.

When paper mill is permanently closed, it has a wide economic affect to overall business environment e.g., local stores, support business owners, tax income to local authorities etc. As a case example the permanent shutdown of UPM Kaipola Mill in Jämsä, Finland, affected 450 direct workers at three paper machines, and according to the Mayor of Jämsä, the negative reflection to employment in other businesses in Jämsä town was at least 15%.

Q3 How would the use of alternatives to PFAS induce an increased risk for workers' safety? (e.g., leakage)

In evaluating the PFAS ban to safety, the reasoning is associated with the increase in un-planned shutdown level of all mills in Pulp and Paper industry in Europe.

The core is the fact that these unplanned shuts e.g., caused by different sealing failures causing eye damage, skin burns and falling injuries caused by slippery floors. **These will double in scenario 1 and quadrable in scenario 2.**

According to Valmet design criteria, increase safety risk on unplanned and un-protected human interactions with

0,5...10 bar pressured steam from drying section components

10...100 bar pressured steam (e.g., in Calander heating systems)

0,1 ... 10 bar pressured water from showers and hydrants

10...300 bar pressured water high pressure cleaning equipment

Low temperature 20-50 C lubrication and hydraulic oils from 100+ rolls and related components per machine and from their lubrication and hydraulic centers

High temperature oils 50 – 280 C hydraulic and heating oils from Thermo-rolls and other oil heated rolls

Additionally, lubrication oil or lubrication crease to bearings etc. needs to be free of water. As many critical seals in rolls, pumps and valves separates cleaning or process waters for lubrication oils or greases, the non PFAS replacement seal that would break or leak suddenly compromising machinery lubrication. **This raises the risk of major breakdown, which results in an increased risk of injury or death on these equipment's operation and maintenance personnel**

Q4 How would the use of alternatives to PFAS induce an increased risk for the environment?

The current use of PFAS contains technologies and components used in pulp and paper industry. Emissions are therefore very low. PFAS containing products (e.g., sealings) and components are used in machinery in such places that must tolerate high pressure, high temperature, and exposure to harsh chemicals. Such materials are used as they do not wear down and cause leakage.

Similarly, **all water exiting the production plants is carefully treated according to existing legislation.** In Europe paper producers must have permits to treat water. All water goes through effluent treatment process where many producers produce biogas and recycle some of the water back to mill after biological treatment process.

The risk caused by sudden PFAS ban to environment would relate to untypical chemicals entering to mill process waters and further to water treatment plant, due to the use of new sealing materials that have not been used in the design criteria and therefore cannot be expected to function equally well . Mainly different oils mentioned in Q3 would disturb current water treatment systems. All untypical chemicals compromise the water treatment process by killing the essential microbic.

Q5 What impact would the ban have on the lifetime of the machines? (Including increased frequency of maintenance, need for spare sparts, consequences of an absence of spare parts containing PFAS)

1. Introduction

Valmet is and has been using reliability analytics tool called "ELMAS" to identify component level performance and availability to the total machine or mill production performance. ELMAS is a fault tree (FTA) and failure mechanism & effect analysis (FMEA) tool, developed as derivative of Finish government funded technology programs on developing reliability analytics, methods and tools.

One of the use cases where this analytics method and tool is used, is the nuclear waste depository under Finish bed rock (storage time100.000 years). Source: http://www.ramentor.com/cases/

With FTA+FMEA analytics approach, the effect of machine components using PFAS on the production capability of Board, Paper, Tissue and Fiber lines can be estimated.

2. PFAS containing products in pulp and paper industry

Factories and machines in the pulp and paper industry can technologically be expressed as factories in a factory. Meaning that the total production plant consists of interlinked and cascading sub factories called machine sections or technology islands (in pulp industry).

Valmet has identified on component level of machine sections and technology islands the existence of PFAS containing parts, mainly sealings, lubricants and engineered surfaces to the machines, its frames or rotating parts, e.g., rolls, needed in these machines.

The following overall illustration (Figure Q5/1) demonstrates PFAS usage in Papermaking. The paper machine line includes automation throughout the plant. The picture demonstrates the wideness of PFAS use in the components mentioned. Paper Machine and Stock preparation belong to Valmet Paper Business, but other Valmet businesses (Automation Systems, Flow Control, Services, Pulp&Energy, Textile, Biorefiners) and their products are similarly including PFAS components.

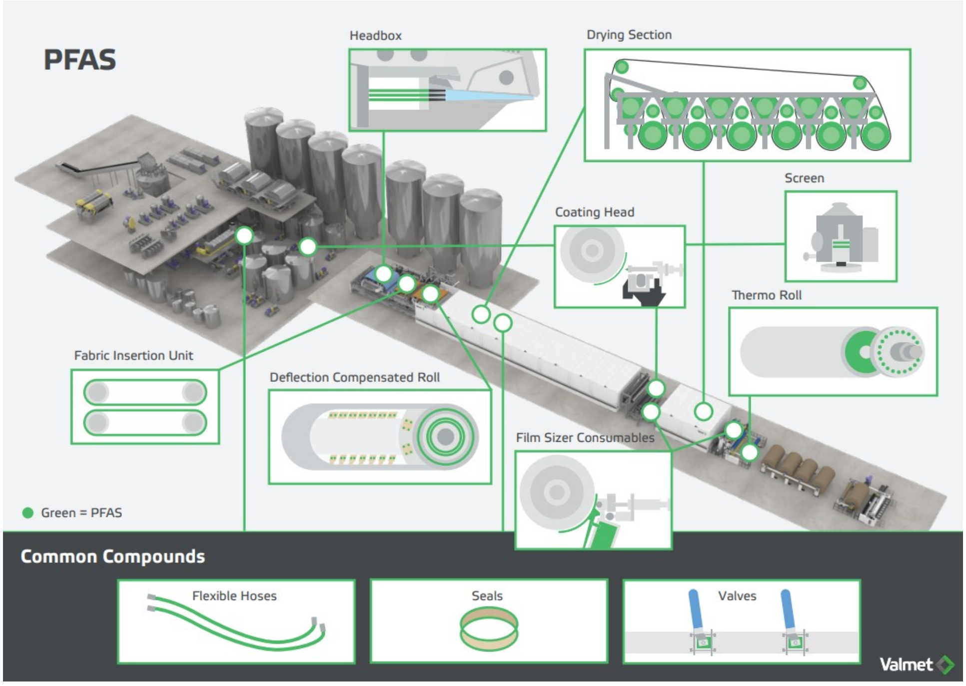


Figure Q5/1. PFAS use in Papermaking

3. FTA+FMEA approach for system performance connected to PFAS containing products in pulp and paper industry

FTA+FMEA analytics for paper and pulp production machines and mills component level faults are connected to component level effects and cascades to sub system level effect (machine sections / technology islands) and eventually to system effect (the whole mill)

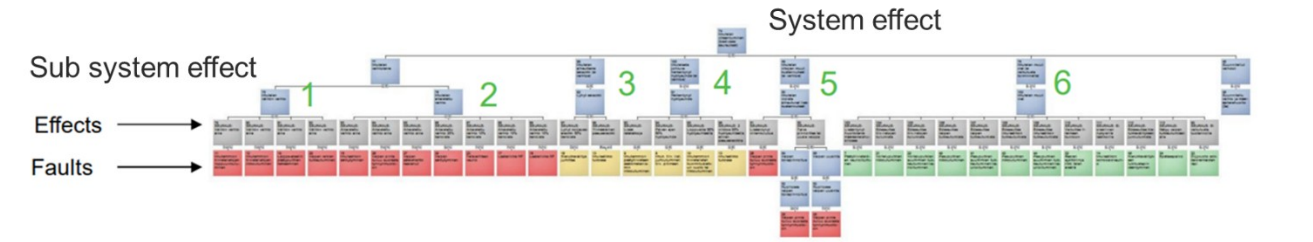


Figure Q5/2. FTA tree example.
In such analytics the component fails need to have known failure interval (like bearing can take 50.000 rotations before statistical failure).

PFAS containing components mainly seals, lubricants and engineered surfaces to the machines, the effect can be described in following way:

a. Component level
1. No measurable effect
2. Shortened component/surface change interval
3. Immediate component change

b. Sub machine level
1. No measurable effect

2. Decreased sub machine / technology island production efficiency
3. Unplanned, but short maintenance shutdown
4. Other increased costs (e.g., effect on cascade downstream sub machines / technology islands)

c. Mill level

1. No measurable effect
2. Reduced plan shut down interval
3. Short Unplanned maintenance shutdown
4. Catastrophic failure preventing the production
5. human safety shut down

Each fault described above has – average period of occurrence – extra costs related to spare parts and repair – Maintenance – effect on probability of occurrence.

The system effect is a result of simulation calculated for 10 000 cases over 10 year running time (number of simulations and running time can be adjusted). In other words, from 10 000 runs ELMAS gives distribution of running cases based on configuration information given – Average number of faults and effects – Probability of faults and effects to happen.

<u>The effects of trying to replace current PFAS containing seals and surfaces will have the following effects.</u>

Leading to

Component level

- Shortened component/surface change interval
- Immediate component change

Sub machine level

- Unplanned, but short maintenance shutdown
- Other increased costs (e.g., effect on cascade downstream sub machines / technology islands)

Mill level

- Catastrophic failure preventing the production
- human safety shut down

4. Conclusion

A legislative ban on PFAS would likely boost the R&D of viable alternative non-PFAS chemicals and components. However, as demonstrated by FTA+FMEA analytics, the performance of such products is utterly important for the system performance of paper, tissue, board and fiber machines and mills. There would need to be enough time to validate properly emerging viable alternative for non PFAS containing products in order to prevent radical and catastrophic system failures of all the mills and factories concerned. Otherwise, the lifetime of the machinery would be radically reduced. Furthermore, the lack of spare parts would already hit the sector in a matter of months, leading to an unforeseen closure in a record time.

Q6 How would the ban affect your energy consumption?

Advanced technologies and increased reliability of machinery have been the key reasons for major improvements in pulp and paper industry energy efficiency. Between 1991 and 2021 the production of pulp and paper has increased by 43 %, while energy consumption has decreased by 24 % and CO_2-emissions by 53 % per production ton CEPI Key Statistics 2022. CEPI has also established Energy Efficiency Solutions Forum (EESF) CEPI sustainability where the goal is *to accelerate the development and implementation of emission-reducing technologies* and to *contribute to achieving the European climate neutrality target by 2050*. One example of EESF's work is the collaboration with the heat pump industry which has a potential to provide about 50 % of the heat needed in paper mills in the long term. **CEPI has projected that to achieve climate targets to reduce greenhouse gas emissions by 80 % by 2050 the investments of pulp and paper industry would need to be increased by 40 %** compared to average 3,5 billion € per year CEPI roadmap to 2050 (2017) . Investing in new technologies requires stable and predictable business environment and total PFAS ban would shift the focus of paper industry companies from new technologies to sustaining current performance and limit the investments needed to achieve energy efficiency and climate targets. According to Global energy consumption due to friction in paper machines 15-25 % of the electricity in paper mills is consumed to overcome friction. Friction losses are distributed as 23% due to friction in elastohydrodynamic rolling contacts, 22% due to friction in elastohydrodynamic rolling–sliding contacts, 15% due to friction in oil-lubricated seals and 8% due to friction in hydrodynamically lubricated contact. It was estimated that with improved friction control 98 000 GWh/a could be saved globally in 2025 compared to baseline machine from 1980's.

It can be projected that PFAS ban would impact machine speed and reliability if components with similar performance would not be available. In both senarios1 and 2, due to increased un-planned shuts the paper / board / tissue machine sub sections / pulp technology islands are on at idle power waiting for repair of one affected section by non PFAS product replacement. It is estimated that in scenario 1 these values shown in table Q6/1 will increase by 5% and respectively in scenario 2 by 15%. With the current production amount, electricity consumption would increase from 92 800 MWh/a CEPI Key Statistics 2022 to 97 500 MWh/a in scenario 1 and to 106 800 MWh/a in scenario 2 and specific energy consumption from 1 357 000 TJ to 1 425 000 TJ in scenario 1 and to1 560 000 TJ in scenario 2. Direct and Indirect CO_2-emissions would increase by 1,89 MtCO2 in scenario 1 and by 5,67 MtCO2 in scenario 2. Note that there is a big variation in consumption figures between different products and producers and that in some machines gas is replaced with electrical air dryers to remove the need to use fossil fuels directly on paper machine.

*Table Q6/1 shows 2022 EU P&P production consumption averages. Source: 2022 Valmet customer production statistics. *) applicable only to coated paper products, like LWC and WFC*

	specific electricity consumption (kWh/t paper)		specific steam consumption, (kWh / t paper)	specific gas consumption, (kWh/t paper)	specific water consumption (m3/t paper)
Cartonboard	592		1011	118	8,7
Containerboard	610		1117	0	7,2
Paper	479 / 929*		1109	88*	8,8

Replacing current PFAS seals with something else would lead to increased energy consumption due to the increased coefficient of friction of the replacement materials. For example, replacing PTFE seals with the currently best-known candidate PEEK, would increase friction by four times. In addition to energy consumption, this will increase the wear of the components and thus shorten the life-time of the components.

Q7 Would the ban lead to an increased environmental impact of your production process? (e.g., more waste generated, more water consumed)

In **scenario 1** (ref Q1) the scrapped paper amount per machine line will double from current levels as doubling shutdown will double ramping up the process related paper/board and tissue waste.

In **scenario 2** (ref Q1) the scrapped paper amount per machine line will be quadrable from current levels as respectively increased shutdown will cause ramping up the process related paper/board and tissue waste.

Most of the broke can be processed again to end-products but that requires energy, water and chemicals and decreases production capacity.

Table Q7/1. Production broke in P&P Europe (not in specification product) as % of total production. Source: 2022 Valmet customer production statistics.

Grade	Broke, (%) of production
Cartonboard	9,7
Containerboard	4,7
Paper	5,9

From water consumption perspective it is difficult to estimate the effects accurately. Nonetheless in pulp and paper mills there are many water consumption points where the consumption is constant despite the production amount. For example, if PFAS ban would limit the machine speeds (currently up to 2000 m/min in fast paper machines) the production amount would decrease but all the cleaning showers would be run like before to keep the machine components clean, and the specific water consumption would increase. Also, if reliability of components decreases that would lead to bigger number of breaks in production and increase water consumption per produced ton.

Q8 Would the ban affect the volume/quantity of paper produced in your plants, and if so, can you provide an estimation?

Answered in Q1 with two scenarios with same likelihood relating to sudden ban of PFAS containing seals, lubricants and engineered surfaces.

Q9 How would the ban affect your production costs, and eventually, your prices?

Indirectly answered in Q1 with scenarios of 50% and 90% mill closures due to increased production cost and workplace safety affected by increased unplanned and planned shutdowns of production assets. Estimation in Table Q1/3.

Q10/a) Is the demand for paper in the EU growing in the present period?

As analyzed through AFRYSmart database, global annual Paper&Board consumption (demand) was **430 million tons in 2021**, and global annual production was **427 million tons**. Europe's

(WE+EE) share of global **production** was **24.6 % (105,0 Mt).** European consumption (demand) was **~93 Mt** (2021). In Europe there are **~950 paper mills** producing different paper grades. European production capacity is capable of producing the demand in Europe. **Paper & Board growth in Europe** is **driven by board grades**, mainly containerboard and cartonboard, where the annual growth rate is around 1,5-2% **and tissue** with annual growth rate around 2%, the demand is declining in Paper (Printing&Writing and Newsprint).

Valmet has estimated the theoretical number of possible machine investments in Europe within 3-4 years. The estimated number of high technology machines either by conversion or new installation is presented in Table Q10/1. The number of machines depends on the technology and the size of the machine (produced capacity/a), and Table Q10/1 is an illustration of what the growing demand means from a machine technology provider's perspective. Board/paper mill investment is typically 300-500 M€ where the machine(s) operate 24/7. Investment time, from planning to start-up, is approximately three years. **This gives a reader an understanding of the market that is affected by the proposed PFAS ban.**

Table Q10/1: Illustration of what growing demand means from machine technology provider perspective

Grade	**Estimated capacity of board/tissue producing high - technology machine Ktons/a**	**Estimated nr of high-technology machines (converted or new machine) within 3-4 years in Europe**
Containerboard	400-600	~11-7
Cartonboard	500-800	~3-2
Tissue	30-60	~29-14

Q10b) If so, which uses are particularly subject to this growth (e.g., packaging)?

The megatrends like sustainability (driven also by consumers), eCommerce, hygiene awareness and regulations (e.g., SUP/plastic replacement) support long-term growth in fiber-based packaging and tissue grades.

From the consumer point of view sustainability is very important. Already in 2020 77% of consumers had a positive image of companies that package products in fiber-base packaging, and 84% of consumers expressed concerns about the environment, as discussed in the Paper360 article.

According to Statista 44% of consumers are more likely to buy from a sustainable brand, and 54% of consumers plan to avoid buying new goods for sustainability reasons.

According to Smithers, **worldwide demand for fiber-based packaging** is set to rise to **$503.4 billion in 2027, CAGR 3.4%**, and the total weight of fiber packaging to **316.3 million tonnes** from 264.4 million tonnes in 2022, CAGR of 3.7%. Source: Packaging Europe

According to article in Paper360 "Plastic replacements create new opportunities" by Nancy Hasson it is *projected that* ***virgin and recycled paperboard will see a significant increase in demand, as paper food-grade containers and paper cups replace plastic*** *over the next five years. Considering plastic beverage cups, replacing 10 percent of plastic cups globally with paper would require an estimated 588,000 tons of cup stock, an increase of 20 percent over 2021 global capacity of 2.9 million tons.*

In 2021, retail **eCommerce** sales amounted to approximately 5.2 trillion USD globally, and it is forecasted to **grow by 56 %** over the next years, reaching ~8.1 trillion USD by 2026. With an average yearly revenue **growth of 12%** between 2020 and 2026, the **eCommerce market in Europe** is projected to continue developing strongly and surpass the milestone of **US$1 trillion** of eCommerce revenues by the middle of the decade (source: Statista). These figures do not include eCommerce in B2B sectors.

Q11 A) What is the role of the paper sector in the green transition?

Paper sector green transition can be discussed and measured by the industry's target to improve its energy, material, and water efficiency and to reduce emissions to air and water on its production plants. As described in Q6, European pulp and paper industry has decreased specific energy consumption by 25 % between 1991 and 2021. During the same period direct and indirect CO_2-emissions have decreased from 52,9 $MtCO_2$/a to 37,8 $MtCO_2$/a and specific emissions by over 50 % CEPI Key Statistics 2022. Also, as can be seen from figure Q11/1 below, specific emissions to water (COD, AOX) and non-CO_2-emissions to air (SO_2, AOX) have decreased 50-95 %.

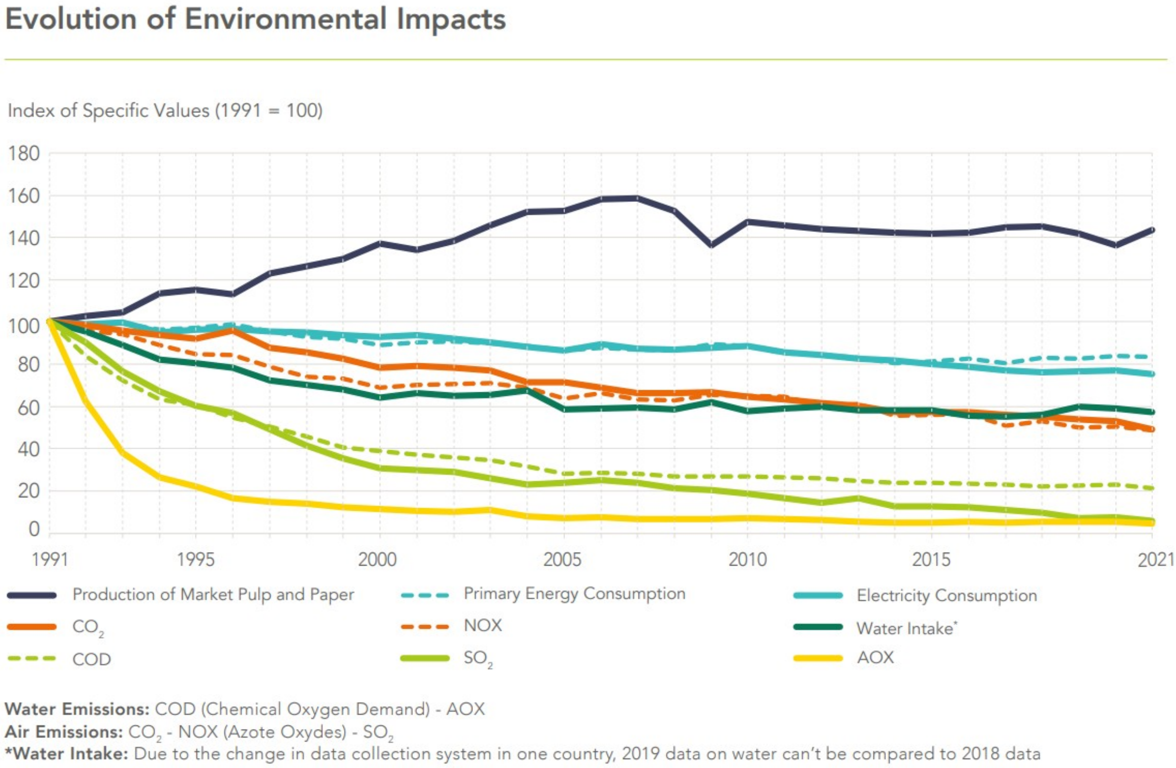


Figure Q11/1: Evolution of Environmental Impacts (CEPI Key Statistics 2022)

The target for European pulp and paper industry is to contribute to reaching European carbon neutrality in 2050 and drive the transition to a low-carbon circular bioeconomy and to reduce its CO2-emissions by 80 % compared to 1990-levels. CEPI sustainability The sources of emission reductions are show on figure Q11/2 below CEPI roadmap to 2050 (2020) Energy efficient and breakthrough technologies and decarbonization of electricity have the biggest effect on emission reductions. Most of the energy consumed by pulp and paper making processes is used in heating and drying which is the reason that heat pumps and new drying methods like superheated steam drying and water removal without evaporation are seen as potential breakthrough technologies. **Developing new technologies requires significant investments in R&D and with total PFAS ban companies and technology suppliers would need to move most of their R&D efforts from future technologies to finding PFAS replacements.** Target in R&D would be to maintain current performance and not to improve energy efficiency and to reduce greenhouse gas emissions.

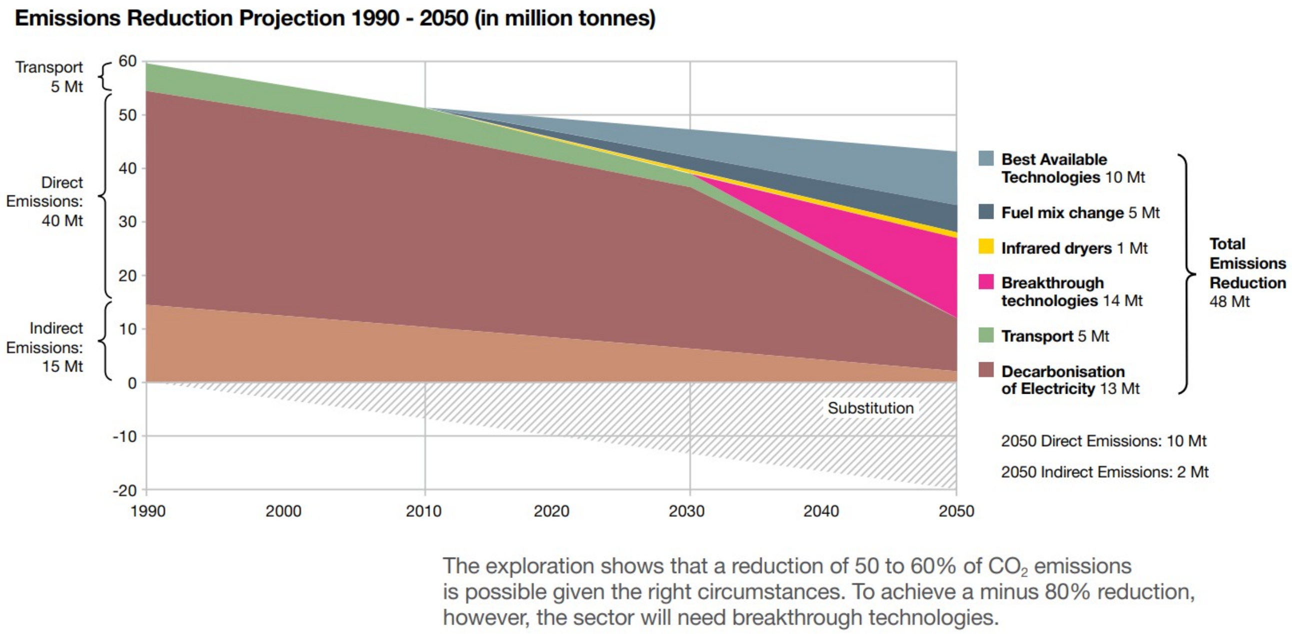


Figure Q11/2: Pulp and paper industry emission reduction CEPI Roadmap to 2050 (2020)

Same topic has been studied in Satu Lipiäinen’s doctoral thesis The role of the forest industry in mitigating global change: towards energy efficient and low-carbon operation (2022)

From conclusions (p. 80):
“4) What are the future prospects for energy use and CO2 emissions in the forest industry, and how can the sector contribute to meeting climate targets?

The forest industry is expected to continue to develop towards more sustainable production. As there are no crucial barriers and new pulp mills can already achieve carbon neutrality during normal operation, **it can be rather safely argued that the forest industry has an opportunity to eliminate industrial fossil CO2 emissions by 2050**. There is still the potential for energy efficiency improvements and there are also possibilities to increase the use of on-site biomass for energy or raw materials. Modern pulp mills can already produce notable amounts of excess electricity. Especially pulp mills provide interesting platforms for bioenergy carbon capture. However, the development pace so far has been moderate, and the investment cycles are long in the sector. Mills are renovated within 30–50 years, and therefore changes may not be fast in the future. **2050 is already only one investing cycle away, and thus significant efforts must be put into decarbonization immediately.** Moreover, reaching net-zero emissions in the relatively near future may require adding the carbon capture to a portfolio of measures for cutting CO2.

The forest industry has good premises to achieve carbon neutrality and the sector can contribute to achieving climate goals. **The reduction of industrial fossil CO2 emissions can play a substantial role in mitigating global change, but the forest sector may have a significantly larger role as it has possibilities to produce renewable energy, fuels and products, and strengthen forests as carbon sinks. The palette of possible new products is wide, including textile fibres, lignin-derived products, power-to-x fuels, chemicals, and more.** The realization of novel concepts must be profitable for mills, which in many cases requires changes in the political environment. **In Finland and Sweden, the forest sector is expected to provide additional annual CO2 benefits of 11.4 MtCO2 and 12.0 MtCO2 by 2050.** “

From BECCS (bioenergy carbon capture and storage) point of view pulp mills are one of the most potential sources in Europe Assessment of carbon dioxide removal potential via BECCS in a carbon-neutral Europe Pulp and paper mills are the largest BECCS point sources with 62 (±5) $MtCO_2$/a from the total 202 $MtCO_2$/a. In figure Q11/3 below especially Swedish and Finnish pulp mills with none to little use of fossil fuels have BECCS potential of almost 50 $MtCO_2$/a. The EU level target in EU Net-Zero Industry Act proposed by EU Commission March 2023 sets a target of 50 million tonnes of annual CO2 storage capacity by 2030.

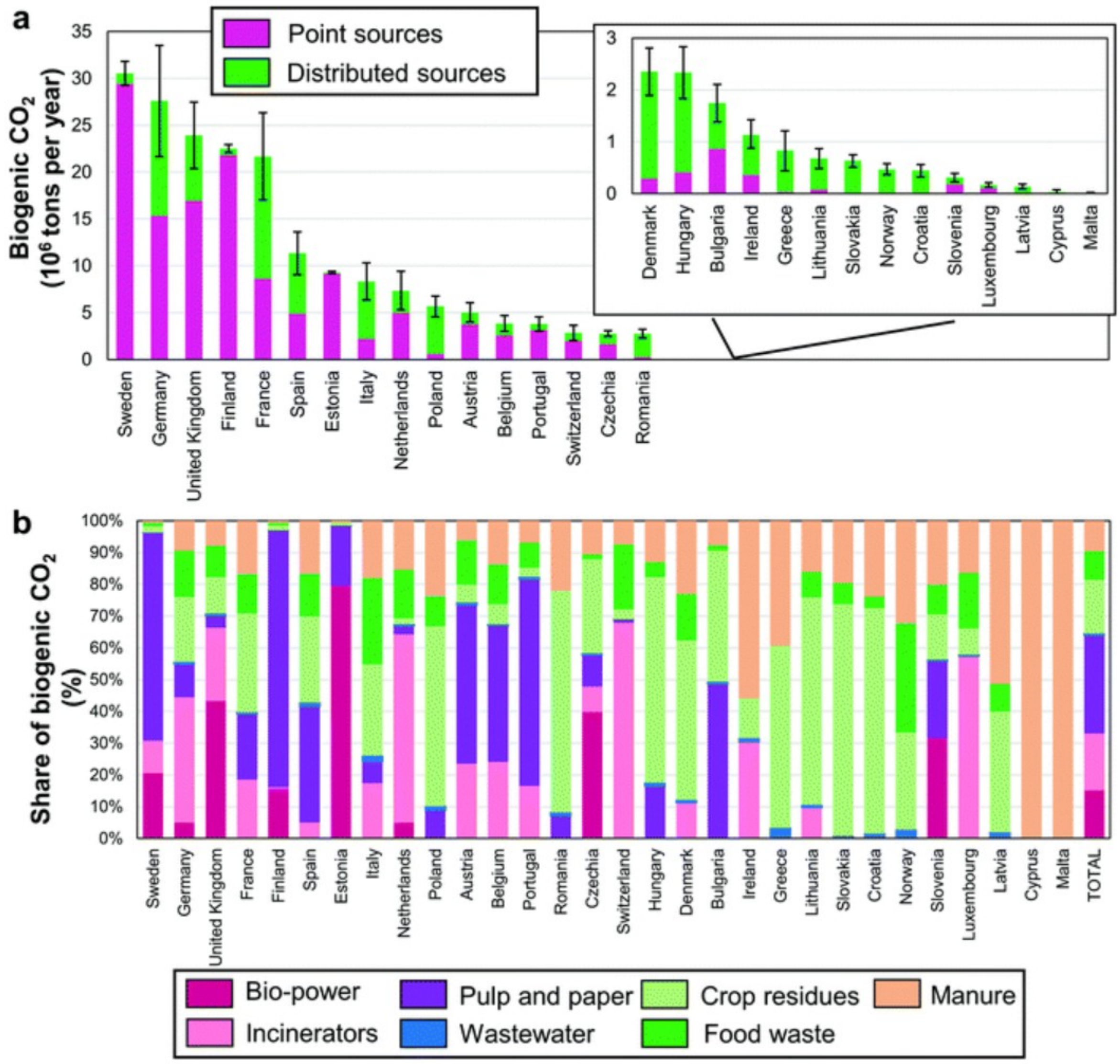


Figure Q11/3: BECCS potential and sources in European countries

However, BECCS is not the only possibility to use pulp mills' bio-based CO2. Lignin, which is currently combusted in in pulp mills' recovery boilers can be used as a raw material for bio-based products. When lignin is extracted from the pulping process, less bio-based CO2 is generated which decreases the BECCS potential. Modern pulp mills are energy self-sufficient, so there is potential to use some of the lignin without the need to purchase energy externally. For example, Stora Enso Stora Enso - Lignin has produced lignin at industrial scale since 2015 and the end product can be used in multiple different use-cases. Some examples are biodegradable polymers, phenols, and binders or even bio-asphalt and anode materials for batteries.

Q11 B) Has there been any significant increase in paper demand in respect to the progressive phasing out of single-use plastics?

SUP ban took place July 3rd, 2021, covering the following: *From 3 July 2021, single-use plastic **plates, cutlery, straws, balloon sticks and cotton buds** cannot be placed on the markets of the EU Member States. In addition, the same measure applies to cups, food and beverage containers made of expanded polystyrene, and all products made of oxo-degradable plastic. Single-use plastic products are made wholly or partly of plastic and are typically intended to be used just once or for a short period of time before they are thrown away. Under the new rules, certain throwaway plastic products for which alternatives exist are banned. Specific measures are also introduced to reduce the use of certain products. Source: Environment.ec.europa.eu*

The SUP ban started "a new era" for sustainable products. Stora Enso presented in its Capital Market Day 2022 that *~20 million tons of plastic packaging is wasted in Europe every day, and ~25% could be substituted by recyclable and low CO2 fiber-based solutions.*
Pulp&Paper producers have increased their sustainability investments and the ban has created new opportunities to Pulp&Paper producers e.g., global **molded pulp packaging** is expected to grow at a CAGR of 7.4% (2022-2023), to reach a value more than **9 billion USD**. Molded pulp is typically made from recovered paper and natural fibers (e.g., sugarcane bagasse and straw). Molded fiber packaging is used across various applications, including food packaging, food service, and electronics (source: Statista). **In technology side** e.g., at the end of 2020, Metsä Group's innovation company Metsä Spring and **Valmet** announced they would be investing a total of approximately 20 million euros in **3D fiber product** demo plant. The demo plant is part of Metsä Group's integrated mill site in Äänekoski, and it produces finished 3D fiber packaging products directly from wet pulp without intermediate phases. **The molded fiber-based packaging can replace plastic, for example in food packaging.**

Referring to Plastic Replacements Create New Opportunities article in Paper360, *molded fiber packaging has seen steady growth over the past couple years, as reported by the International Molded Fiber Association. **Foodservice items and a number of consumer and household product packages are now made with biodegradable molded fiber instead of plastic.** As advancement in manufacturing technology continues for molded fiber, cost reductions and performance improvements will allow more packages to convert to molded fiber, using both virgin and recycled pulp.*

Q12 In which uses can paper be an alternative to plastic?

There are **multiple product groups and products** that can be utilized as an alternative to plastic e.g., Liquid packaging, Food packaging, Consumer bags and sacks, Industrial bags and sacks, Cups, Trays, Plates, Display packaging, Bio-barriers, Bottle and Cup Carriers, Packaging materials e.g., Fold packaging or paper-based packaging groats or shredded board **to replace Styrofoam** as demonstrated in figures Q12/1, Q12/2, and Q12/3 underneath.

Figure Q12/1: Fold packaging (www.vtt.fi)

Figure Q12/2: Packaging groats (www.napakka.fi)

Figure Q1 3: Board shredder by Wessex Packaging: Recycle your waste cardboard into packaging in YouTube

The EU has a project called R3PACK which is developing sustainable, fiber-based alternatives to plastic packaging that should prevent harmful chemicals from coming into contact with food. With **the budget of €95.5 billion**, R3PACK is part of Horizon Europe's seven-year project. **"The R3PACK project aims at developing sustainable fiber-based and plastic-free technologies and fostering reuse schemes,"** says Carla Valeiras Álvarez, EU policy officer at Safe Food Advocacy Europe (SAFE). Source: R3PACK

Already in 2019 **Paperboard was the most used packaging material worldwide, accounting for approximately 33% of packaging material consumption.** Types of paperboard packaging include cardboard (cartonboard) and folding boxboard (containerboard) as presented in Figure Q12/2. Since then, e.g., the SUP ban and R3PACK (developing sustainable fiber-based and plastic free technologies) have taken place in Europe, and consumers prefer sustainable packaging, which means that the Paperboard packaging share of the packaging material consumption will grow. **PFAS ban would compromise the production of fiber-based packaging materials.**

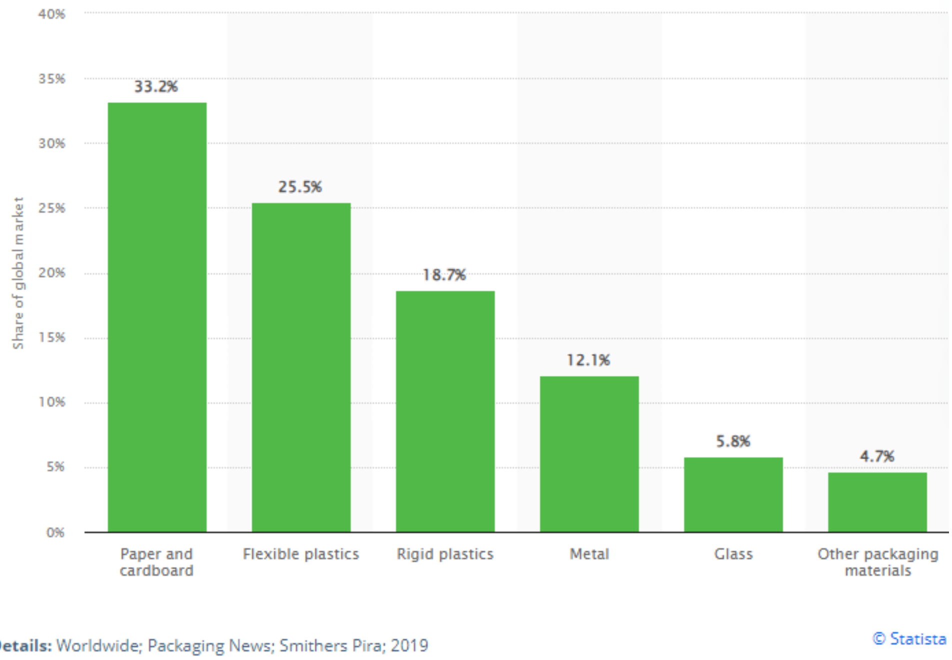


Figure Q12/2: Statista: Distribution of packaging demand worldwide in 2019 by material type (publication date March 2022)

Q13 What is the part of the paper industry in the EU's economy (employment; export; autonomy)?

Employment

According to Statista, in 2022 there were **179,951 people employed** in the European pulp and paper industry (CEPI countries). **CEPI countries account for 91% of European pulp and paper production (excluding Russia).**

Pulp&Paper Industry turnover 2022 in CEPI countries was 115 billion Euros. Source: [CEPI Key Statistics 2022]

The three biggest Pulp&Paper technology companies (machinery providers) have almost 40 000 employees in Europe (Valmet ~ 10 000, Voith ~12 900, Andritz ~15250*). These companies have also their Headquarters in Europe. If calculating with the earlier presented method (Q2) and including the indirect workforce in the figure (supply chain, subcontractors etc.) the amount would at least triple, being **120 000.** There are also several smaller machinery providers in Europe.

Orders received/intake 2022 for the three biggest Pulp&Paper technology companies globally/in Europe (all industries) *:

Andritz	Total order intake 9,263 M€	Europe 27% = 2,501 M€
Voith	Total orders received total 5,164 M€	Europe 43% = 2,220 M€
Valmet	Total orders received 5,194 M€	EMEA 40% = 2,098 M€ Europe, Middle East, Africa

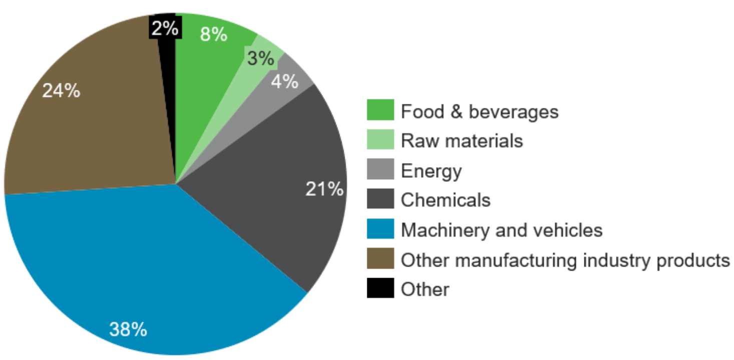
*Company web sites, Annual Reports

Export

Eurozone exports are presented in Figure Q13/1. Paper&board belongs to the export product group “Other manufacturing industry products”. Paper/Board/Tissue and biorefinery machine technology providers belong to the category “Machinery and vehicles”. **The product groups** *energy, chemicals, machinery&vehicles and other manufacturing industry products* equals to **87% of export** and **PFAS chemicals are used in these groups at least to some extent.**

PFAS ban’s effects should be analyzed value chain by value chain and by their relation to each other. E.g., if a machine technology provider cannot provide machines to the paper producer, paper production is closed down. If paper producers cannot provide paper/board to the converter, the converting industry goes bankrupt etc. The product groups in Figure Q13/1 have a relation to one or more other groups.

Eurozone export outside EU 2021 by product groups



Data source: The Bank of Finland, Eurostat and calculations of the Bank of Finland
@Suomen Pankki 29.9.2022 (SP/FIVA – no limitations)

Figure Q13/1: Eurozone export outside EU 2021 by product groups

As covered in Q10 European production capacity is capable of producing the demand in Europe. **Paper & Board exports from CEPI countries were 17.563 million tons** as seen from CEPI Table Q13/1.

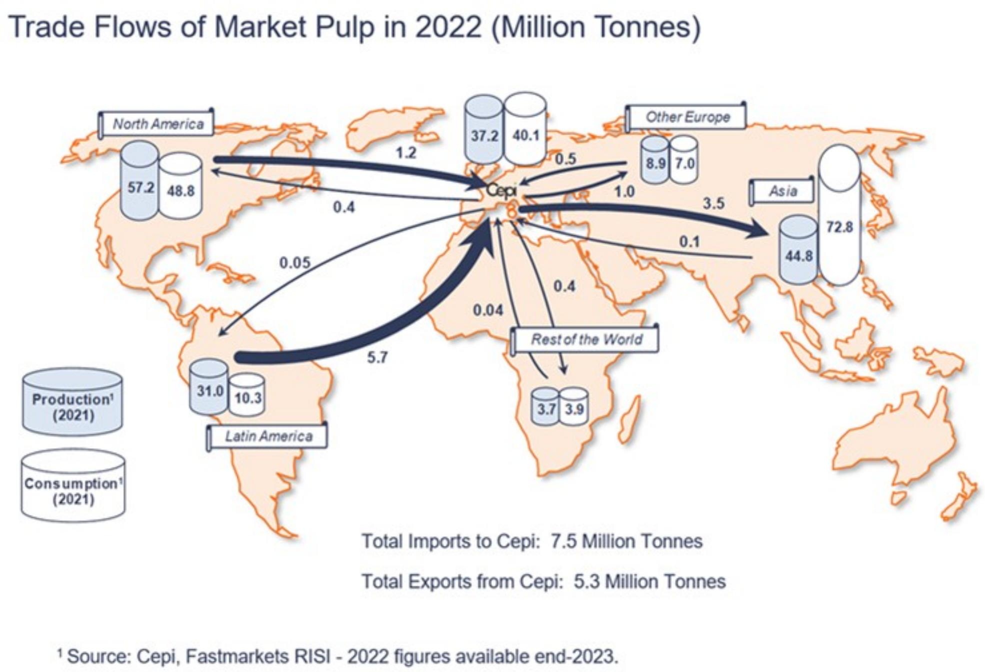
Table Q13/1: Paper and Board exports to other regions by Cepi Key Statistics 2022

Paper and Board Exports to Other Regions

'000 Tonnes	2000	2010	2015	2021	2022	% Change 2022/2021	% Share of Total
Other Europe[1]	6 090	7 349	7 288	7 690	**6 562**	-14.7	37.4
North America	2 283	2 055	2 069	2 573	**2 607**	1.3	14.8
Latin America	874	1 879	1 794	2 011	**1 743**	-13.3	9.9
Asia	2 933	5 099	4 980	4 865	**3 737**	-23.2	21.3
Rest of the World	1 707	2 783	3 063	2 995	**2 914**	-2.7	16.6
Total	**13 887**	**19 164**	**19 194**	**20 134**	**17 563**	**-12.8**	**100.0**

European Paper&Board manufactures are producing 24.6% of the world's total production as covered in Q10. If the manufacturers' production was to decline due to unplanned shutdowns as covered in scenarios 1 and 2, other areas would not be capable of replacing the needed demand, as Europe is also a net exporter. The global trade flows would also be compromised. Trade flows as presented in figure Q13/1 and are based on the **installed base capacity** and **any sudden changes in production capacity would have a devastating effect on global demand and trade.**

Nordic countries are one of the main sources for global soft-wood virgin fibers. If the worst-case scenario (3) was the outcome, Nordic Countries would change from the high value-added product supplier to low value-added raw material provider.



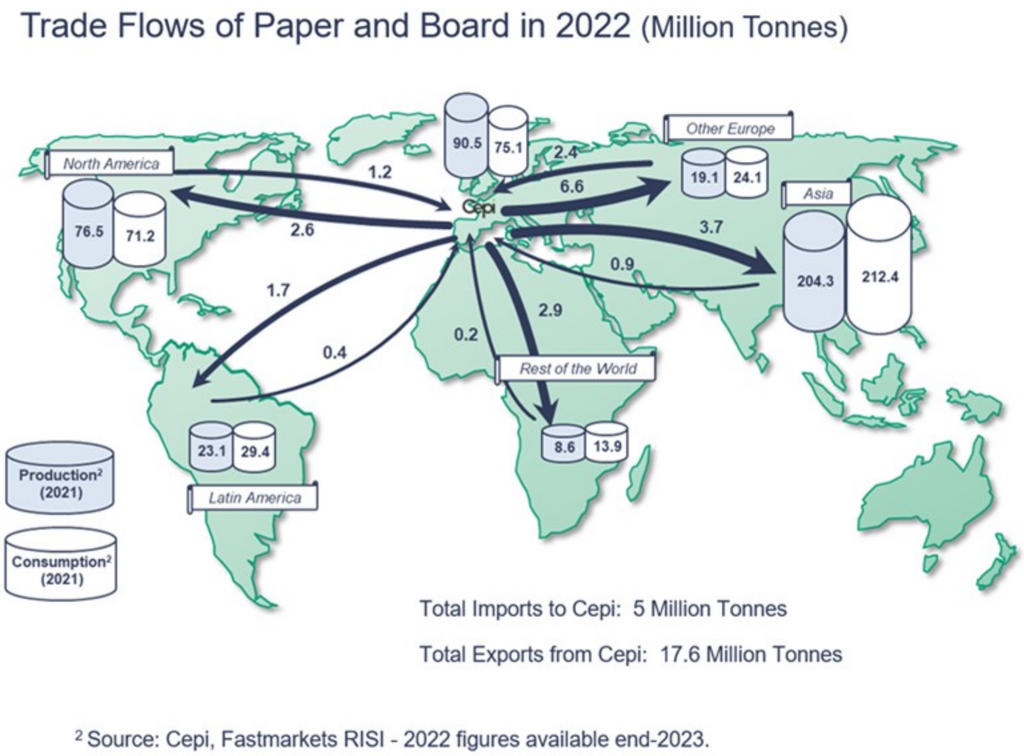


Figure Q13/1: Trade flows of pulp, paper and paperboard 2022

Q14 Can you assess the readily availability and quality of paper imported from outside of the EU? (e.g., how is the EU paper industry to fulfill the needs of the EU consumers)

Paper&Board Imports are low compared to Exports as shown in CEPI Table Q14/1 European product quality in general is high on all paper products. Europe's production of Paper, Board and Tissue fulfills the need of European citizens.

Table Q14/1: Paper and Board imports according to [Cepi Key Statistics 2022]

Paper and Board Imports from Other Regions

'000 Tonnes	2000	2010	2015	2021	2022	% Change 2022/2021	% Share of Total
Other Europe[1]	3 318	2 525	2 544	2 610	**2 389**	-8.5	47.4
North America	2 191	1 829	1 608	1 176	**1 184**	0.6	23.5
Latin America	198	498	363	324	**378**	16.4	7.5
Asia	332	625	581	501	**855**	70.6	17.0
Rest of the World	344	307	270	131	**238**	81.8	4.7
Total	**6 383**	**5 783**	**5 367**	**4 743**	**5 044**	**6.3**	**100.0**

Q15 Biorefinery technologies as an export article for the EU economy, and their role in the global green transition?

Effect on exports and EU economy described in other chapters e.g., Q10b, Q13.

PFAS band and extension time needs to be agreed value chain by value chain and we need at least 15-25 years of derogation for all biorefinery value chains. Underneath the figure Q15/1 of illustrative value chains in Paper&Board, Textile and Energy. Sub products under value chain are illustrative and non-exhaustive.

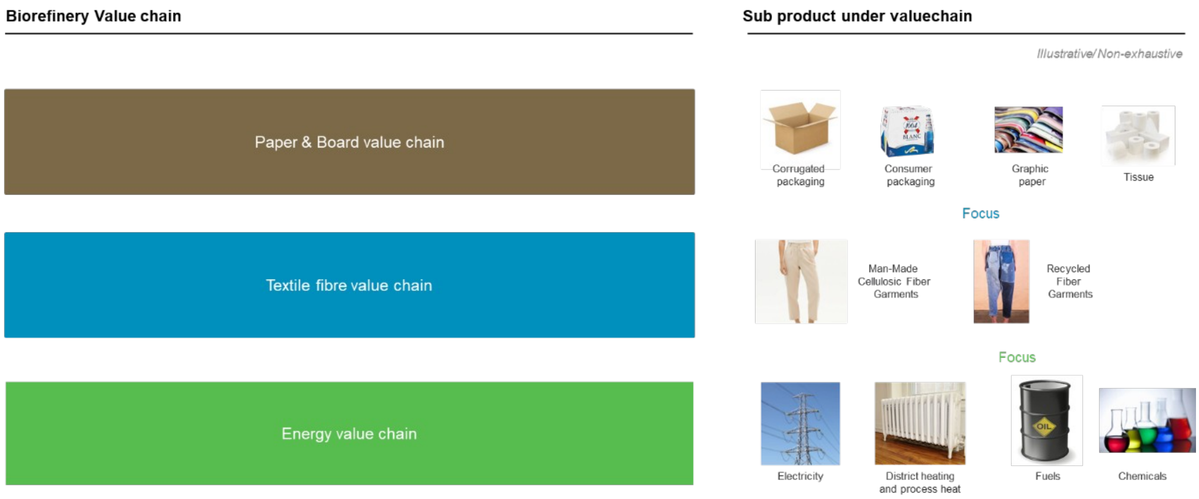


Figure Q15/1 Value chains in Paper&Board, Textile and Energy

Biomass boilers

The EU is one of the largest producers of technology for bioenergy production. For example, in the case of the main boiler type, where the primary or only fuel is biomass (= fluidized bed boilers), in the past 10 years close to 80 % of the boilers have been produced by companies, where this expertise and most of production, is located in the EU. These boilers are widely used for bioenergy production from the pulp and paper industry to utilities and municipalities. PFAS chemicals are widely used in them especially for sealing purposes. Bioenergy is the largest form of sustainable renewable energy in the EU accounting for 57 % of production (Bioenergy Europe). Therefore, a restriction on the use of PFASes would have severe consequences to the EU's ability to produce CO2 neutral energy and meet its climate targets before alternative chemicals are found.

Textile recycling

In addition to biorefinery products there is a lot of potential for pulp and paper companies and technology companies in **textile industry**. According to McKinsey, currently less than 1 % of textile waste is **fiber-to-fiber** recycled and collection rates are around 30-35 %. By scaling textile recycling in EU-27 and Switzerland could in base-case scenario by McKinsey yield annual holistic impact between 3,5-4,5 billion € in 2030 and reduce CO2-emiossions by approx. 4 Mt and create about 15 000 new jobs. **Some recent orders from Valmet include the main equipment** for Renewcell's textile recycling plant and drying technology for the Spinnova-Suzano joint venture textile fiber factory. Renewcell processes used cotton and other cellulose fibers and Spinnova is producing textile fiber from cellulose or waste streams without harmful chemicals, with minimal water use and emissions, and zero waste.

Bioethanol, Biochemicals

Together with Circa, **Valmet is currently building a plant for renewable chemicals** (CyreneTM) in France. Valmet has delivered pretreatment, automation and steam generation technologies for

2nd generation cellulosic bioethanol plants for example in Romania, Poland and India, as well as for steam-treated pellet plants e.g., in France.

Lignin

Wood is a composite of cellulose fibers embedded in lignin, a natural glue that keeps the fibers together. LignoBoost®, Valmet's lignin extraction technology, makes it possible to extract lignin from pulp mill black liquor. Lignin is quickly becoming a valuable and renewable raw material in a wide range of industries. There are four LignoBoost plants in operation today in Finland and the USA. They have a combined design capacity of 75,000 tonnes of lignin per year.

Bioenergy and CCS/CCU

Biomass, including side streams from the pulp and paper industry, can be converted into biofuels or used in power and/or heat production, providing benefits by reducing impacts on the environment particularly when combined with carbon capture and storage (CCS) or utilization (CCU). Bioenergy with carbon capture and storage (BECCS) is the only carbon dioxide removal technique that can also provide energy. Because bioenergy can provide high-temperature heat and fuels that work in existing engines, BECCS can play an important role in decarbonizing sectors such as heavy industry, aviation, and trucking.
The captured CO2 can also be used as an input to a wide range of products and services (CCU). The potential applications include direct use, where the CO2 is not chemically altered, such as boosting crop yields, and conversion of CO2 to other products such as fuels and chemicals.

Pyrolytic conversion of forestry residues is a technology to produce advanced biofuels that has been proven in operational environment. Valmet has delivered a pyrolysis system for a plant in Finland and is piloting an advanced process on small industrial scale to produce transportation fuels that are better compatible with refinery processes. **These technologies are critical for decarbonizing transportation as raw materials currently used for renewable fuels are limited. Technologies for heat and power production as well as technologies that are required to treat flue gases so that carbon can be captured and eventually stored or utilized are part of Valmet's product portfolio.**

The pulp and paper industry has identified multiple new potential use cases for forest fibers, for example in CEPI 2050 Roadmap to a low-carbon bio-economy. This includes industrial and consumer products where products from biorefineries have a potential to replace fossil-based products. Some examples of modern biorefineries are UPM Lappeenranta where renewable diesel and naphtha are produced from crude tall oil and UPM Leuna where products include renewable Bio-Monoethylene Glycol which is a base material for example for PET bottles, polyester and coolants, monopropylene Glycol than can be converted into cleaning agents, deicing fluids, fragrances, and cosmetics and lignin-based Renewable Functional Fillers than can replace carbon black and precipitated silica in various rubber applications such as tires and other rubber applications. Stora Enso - Lignin has produced lignin at industrial scale since 2015 and the end product can be used in multiple different use-cases. Some examples are biodegradable polymers, phenols, and binders or even bio-asphalt and anode materials for batteries (also in Q11 A).