Circular economy challenges in changing world on the example of the pulp and paper industry

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Executive summary

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Last decade policymakers worldwide used the circular economy concept to establish and promote sustainable development. This approach firstly appeared in western society, but nowadays spread around across the globe. The circular economy is an essential issue following Agenda 2030 and the Paris Agreement regarding resilience and sustainable growth. A standard definition of the circular economy does not exist. Still, the concept's main idea is to transition from a "take-make-dispose" linear economy based on resource extraction to a circular economy that supports reducing, reusing, and recycling resources.

The main aim of the thesis is to explore the current difficulties of implementing circular economy approaches in the deglobalizing world on the example of the European pulp and paper industry as a case study.

1st objective of the thesis is to show which aspects of circular economy are becoming missing and dysfunctional in deglobalizing world.

2nd objective of the study is to show the fate of the pulp and paper industry as a successful traditional example of circular economy implementation under new conditions.

3rd objective of the thesis is to propose biomass-based solutions as a resource for the energy-dependent regions to continue implementing the circular economy approach in the pulp and paper industry under new circumstances.

The research design is based on a qualitative method and case study approach, with the pulp and paper industry as an example. During the research process, seventeen Russian experts from the field of the wastepaper recycling industry were interviewed regarding their understanding of the circular economy approach and its implementation in Russia.

In relation to 1st objective of the thesis, the term «circular economy» has many definitions, and there is not a single one stipulated. The circular economy also usually does not consider energy production and sources as part of the concept. Energy could be saved but not recycled, so the circular economy approach usually does not view energy cycles and the source of energy, mainly concentrating on the prevention of waste and waste management. In the current situation, the circular economy approach should be developed when it considers material and energy flow across the value chain and a complete picture of the whole life cycle of the products that accept energy consumption, especially right now when the era of free

international trade and the globalized economy started transformations to nationalization.

In relation to 2nd objective of the study, currently, there is an industry that could be considered circular, and it is a forest-based industry. For example, in Europe, the percentage of biofuel used for paper production is extremely high – more than 60 % and could be even more. Following CEPI statistics, the recycling rate in the European paper industry is approximately 74 %, and the global recycling rate (average) was approximately 58,6 % in 2020. It means that sustainable circular solutions have already existed.

In relation to 3rd objective of the study, the pulp and paper industry still has opportunities to improve circularity in production processes. Biomass can be used to generate heat and energy that substitutes fossil fuels and reduces the emissions of greenhouse gases. Circular economy solutions should be profitable. Currently, one of the reasons for the use of biomass is the high price of fossil fuels. Environmental policies also play an essential role in implementing biomass boilers in different industries. For example, in 2019, renewables represented 41% of Sweden's total energy supply in Sweden. Around 60% of renewable energy was from biomass[1]. Policies helped to achieve this result. Sweden implemented investment grants for new equipment, carbon tax, green certificates, and an emission trading system. It

[1] Implementation of bioenergy in Sweden. 2021 update. IEA Bioenergy

means precise tools exist if the state is interested in implementing a bio-based economy.

Given these findings, there are the following suggestions to adapt the circular economy approach to modern geopolitical trends:

1. Energy supply and energy sources should be included in the policies and directives regarding the circular economy.
2. The policy could stimulate the use of biomass and organic residues to produce biofuels.
3. Policies should secure sustainable management of forests and other natural resources for biomass production.
4. The policy should stimulate local waste handling.
5. In the pulp and paper industry, the policy could limit the use of chemicals like ink, glue, and dye to improve recyclability.

Some areas for **future research** were founded in the process of the study. First, it is essential to communicate with European sustainability professionals to find the gap between theory and practice in the circular economy. It is crucial to analyze policies in countries that highly use biofuel for energy production. Through this research, it is possible to find the best policy practices or market conditions for bio-based economy implementation. Furthermore, it is essential to learn and compare the current financial models of circular economy in different industries to find differences and similarities to find best practices and create predictions regarding

the future development of the circular economy. Also, it is important to understand the motivation of those countries with enough hydrocarbons to develop circular economy solutions. International theoretical debates regarding circular economy development could be stimulated by the support of research regarding the bio-based economy as part of the circular economy concept.

Keywords: Circular economy, pulp and paper industry, biomass, energy.

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1. Introduction

1.1. Background

The circular economy concept appeared as a scientific idea in the late 1960s after observation of the economic systems and industrial processes. The idea of the circular economy was inspired by nature. Nature does not create waste, does not overexploit, and uses resources during decomposing. Nowadays, the concept of the circular economy is in the process of development.

1.2. Problem definition

The circular economy still does not consider energy production and sources as part of the concept. Energy could be saved but not recycled; the circular economy approach usually does not view energy cycles and the source of energy, mainly concentrating on the prevention of waste and waste management. In the current situation, it could not continue similarly. The circular economy approach should be developed when it considers material and energy flow across the value chain and a complete picture of the whole life cycle of the products that accept energy consumption, especially right now when the era of free international trade and the globalized economy started transformations to nationalization.

1.3. Aim and research objectives

The main aim of the thesis is to explore the current difficulties of implementing circular economy approaches in the deglobalizing world on the example of the European pulp and paper industry as a case study.

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1.4. Scope and limitations

The theoretical circular economy approach is developed by many noncommercial local and international institutions: United Nations, Organization for Economic Cooperation and Development, MacArthur Foundation, etc. Also, industries worldwide create a closed loop in the production process, for example, the pulp and paper industry and the metal industry. It could be fruitful for theory and practice to use the result of interdisciplinary studies that combine knowledge exchange between science and industry. These studies can help to rethink the circular economy in current situations and provide actual information and proposals based on practice to policymakers.

The main limitation of the research relates to the unspecified understanding of the circular economy among policymakers, scientists, and sustainability practitioners.

There is no one definition of the circular economy that provides a wide range of interpretations. One of the limitations relates to the accessibility of professionals from the environmental field. Interviews were conducted with Russian professionals that included perception of the circular economy ideas and understanding by representatives from one state and could not be extended to other countries.

1.5. Ethical considerations

This research design does not require a statement from the ethics committee of Central European University. Professionals were asked to review and provide consent for the interview verbally. Throughout the interviews, participants were identified based on their organizations. The anonymity principle was used to ensure the opportunity to speak freely about their experience and understanding of the circular economy approach. No funding was provided to create the thesis.

1.6. Audience

This thesis analyzes the link between current geopolitical trends and the circular economy, as well as the observation of the theory and practice connected with circularity. There are findings regarding dysfunctional aspects of the current circular economy understanding. During the case study, the best practices of circularity were also found. Those findings could be valuable for the policymakers and interdisciplinary practitioners interested in circular economy implementation.

Findings could also be relevant for practitioners doing public explanatory work to spread knowledge about the circular economy to a broad audience.

2. Literature review

The primary purpose of this chapter is to provide the historical development of the idea of the circular economy concept and understanding of the circular economy by different actors. It also gives an understanding of the current representation of the ideas of circularity.

2.2. Evolution of the circular economy ideas in science and policies

High economic and demographic growth followed the end of the Second World War. Scientists became aware of resource consumption and waste generation. Computer modelling also allowed to create predictions about finite resources and construct different ways of global development to observe the potential consequences before their existence. The famous report «The Limits to Growth» prepared by a group of researchers was published by Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, and William W. Behrens III in 1972[2], just before the oil crisis of 1973. It was a fundament for a new way of thinking and questioning the values of growth, progress, production, and industrialization.

During the next decade, more papers connected with the circular economy were published in academia[3]. In 1982 the interest in the circular economy appeared outside the scientific community. Organization for Economic Co-operation and Development published the paper «Product durability and product life extension,

[2] http://www.donellameadows.org/wp-content/userfiles/Limits-to-Growth-digital-scan-version.pdf
[3] «Barefoot economics» by Chilean Max Neef, «The entropy law and the economic problem» by Nicolas Georgescu-Roegen, «Small is beautiful—economics as if people mattered» by Fritz Schumacher etc.

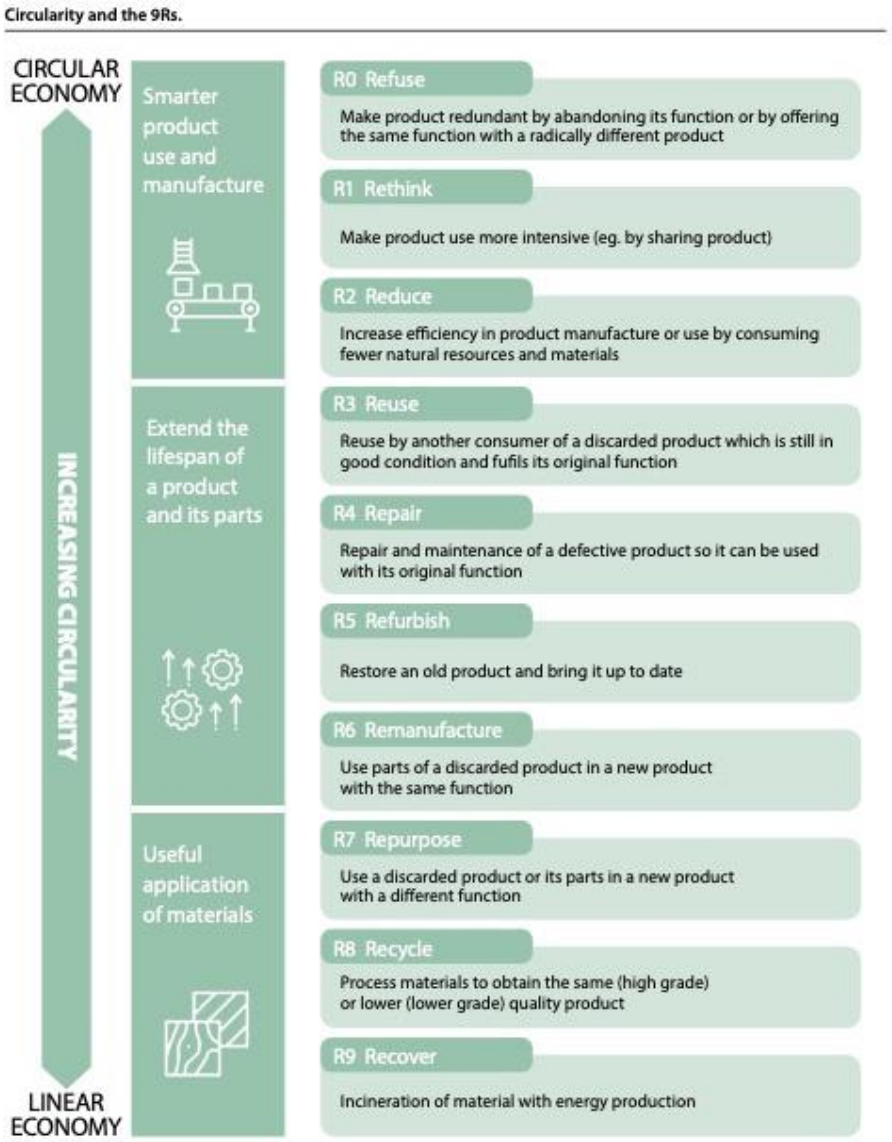
their contribution to solid waste management». It was one of the first policies in Europe that represented the implementation of the circular economy concept[4].

During the development process, the circular economy approach came from the 3R principle (refuse, reuse, recycle) to the 9R approach (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, and recover). The 9R method uses fewer resources and energy during the whole chain and avoids waste. The Ellen MacArthur Foundation created a visual representation of material flows in the circular economy, dividing the model into two streams: biological and technological cycles (Figure 1)[5]. By this representation, we can see that Foundation started to recognize the energy as part of the loop and divide the material flows into biological, for example, biomass, which could come back to the environment as feedstock, and technical materials such as plastic and metal that could not be decomposed by nature but can be a fruitful part of the recycling process, closing the loop.

In the 3R approach, the primary purposes were avoidance of creating waste and handling waste as a resource, but the 9R approach broadened perspective till raw material usage and system change[6].

[4] The Circular Economy in the European Union. Sepp Eisenriegler. p. 9
[5] Circularity concepts in forest-based industries. United Nations
[6] Potting, J., Hekkert, M., Worrell, E., Hanemaaijer, A., 2017. Circular Economy: Measuring Innovation in the Product Chain. PBL Netherlands Environmental Assessment Agency

Figure 1. Demonstration of 9R approach in the circular economy



Source: UNECE/FAO, adapted from Ellen MacArthur Foundation (https://www.ellenmacarthurfoundation.org)

In the 2000s, the circular economy concept appeared in European policies. The European circular economy action plan was adopted in 2015[7]. The focus of the plan relied on waste management. The circular economy packages also influenced

[7] https://ec.europa.eu/environment/circular-economy/first_circular_economy_action_plan.html

chemical, industry, plastics, sustainable development, and recycling policies [8]. The plan concentrated on the waste management life cycle of the products and materials. In 2018 the waste legislation was adopted[9]. It created targets for reduction of waste and established long-term plan for waste management and recycling[10]. In 2020 European Commission adopted a new Circular economy action plan[11].

The circular economy concept became more and more attractive to the public and policymakers because circularity is based on local sourcing and utilization. But implementation of the idea was not perfect for decades. From the late 1990s, developed countries preferred to tackle their waste management issues by shipping their waste to developing countries. Europe was no exception[12]. It was possible because the world was very globalized. International shipping was safe, cheap, and developed.

The European continent consumed a lot of goods that became the resource for production at the end of the life cycle. As growing economies, China and other Asian countries were ready to get waste from all over the world, especially from Europe, because of the waste quality.

[8] First circular economy action plan
[9] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2018:150:TOC
[10] https://ec.europa.eu/environment/circular-economy/first_circular_economy_action_plan.html
[11] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN
[12] China's plastic import ban increases prospects of environmental impact mitigation of plastic waste trade flow worldwide. Zongguo Wen, Yiling Xie, Muhan Chen & Christian Doh Dinga. Nature

For example, in 2015 and 2016, Europe exported up to 300 000 tons to China and Hong Kong every month. In 2019 those numbers decreased to 150 000 tonnes monthly[13].

It was a win-win deal for both parties because Europe had a limitation of space to handle waste by themselves, and China and other Asian countries needed cheap resources for the production of goods that the Europe population consumed[14]. It also was the implementation of the idea of circularity, but on a global scale. Global waste shipping was an essential part of waste management in Europe countries.

China was the leading accepting country and the biggest producer of plastic goods in the world. China imported around 8.88 million tons of plastic waste annually. Still, even for China's production, it was too much, and the quality of wasted plastic was not enough for recycling, so China faced severe environmental problems connected with waste mismanagement. Probably that situation could be continued, but China stopped accepting waste from outside the country. China improved its collection system and implemented an extended producer responsibility, so the demand for waste as a resource was satisfied domestically.

China in 2017 issued a ban on the import of 24 types of waste, including plastic. In 2021 China updated its policy regarding the import of waste and made it even more strict. Any solid waste, even wastepaper, could not be imported anymore.

[13] https://www.eea.europa.eu/publications/the-plastic-waste-trade-in
[14] https://www.eea.europa.eu/publications/the-plastic-waste-trade-in

Those events dramatically influenced, in the short term and long term, the circular economy, waste management, and waste treatment systems in many countries worldwide, especially in Europe. Now European Union should tackle its waste locally. It was a big step in the deglobalization process implemented through trade. This situation also showed that not all circular approaches are environmentally friendly and economically viable. In some cases, circularity can create environmental and social externalities.

Figure 2. Visual representation of the circular economy concept

Source: World economic forum

Nowadays, the circular economy concept is subject to varied conceptual definitions. Figure 2 gives one example of an understanding of the circular economy approach. The United Nations and the European Union extensively promote the circular economy and its principles. UNEA 4. Resolution 1[15] specifies that a «circular

[15] UNEP/EA.4/Res.1. Resolution adopted by the United Nations Environment Assembly on 15 March 2019

economy is one of the current sustainable economic models. Products and materials are designed to be reused, remanufactured, recycled, or recovered and thus maintained in the economy for as long as possible, along with their resources. Waste generation is avoided or minimized, and greenhouse gas emissions are prevented or reduced». The circular economy approach could be recognized in multiple sustainable development goals presented by United Nations, including sustainable development goals № 6 on energy, № 8 on economic growth, № 11 on sustainable cities, № 12 on sustainable consumption and production, № 13 on climate change, № 14 on oceans, and № 15 on life on land.

Ellen McArthur Foundation became an essential and influential popularizer of the circular economy concept. They create studies and events to spread and explain ideas of circularity among businesses and industries. In 2013 Foundation published a summary, «Towards a circular economy: Business rationale for an accelerated transition»[16]. This and other papers by Foundation have influenced the European environmental rhetoric and policies.

Ellen Macarthur Foundation pointed out and explained the fundamental principles of circular economy:

- Eliminate waste and pollution
- Circulate products and materials (at their highest value)

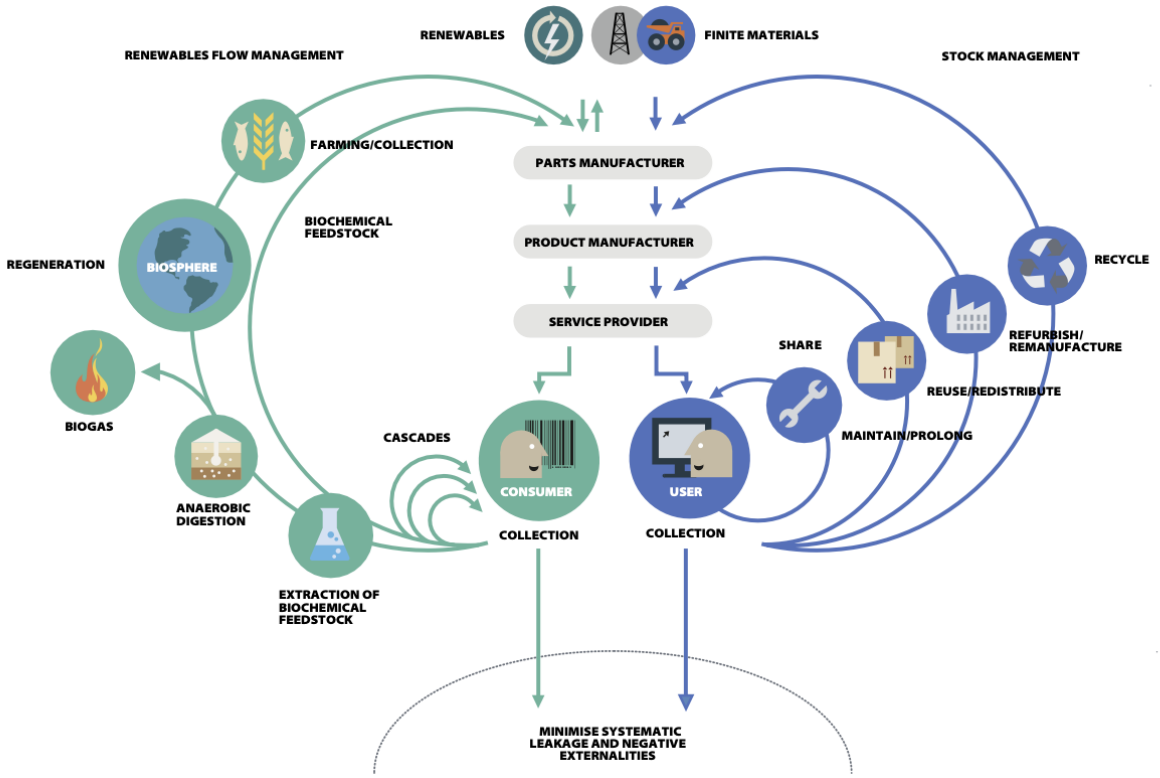
[16] «Towards a circular economy: Business rationale for an accelerated transition»

- Regenerate nature[17]

Foundation explains a circular economy as material use and economic system (Figure 3). Foundation believes that a transition to renewable energy and materials is needed. But on the other hand, NGO understands that hydrocarbons are still a significant energy source. In the document «Toward a circular economy: Business rationale for the accelerated transition» they said about supply risks of relying on import of oil and gas. For example, European Union imports more materials, petroleum, liquid fuels, and other natural resources than exports. In this case, a circular economy in European Union can work before the end of the energy transition only when the supply chain of hydrocarbons is secured, diversified globally, and safely optimized.

[17] https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

Figure 3. Biological and technical cycle in a circular economy model by the Ellen McArthur Foundation



Source: https://www.ellenmacarthurfoundation.org/circular-economy/concept/infographic. Copyright © Ellen MacArthur Foundation (2017)

But Foundation mainly concentrates on sustainable design and cradle-to-cradle principles, which are most connected with waste prevention and handling. As they said, the idea of circularity should be implemented at every production stage, from research and design to use, reuse and disposal[18].

2.3. Recent representation of the circular economy concept in European policies and its connection with energy policies

[18] Su, B., Heshmati, A., Geng, Y., Yu, X., 2013. A review of the circular economy in China: moving from rhetoric to implementation. Journal of Cleaner Production 42, 215-227

The current version of the European Circular Economy Action Plan was adopted in 2020[19]. It established principles and a new plan for sustainable growth. This action plan offered actions along the whole life cycle of the products. It is focused on electronics, batteries and vehicles, packaging, plastics, textiles, construction and buildings, food, water, and nutrients. These areas European Union recognizes as the sectors that use a lot of resources and has the potential to raise sustainability and recycling. But what can be pointed out is that the energy source's role was not the priority. But also, there is a point about potential influence and connectedness of the circular economy measures and legislation regarding National Energy and Climate Plans and climate policies[20].

European Union planned energy transition to renewable sources to be completed by 2050, but now, it still heavily relies on imported natural gas, coal, and crude oil. The European economy is highly resource-demanded, and the continent does not have enough hydrocarbons to supply domestic industrial needs.

The energy sector is one of the main bases of the modern economy that provides the growth and opportunity to compete and develop. In perfect conditions, a circular economy should be based on renewables, not finite hydrocarbons. Firstly, because they are limited, secondly, because the extraction of oil and gas produces CO2 and changes the air composition. Secondly, hydrocarbons use one of the main reasons for climate change. Thirdly, hydrocarbons nowadays are highly demanded around

[19] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN
[20] Paragraph 6.1. of the new Circular Economy Action Plan https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN

the globe, which divides countries into resource-dependent countries and resource-rich countries. But right now, there is no technical possibility of switching to renewables.

Ellen Macarthur Foundation is aware of the role of sustainable energy in the circular economy. But European circular economy policies primarily focus on waste management, dumping prevention, recycling construction waste, and consumer products such as packaging, textile, electronics, vehicles, food, extended producer responsibility, etc.

Energy transition policies in Europe are represented by Renewable Energy Directive[21], Energy Efficiency Directive[22], or Electricity market design Directive[23], and they are not correlated with circular economy directives. European Union's strategy on energy system integration contains ideas about circular energy system[24]. But still, the concept of a sustainable and circular energy system relates to the promotion of energy efficiency, reuse of waste heat from industrial sites, improvement of synergies between energy infrastructures, and incentives for the use of agriculture residues for biofuels production, but not with the import of hydrocarbons, energy logistic and sources of energy.

[21] Renewable energy directive
[22] Energy effective directive
[23] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (Text with EEA relevance)
[24] Powering a climate-neutral economy: An EU Strategy for Energy System Integration

The energy and energy sources are usually not mentioned in circular economy policies, only as the rule that industry should sustainably use energy and save it in production. Policies regarding energy transition are disconnected from circular economy policies.

2.4. Explanation of deglobalization trends and their influence on the circular economy implementation

Since the world has become very globalized during the last 50 years, it is also a significant result of recourses traded. Technologies and broad international cooperation made the world more connected and safer than ever.

Economic relations between countries, international trade, and all types of logistics, especially sea shipping and railway connections, used to be stable for an extended period from the late 1970s till the 21st century. In this case, resource-dependent countries lost awareness of their energy deficit and potential risks. For example, European Union is highly dependent on Russian hydrocarbons.

But there is another risky side of globalization. It is the interdependence of the world economy and cultures. Countries built strong supply chain connections with each other; the cooperative mood was dominated for decades. Globalization trends are related to the idea of global value chains. OECD and WTO are organizations that described and developed the principle of global value chains (GVC)[25]. The growing interconnectedness among economies created:

[25] Interconnected Economies. Benefiting from Global Value Chains. https://doi.org/10.1787/9789264189560-en

- the resilience of the whole system,
- significant opportunities for entering the international market for every country, even for developing countries, through global investment,
- incentivize international trade and decrease production costs.

Since globalization created new trade opportunities, global value chains are also characterized by the possibility to quickly move commodities, people, capital, and technology across borders.

But this concept of global value chains was not without risks. The respective countries' main dangers violated responsibilities in fulfilling their obligations and wars[26].

Pandemic has already opened the fragility of many industries because of unsustainable use of energy resources. The current geopolitical situation even sharpened this fragility. The country's dependency upon commodities in a shaking geopolitical situation creates the country's dependence on those who control these commodities.

On February 24, 2022, Russian Federation started so-called «special military operation» in Ukraine. I would avoid discussing the moral aspects of this action and concentrate on global changes, trends, and the economic and environmental influence of this geopolitical action.

[26] OECD. Multilingual Summaries.Interconnected Economies. Benefiting from Global Value Chains

Some famous financial professionals predicted the end of globalization. Russian economists Michail Khazin and Kobyakov Andrey in 2020 published the book «The Decline of the Dollar Empire: The End of Pax Americana»[27], where they predicted a global economic crisis that was highly connected with the system of the USA dollar as a reserved currency.

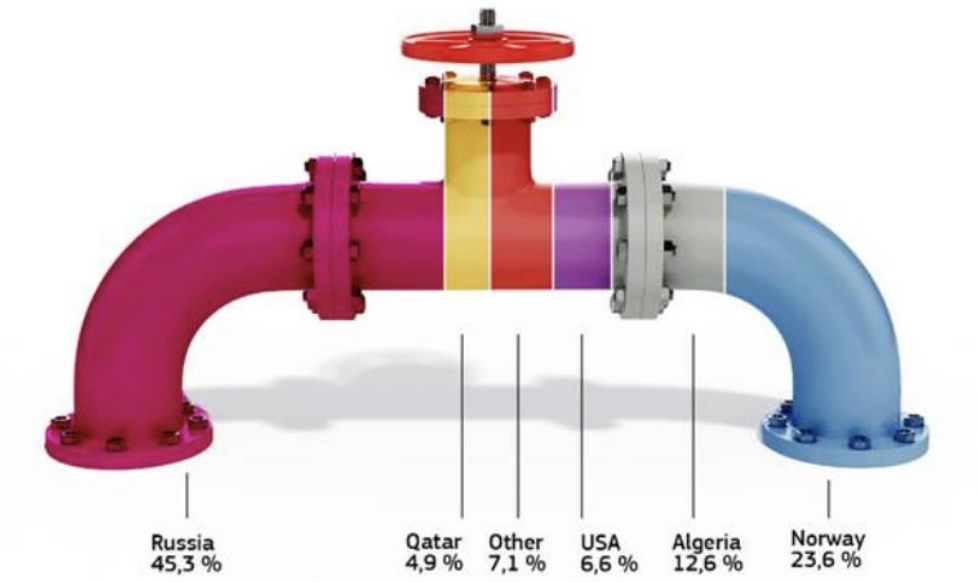
Larry Fink, the Chief of BlackRock, which oversees $10 trillion as the world's largest asset manager,[28] wrote in his letters to shareholders of BlackRock that now it is the end of globalization[29].

In the book «Changing world order» Ray Dalio also points out: «Over the last few years, the world has been moving from being more globalist to being more nationalist».[30]

Russia and Ukraine are major world suppliers of grain and fertilizers. It creates tension in the world food market and raises prices, especially for dependent countries. Russia and Ukraine are significant producers of neon gas used to produce semiconductor chips. Searching for a new contractor would not be quick.

[27] The Decline of the Dollar Empire: The End of Pax Americana. M. Khazin, A. Kobyakov. January 2020
[28] https://www.ft.com/content/0c9e3b72-8d8d-4129-afb5-655571a01025
[29] https://www.blackrock.com/corporate/investor-relations/larry-fink-chairmans-letter
[30] The Changing World Order: Why Nations Succeed or Fail. November 2021. p. 117

Figure 4. Share in EU gas import



Source: European Commission

The most needed commodities by European Union are Russian gas, oil, and coal. Following the official statistic of the European Union Commission in 2021, 62 % of the EU energy was imported from Russia at the cost of €99 billion. The EU imported from Russia more than 40% of its total gas consumption (as represented in Figure 5), 27% of oil imports, and 46% of coal imports.[31]

[31] https://ec.europa.eu/info/news/focus-reducing-eus-dependence-imported-fossil-fuels-2022-apr-20_en

Figure 5. Largest gas-consuming countries in Europe

Largest Gas-Consuming Countries in Europe

2020, bcm

	Gas consumption	Pipeline gas from Russia	LNG from Russia	Total gas from Russia	Share of Russian gas supplies in consumption
Germany	86.5	56.3		56.3	65.1%
UK	72.5	4.7	2.9	7.6	10.5%
Italy	67.7	19.7		19.7	29.1%
France	40.7	2.6	5.0	7.6	18.7%
Spain	32.4		3.4	3.4	10.5%
Europe	494.7	152.1	17.0	169.1	34.2%

Source: Fitch Ratings, BP's Statistical Review of World Energy

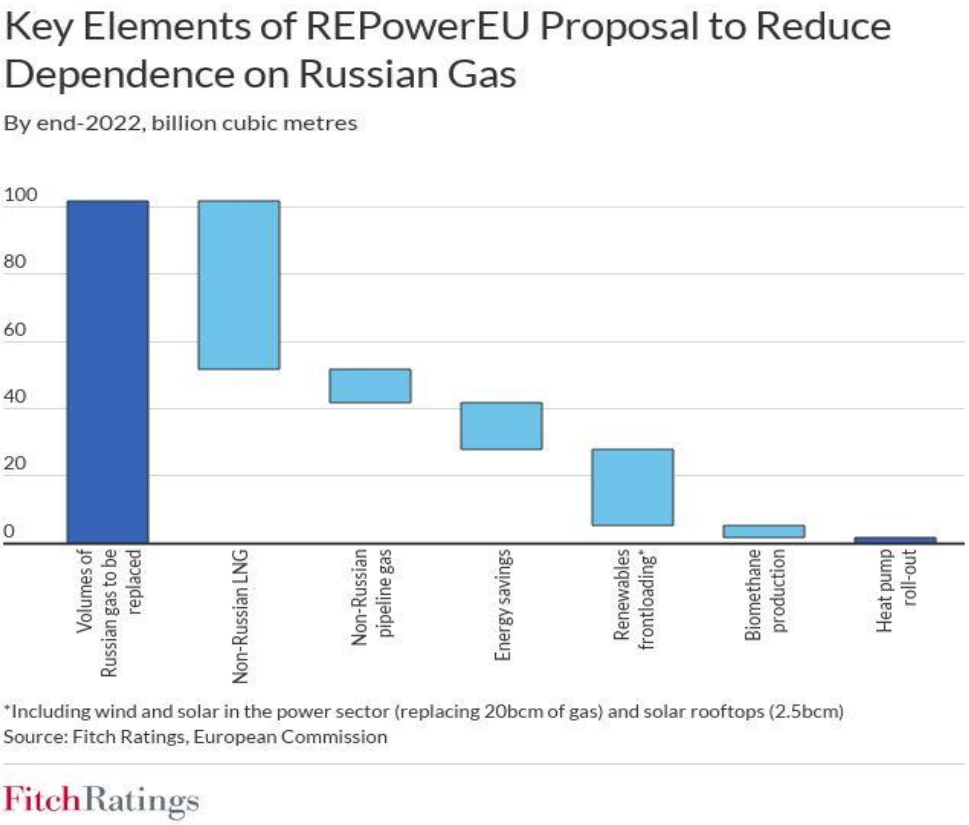
European Union reacted to the Russian invasion with the REPowerEU plan, which contains proposals and measures to reduce the import of Russian gas before the end of 2022 and as an ideal scenario to finish the dependency on Russian fossil fuels before the end of the decade. To implement this plan European Union wanted to diversify supplies, decrease the demand, and speed up the production of green energy locally in the EU[32].

Figure 5 demonstrates the difference in gas consumption between European countries. This table can also explain the pluralism of positions among European countries regarding future Russian energy import cuts that arose during the last months. Since European countries have a different level of dependency on the

[32] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A108%3AFIN

Russian energy supply, every country would have and continue arguing different opinions regarding supply cuts. As we can see, it is already happening. For example, Hungary claimed the potential opportunity of a Russian gas ban in the European Union's next package of sanctions[33]. So, it is possible that the percentages that are pointed out in Figure 6 could be changed during the implementation of the plan.

Figure 6. Key elements of REPowerEU proposal to reduce dependence on Russian gas



[33] https://www.cnbc.com/2022/06/10/russian-gas-ban-hungary-says-eu-cant-impose-a-gas-ban-on-russia.html

The price for REPowerEU plan implementation is very high. European countries should have special terminals for liquefaction and regasification processes to transport liquefied natural gas across continents. In May, Germany offered 3 billion euros for renting floating liquefied natural gas terminals for a decade[34].

The creation of the Greece-Bulgaria pipeline can complement existed system. This pipeline will connect Europe with Trans Adriatic Pipeline. So, Europe can get access to gas from Azerbaijan. The construction itself is costly. Europe estimated it to be around 160 million euros[35]. But the amount of gas from Azerbaijan and non-Russian sources is not enough to fulfil European needs, as the executive director of International Energy Agency Fatih Birol said[36].

Relying on renewables has its minuses. For example, during the last decades, Germany highly subsidized the creation of renewable energy infrastructure and cut nuclear power plants. But Germany does not have enough sun and wind to replace hydrocarbons[37].

[34] https://www.dw.com/en/germany-earmarks-3-billion-for-floating-lng-terminals/a-61480593
[35] https://www.hydrocarbons-technology.com/projects/gas-interconnector-greece-bulgaria-igb-pipeline/
[36] IEA chief warns Europe its gas efforts won't be enough even as Brussels inks deal with Azerbaijan, July 2020
[37] https://www.iene.eu/germanys-energy-policy-is-expensive-harmful-and-short-sighted-p579.html

Figure 7. Energy balance of Germany

Unit: Mtoe

DEMAND							
FINAL CONSUMPTION	**1973**	**1990**	**2000**	**2010**	**2016**	**2017**	**2018p**
TFC	**241.7**	**240.8**	**231.4**	**228.9**	**224.2**	**227.0**	**..**
Coal	55.7	39.2	9.0	7.2	7.3	7.2	..
Peat	-	-	0.0	-	-	-	..
Oil	133.3	111.2	114.1	94.7	92.2	94.1	..
Natural gas	18.6	39.1	55.1	56.4	55.0	55.4	..
Biofuels and waste[1]	1.7	3.0	4.7	13.1	14.7	15.2	..
Geothermal	-	-	-	0.1	0.1	0.1	..
Solar/other	-	0.0	0.1	0.5	0.7	0.7	..
Electricity	26.9	39.1	41.6	45.8	44.5	44.6	..
Heat	5.5	9.2	6.8	11.3	9.8	9.8	..

Source: IEA. Energy Policy Review. Germany 2020

In accordance with numbers from Figure 7 Germany energy consumption during last years still was covered mostly by hydrocarbons.

The European Union energy market right now is experiencing shock, which could be a reason for the crisis in the future in certain circumstances. In the first quarter of 2022, European industries that use gas observed price changes. The most significant European energy exchange fixed increasing price five times compared with the same period in 2021. The rising price trend was supported by growing differences between global supply and demand of energy, pandemic, and Russian-Ukrainian conflict. FitchRatings believes that the European plan could be implemented only in the mid-term and with certain conditions, such as obtaining liquid gas from Asia, additional pipeline supply from Algeria, and growing renewables and energy efficiency[38].

Energy supply is a crucial question that relates to the logistic. Logistics is the core of any business, especially in the highly globalized world. During the last two

[38] https://www.fitchratings.com/research/corporate-finance/russian-gas-replacement-only-feasible-in-medium-term-in-europe-08-04-2022

decades, the world has experienced global logistics changes because of the trade wars between the USA and China, natural disasters in Asia, and Covid-19. But the Russian invasion of Ukraine still significantly affects the global supply chain. The rising price of fuel affects transport costs. Europe cannot use Russian transport infrastructure to deliver goods and equipment to and from Asia in general and in China, which means that now it is very costly to support outsourced manufacturing in Asia.

All these events push Europe and North America to localize their production facilities and care about the local supply chain. Disrupted logistics further support these deglobalization trends[39].

In this situation, we can see rising voices supporting the circular economy approach in farming, fertilizers production, and energy supply[40].

Summary of literature review

Existed literature shows the development of the circular economy ideas and their implementations during decades. It helps to understand the current situation.

Overall, modern understanding of the circular economy approach is concentrated mainly on waste management and life cycle assessment of goods. There is no unified definition of the circular economy; consequently, there are different interpretations.

[39] https://hbr.org/2022/03/how-the-war-in-ukraine-is-further-disrupting-global-supply-chains

[40] https://www.iisd.org/articles/insight/russias-war-ukraine-why-doubling-down-green-deal-best-strategy, https://insights.issgovernance.com/posts/russias-invasion-of-ukraine-is-forcing-the-world-to-re-think-the-food-supply-chain/

Circular economy policies do not deep interconnect with sustainable energy policies in European Union. Some authors are already aware of deglobalization trends worldwide that influence the trading system, energy prices, and distribution of commodities between countries.

Section 2.3. shows that some policies and authors have already started thinking about combining energy transition plans with the circular economy approach. It could be a fruitful decision for the future of the energy-depended countries. Section 2.4. provides a broad view of the connection between the current geopolitical situation and challenges of circular economy implementations in the European Union and Russia.

3. Research design, materials, and method

This chapter explains the research design and method, data collection, and limitations of the method.

3.1. Research design and method

After the literature and policy review, a research gap appeared between theoretical and practical understanding of the modern circular economy concept. The current geopolitical situation is not described in fundamental literature yet, so there is limited literature that addresses deglobalization challenges in the context of the circular economy. However, pulp and paper industry practitioners have already developed circular solutions regarding waste and water management, energy supply, and material use. It could be fruitful for the theoretical concept to study those solutions and rethink the concept in current deglobalizing processes.

A case study and in-depth interviews with Russian pulp and paper industry practitioners were chosen to fill the gap. Case studies help to recognize complexity in the systems[41]. The unit for the case study is the European pulp and paper industry.

Pulp and paper production is a successful example of circularity among other sectors. It could be a role model for different industries and an instance of a bioeconomy as an extension of the circular economy.

[41] Flyvbjerg, B. (2006). Five misunderstandings about case-study research. Qualitative Inquiry, 12(2), 219–245

Interviews with practitioners from the sustainability field can clarify the gap between theory and practice in the question of circular economy implementation. It could be fruitful feedback and material for those professionals who disseminate knowledge about the circular economy.

3.2. Data collection

3.2.1. Literature, policies, articles

Literature, policies, and articles were reviewed via the internet to collect relevant information about the circular economy and pulp and paper industry. Data was collected from the relevant websites of government, NGOs, analytical agencies, and newspapers. Only data directly connected with the circular economy, energy, and deglobalization, was collected.

3.2.2. Practitioners' interviews

Seventeen professionals from the wastepaper recycling industry were interviewed for a deeper understanding of the circular economy approach. To fulfill the criteria for the study, professionals should 1) work with circularity in their industry: 2) work with waste management issues: or 3) have working knowledge about circular economy.

Seventeen practitioners gave the interviews; the other thirteen were unavailable during the research.

Different organizations were selected for the interviews.

Interviews were structured, but not strict, that provided a variety of questions and answers. Before the interview, practitioners were asked for oral consent.

3.2.3. Case study

Information for the case study was obtained from the relevant websites: pulp and paper production companies, professional associations of pulp and paper producers, and scientific articles. For the case study European pulp and paper industry was chosen because of the effective operations and circular economy solutions implementation.

3.3. Limitations of the method

Since every professional understands the current environmental and economic situation, their position could be limited by experience and interpretation of the events. So, respondents could have an incomplete understanding of the processes regarding their questions. To eliminate this limitation, different practitioners were elected.

The case study approach is also limited because information about circular solutions in the pulp and paper industry could be hidden. After all, many plants and fabrics simply do not publish information about their activities in this field. To decrease this limitation during the research, professionals from the pulp and paper industry were asked about the implementation of circular solutions.

4. Case study and interviews

In this chapter, the results of interviews and case study are presented.

4.1. Conclusions from the analyses of the interviews

Russia is implementing the new extended producer responsibility system as an essential part of the circular economy. One reason for extended producer responsibility reform was the active representation of circular economy ideas by the Wastepaper Processors Association (Liga PM) and Metal Recyclers Association (Ruslomcom). Those business associations presented to the authorities and public not only environmental values but profitable business models for the producers and government. The Russian market has already created opportunities for producers, customers, and the state to reuse and recycle materials.

Even when some elements of circularity are already implemented in Russia, among waste management specialists, there is no clear understanding of the circular economy concept.

In-depth interviews of Russian experts in the paper recycling industry and questioning[42] shows that the term «circular economy» has many definitions and understandings, and there is not even one that is shared by the majority of professionals participating in the study. When we asked professionals about the circular economy concept, they mostly talked about waste management and recycling, not about energy consumption. As well professionals do not believe in

[42] Interviews and questionings were organized in partnership with Russian Academy of Science and researcher Maxim Tikhonov

opportunities to transition from a linear economy to a circular economy, at least currently.

Table 1. Questionary results

Questions	Quantity of answers Yes	Quantity of answers Rather yes	Quantity of answers No	Quantity of answers Rather no	Quantity of answers I do not know
Does circular economy exist in Russia	2	2	8	5	0
Does the state government support a circular economy in Russia	3	5	8	0	1
What is the main reason for poor state engagement in the circular economy transition in Russia	Lack of economic stimulus in the recycling field	Lack of understanding of waste management system	Lack of support from the authorities in Parliament and state leaders	Lack of knowledge of environmental system	
	5 from 17	10 from 17	10 from 17	9 from 17	

The circular economy concept among wastepaper recyclers in Russia is accepted highly skeptically (see Table 1).

Even theoretically, the term has many definitions, and there is not even one stipulated or shared by most professionals participating in the study.

In the professional community, the share of those who think there is no circular economy in the Russian Federation is high.

Professionals believe the fundamental reason for this phenomenon lies in the lack of understanding of the circular economy's general principles and market mechanisms, demonstrated by the executive and legislative branches. The lack of knowledge about circularity, economic background, and awareness about ecological issues is the reason for the lack of support. Surveyed specialists believe that government does not support the circular economy by actual actions or that this support is fragile.

As well surveyed professionals believe that the current situation is not hopeless. Still, efforts to form such an understanding require both time and a systematic, consolidated approach from the leading players in the recycling industry.

One of the stumbling blocks in the way of a deeper immersion of specialized government agencies in the topic of the circular economy, according to the participants in the study, is the lack of support from the country's top leadership. The professionals believe that shifts in this area can occur mainly due to political will, which they have not yet observed in due measure.

It is not easy to compare the European circular economy approach, which is highly developed on the policy and implementational levels, and the Russian circular economy, which is very new. Promoting and developing the concept is probably a matter of time and effort. The European economy is highly resource-demanded, but the Russian economy, on the opposite, relies on the profit from hydrocarbons supply. So, Europe needs to find circular solutions, but Russia can continue for a while without changes.

4.2. Forest industry as a new oil

Crises are not only the time for losses but also the time to look around. The circular economy concept is well connected with the idea of the bio-based economy model. «Bio-based» means that products in this model are created from renewable resources that could be recovered quicker than depleted. Bio-based economy takes into consideration the location of industry. Bioenergy production is another essential topic in this context.

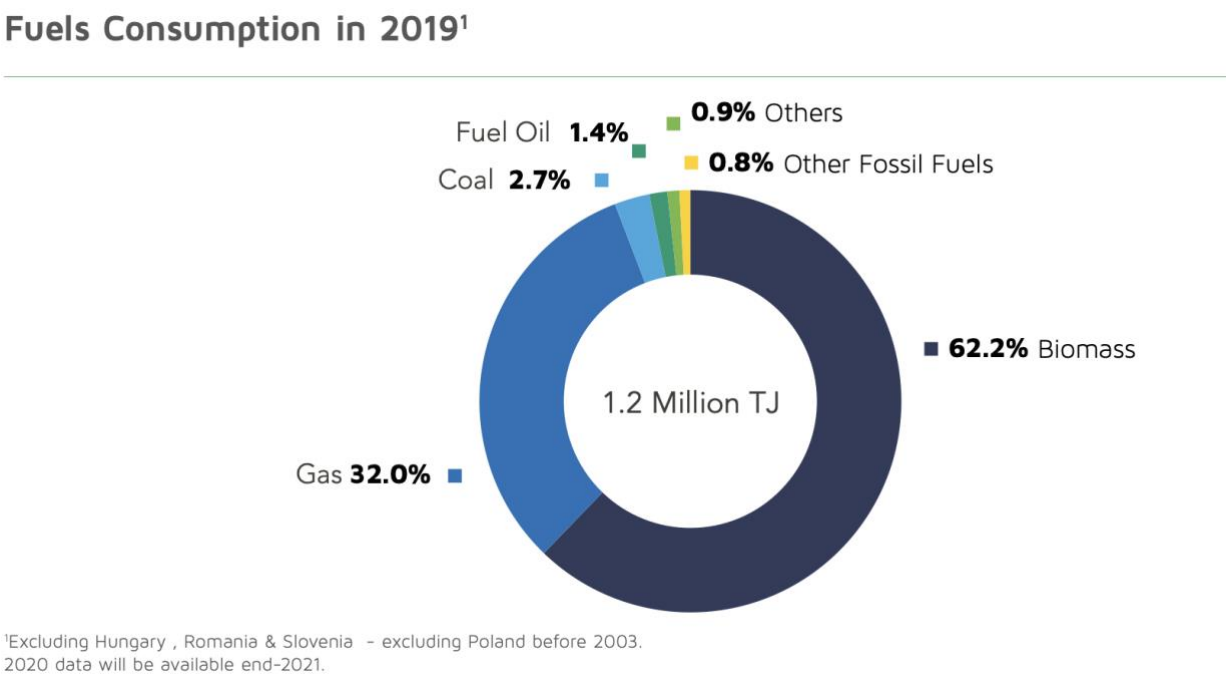
One of the Russian professionals from the pulp and paper industry, who was interviewed, said that the forest industry is becoming the new oil. Biorefining allowed the use of the whole tree without wasting any parts for making different products, such as paper, additives to asphalt, black liquor, biofuel, pharmacy, fertilizers, etc. There is a worldwide intensive need for hydrocarbons, and it is ridiculous that humans use them to produce plastic packaging, which becomes waste very easily and quickly and still is poorly recycled around the world. It is possible to supplement single-use plastic, at least in packaging with paper material, as

substitute competition between materials. Potentially it would decrease the need for crude oil used for single-use plastic production. With sustainably managed forests, it can successfully continue reducing CO2 production.

4.2.1. Case study: European pulp and paper industry observation

A circular economy and diversification in energy sources are already implemented in the European pulp and paper industry. Wastepaper is a highly recyclable material. The European pulp and paper industry successfully uses biofuel as an energy source (Figure 8). Europe's pulp and paper industry still relies on imported hydrocarbons, but this dependence is less intense than other sectors and activities. Biofuel in Europe could be the solution in case of future energy transition and diversification of energy suppliers.

Figure 8. European pulp and paper industries' fuel consumption in 2019



Source: CEPI

Forests play a significant role in carbon sinking. Wood is a natural resource that could be renewed. Wood fiber is a reusable and recyclable material. Even if the wood cannot be recycled, it decomposes for nutrients.

Figure 9. Pulp and Paper Industry in Europe

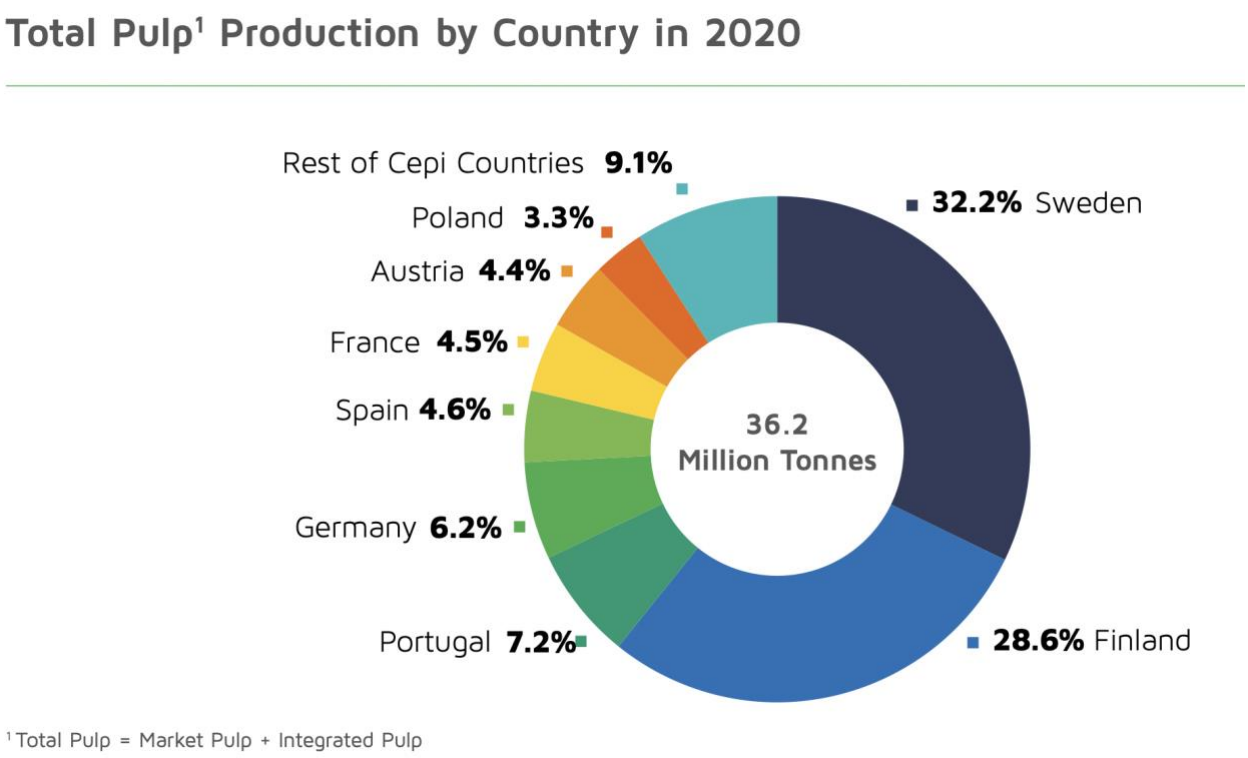
	1991	2000	2010	2015	2019	2020	% Change 2020/2019	% Change 2020/2010
Industry Structure								
Number of Companies[1]	1 082	979	728	688	**685**	**683**	**-0.3**	**-6.2**
Number of Mills	1 570	1 309	994	921	**896**	**894**	**-0.2**	**-10.1**
Pulp	296	233	172	155	**153**	**151**	**-1.3**	**-12.2**
Paper and Board	1 274	1 076	822	766	**743**	**743**	**0.0**	**-9.6**
Number of Paper Machines	2 182	1 858	1 396	1 292	**1 253**	**1 245**	**-0.6**	**-10.8**
Employment	411 113	279 987	194 894	178 418	**180 863**	**179 647**	**-0.7**	**-7.8**
Turnover[2] (Million Euros)	n.a.	79 388	75 790	80 679	**91 500**	**83 000**	**-9.3**	**9.5**
Investments[2] (Million Euros)	n.a.	5 637	2 913	4 181	**5 000**	**4 500**	**-10.0**	**54.5**
Added Value[2] (Million Euros)	n.a.	24 494	16 560	18 262	**20 300**	**18 500**	**-8.9**	**11.7**

Source: CEPI

European Commission highly values the pulp and paper industry because the industry consistently generates substantial revenue, stably provides a lot of taxes and jobs and demonstrates the case of a successful decarbonization strategy and sustainability plan (Figure 9). The pulp and paper industry directly provides 180 000 jobs in Europe. The sector's turnover is near 83 billion euros, which adds 18.5 billion euros to the European Union's gross domestic product. The pulp and paper industry has a high export rate of 23% of its paper and board production[43].

[43] https://www.cepi.org/wp-content/uploads/2021/07/Key-Stats-2020-FINAL.pdf

Figure 10. Total pulp production by country in 2020 (European Union)



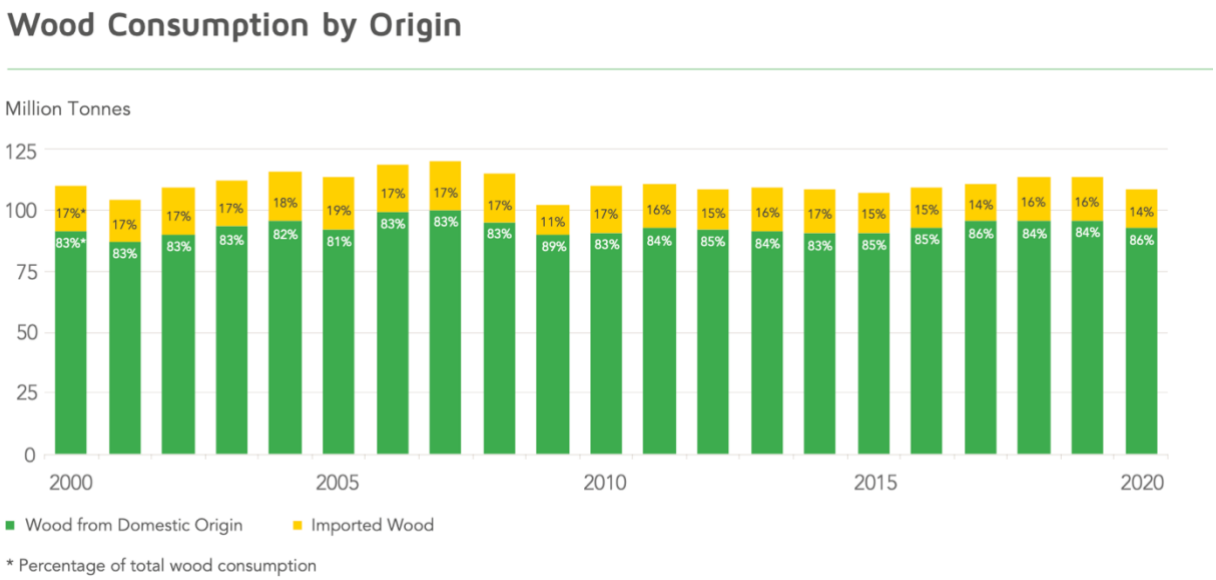
Source: CEPI

Paper production has a long investment cycle and high capital costs. Since pulp and paper production is energy and raw material intensive, it constantly improves records in resource efficiency and innovations. The development of e-commerce, the high demand for packaging materials, and the bad reputation of single-use plastic provide opportunities for paper as a material. It is also the reason for innovative paper products and a low-carbon bioeconomy[44].

Initially, paper production relies on raw materials such as wood, metals, and water and needs high energy for production.

[44] https://ec.europa.eu/growth/sectors/raw-materials/related-industries/forest-based-industries/pulp-and-paper-industry_en

Figure 11. Wood consumption by origin in Europe



Source: CEPI

The European pulp and paper industry is also part of the global supply chain. Before the invasion, Russia, Belarus, and Ukraine provided Europe softwood as a resource for European industry (Figure 12). According to Wood Research International, Russia, Belarus, and Ukraine supplied around 10% of Europe's total demand for softwood lumber in 2021, covering its demand by exporting 8.5 million m^3 of wood. The total exports from those countries collectively were around 17 billion dollars in 2021[45]. However, the sanctions imposed by European Union effectively halted these lumber shipments to Europe. Apart from oil prices, it is one of the immediate impacts of the sanctions on the European paper industry.

[45] https://woodprices.com/wp-content/uploads/2022/04/WRI_Market-Insights_Impact-on-Forest-Markets-From-the-Ukranian-War_Apr-25-2022.pdf

Of relevance, before the conflict with Ukraine, Russia had a 22% share of global trade for softwood lumber and pulpwood logs[46]. Because of sanctions against Russia, geography and trade flows of wood supply can change dramatically.

Figure 12. Selected statistics for Belarus, Russia, and Ukraine regarding forest products exports in 2021

Selected statistics for Belarus, Russia, and Ukraine (BRU) in 2021

	Volume	Note
Forest products exports (BRU)	17 billion USD	Lumber ~45%
Forest products imports (BRU)	4 billion USD	Predominantly paper and panels
Softwood lumber exports (BRU)	34 million m^3	China (47%), Europe (25%)
Softwood lumber exports (Rus only)	28 million m^3	21% of global trade
Lumber exports to Europe (BRU)	8.5 million m^3	9% of European demand

Source: Wood resource international

Fast markets RISI, a cross-commodity price reporting agency, also pointed out that Russia exported different paper products to the European Union yearly. These types of paper were kraftliner, newsprint, and uncoated woodfree. Since there are trade restrictions, European Union has already started to experience short-term paper

46 https://www.fastmarkets.com/insights/how-russias-invasion-of-ukraine-impacts-the-european-pulp-and-paper-industry

shortages in some segments, for example, sack kraft[47]. Russia usually sends 180,000-200,000 tonnes of kraftliner to Europe each year[48].

Russia, Ukraine, and Belarus imported significant volumes of cardboard, about 15% of European production. Few papers production companies such as Stora Enso, Mayr-Melnhof, and Pankaboard stopped their contractual relations with Russia. This paper volume will probably come to the European market and could alleviate the shortage in the European cartonboard market[49].

Even if a shortage of supply exists, Europe is not highly dependent on exports of paperboard packaging from Russia, Ukraine, or Belarus. Those European volumes imported from those countries can be supplemented by changing trading flow or plastic substitution.

It is worth noting that the Russian industry struggles as the country imports chemicals, equipment, parts, wastepaper, and paper products from Europe. Right now, Russia is trying to substitute these needs from Asian markets, primarily China and India. It means that China should adapt to new volumes of requests and changes in trading flow. The geopolitical situation will inevitably impact the world trading of lumber, panels, wood pellets, logs, wood chips, pulp, and paper products[50].

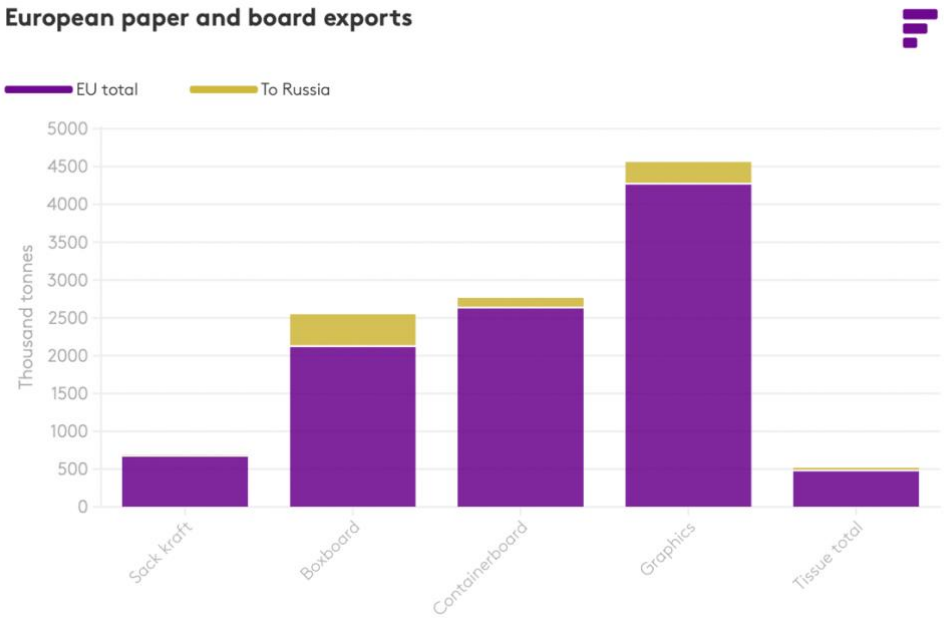
[47] https://www.fastmarkets.com/insights/how-an-eu-ban-on-russian-made-paper-could-transform-the-european-sack-kraft-market

[48] https://www.fastmarkets.com/insights/how-russias-invasion-of-ukraine-impacts-the-european-pulp-and-paper-industry

[49] https://research.rabobank.com/far/en/sectors/fa-supply-chains/european-paper-packaging-braces-for-impact-of-ukraine-crisis.html

[50] https://woodprices.com/wp-content/uploads/2022/04/WRI_Market-Insights_Impact-on-Forest-Markets-From-the-Ukranian-War_Apr-25-2022.pdf

Figure 13. European paper and board exports (annually)



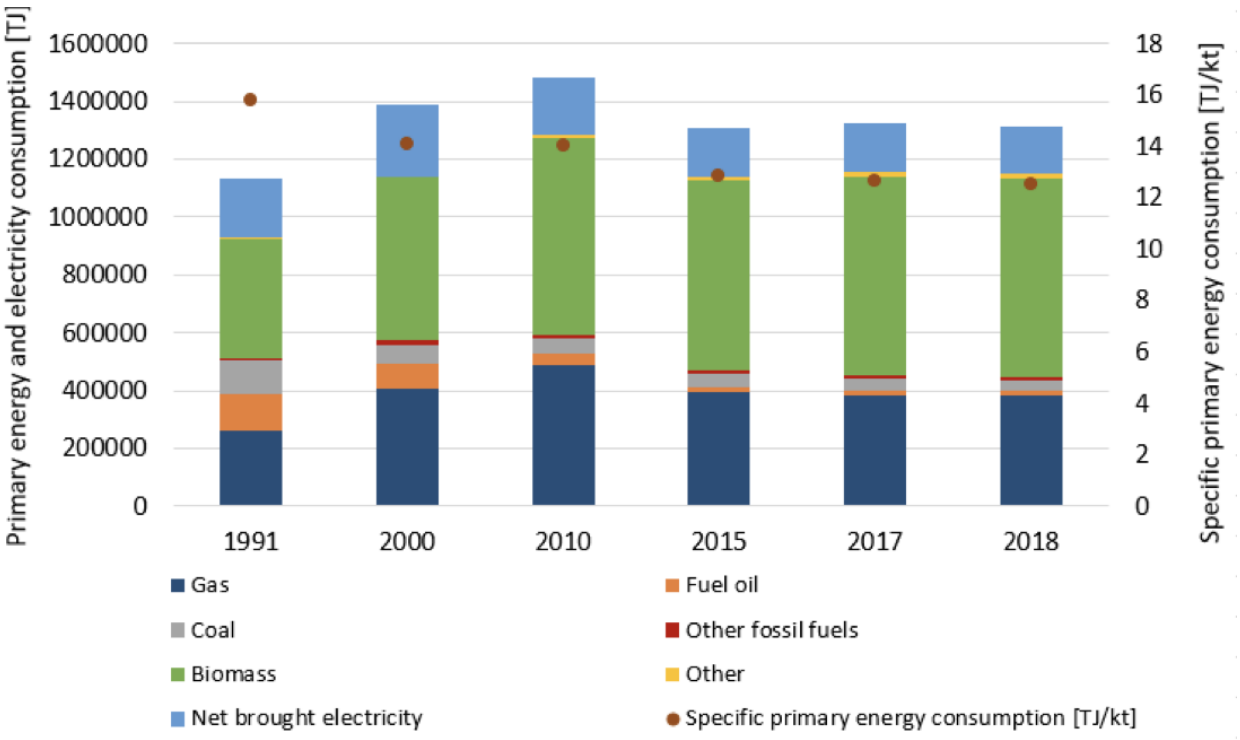
Source: RISI

The European pulp and paper industry uses a lot of biomasses for energy production. In 2018 60.0% of total fuel consumption and 52.5% of total primary energy consumption were covered by biomass. Fossil fuels are also highly used - 38.9% of the total fuel consumption (Figures 14 and 15).

But the percentages significantly differ between countries. For example, in Nordic countries, biomass is more available because mills usually produce pulp and paper both from the woods, which means that those mills can use forest residues as fuel. But those mills in Central and Southern Europe that do not grow their forest lack access to forest residues, so they depend more on fossil fuels, primarily natural gas[51].

[51] https://www.biofit-h2020.eu/publications-reports/Biofit-Factsheet_P%26P_final.pdf

Figure 14. Primary energy and electricity consumption and specific immediate energy consumption in the pulp and paper industry in Europe



Source: Modified from Cepi Key Statistics 2019

Figure 15. Primary Energy and electricity consumption in the European pulp and paper industry

Primary Energy and Electricity Consumption[1]

Primary Energy Consumption TJ	1991	2000	2010	2015	2018	2019	% Share of Total[3]	% Change 2019/2018
Gas	259 593	404 946	489 565	395 064	385 521	**387 514**	28.3	0.5
Fuel Oil	129 461	90 914	37 856	19 368	17 675	**16 754**	1.2	-5.2
Coal	113 867	59 304	53 280	45 925	33 471	**32 648**	2.4	-2.5
Other Fossil Fuels	10 134	19 052	14 529	10 624	10 495	**10 057**	0.7	-4.2
Biomass	413 248	562 865	677 569	657 986	743 867	**754 185**	55.1	1.4
Other	3 560	4 151	8 948	12 374	11 998	**11 134**	0.8	-7.2
Total Fuels Consumption	**929 863**	**1 141 232**	**1 281 746**	**1 141 341**	**1 203 028**	**1 212 292**	**88.6**	**0.8**
Net Bought Electricity	**205 852**	**246 864**	**202 945**	**167 381**	**162 352**	**155 372**	**11.4**	**-4.3**
Total Primary Energy Consumption	**1 135 715**	**1 388 096**	**1 484 691**	**1 308 722**	**1 365 380**	**1 367 664**	**100.0**	**0.2**
Fraction of Biomass in Total Fuels Consumption	**44.4%**	**49.3%**	**52.9%**	**57.7%**	**61.8%**	**62.2%**		**0.4**

[1]Excluding Hungary , Romania & Slovenia - excluding Poland before 2003.
2020 data will be available end-2021.
[2]CHP: combined heat and power (compared to total on-site electricity generation).
[3]Share of total primary energy consumption (including net bought electricity).

Source: CEPI

Some of the facilities are more diversified, some of them less. The European association representing the paper industry (CEPI) that united 895 pulp and paper mills in around 18 countries has already pointed out the need for action because it is crucial to find a way to secure their business existence today and the opportunity to compete tomorrow.

The European pulp and paper industry is already aware of the risks of production shortage and even bankruptcy because of the increase in energy prices, and the situation is likely to continue. Even if the pulp and paper industry generally produces biomass as fuel, many mills need gas, oil, or coal because of technical issues with

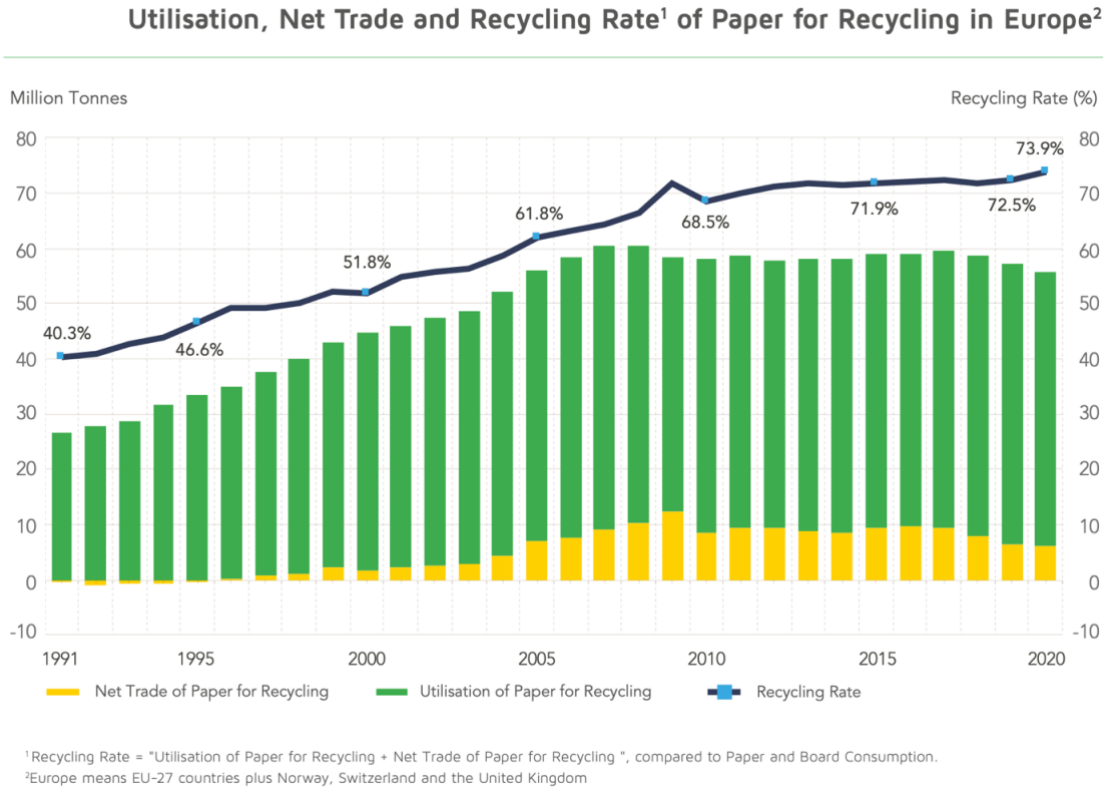
the speed of papermaking machines. It is also a matter of infrastructure and additional options. Most companies prefer to diversify their sources of energy.

CEPI, on April 28, 2022, wrote a reaction paper to the European Commission regarding energy prices. CEPI asked Commission to tackle energy prices and secure the supply.

The recycling rate in the European paper industry is very high – approximately 74 %[52] (Figure 16), and the global recycling rate (average) was approximately 58,6 % in 2020[53].

[52] https://www.paperforrecycling.eu
[53] https://www.recyclingtoday.com/article/paper-recycling-rate-66-percent-2020/

Figure 16. Utilization, net trade, and recycling rate of paper for recycling in Europe

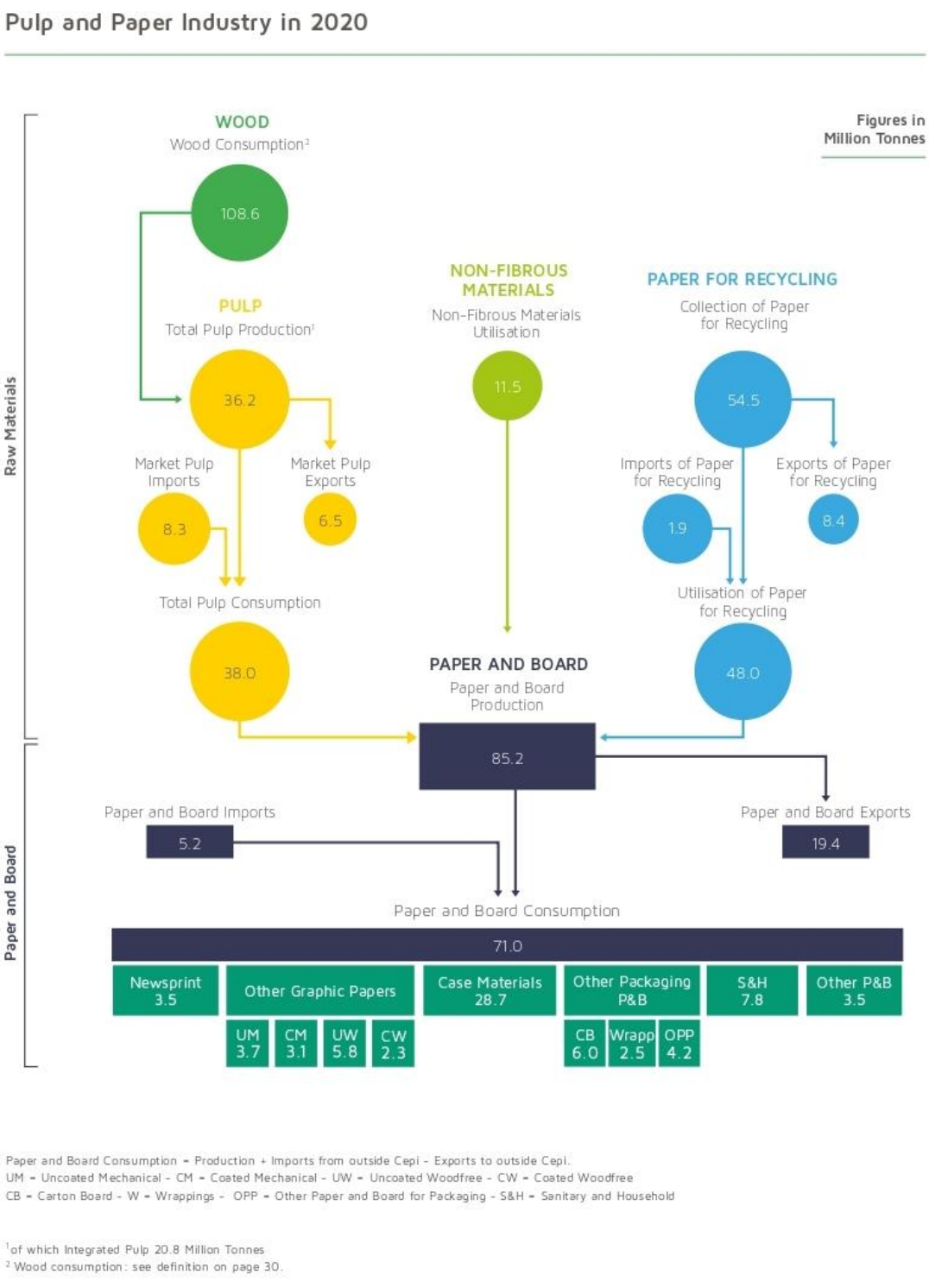


Source: CEPI

Paper-based packaging is even recycled at 84.6%. More paper-based packaging is recycled than all other packaging materials combined[54]. The papermaking industry even plans to improve the recycling rate through the sharing and implication of best practices and to develop cross-sectoral alliances[55]. CEPI, as the association of European papermakers, plays a significant role in this process. But it is essential to point out that there are limitations to the recyclability of paper. Fiber tends to be a shortage during every reproduction cycle and cannot be recycled without downcycling more than five to seven times[56].

[54] https://www.cepi.org/policy-area/sustainability-%20circularity/
[55] https://www.cepi.org/policy-area/sustainability-%20circularity/
[56] https://www.worldatlas.com/articles/how-many-times-can-paper-be-recycled.html.

Figure 17. Pulp and paper production scheme (fiber and wastepaper)



Source: CEPI

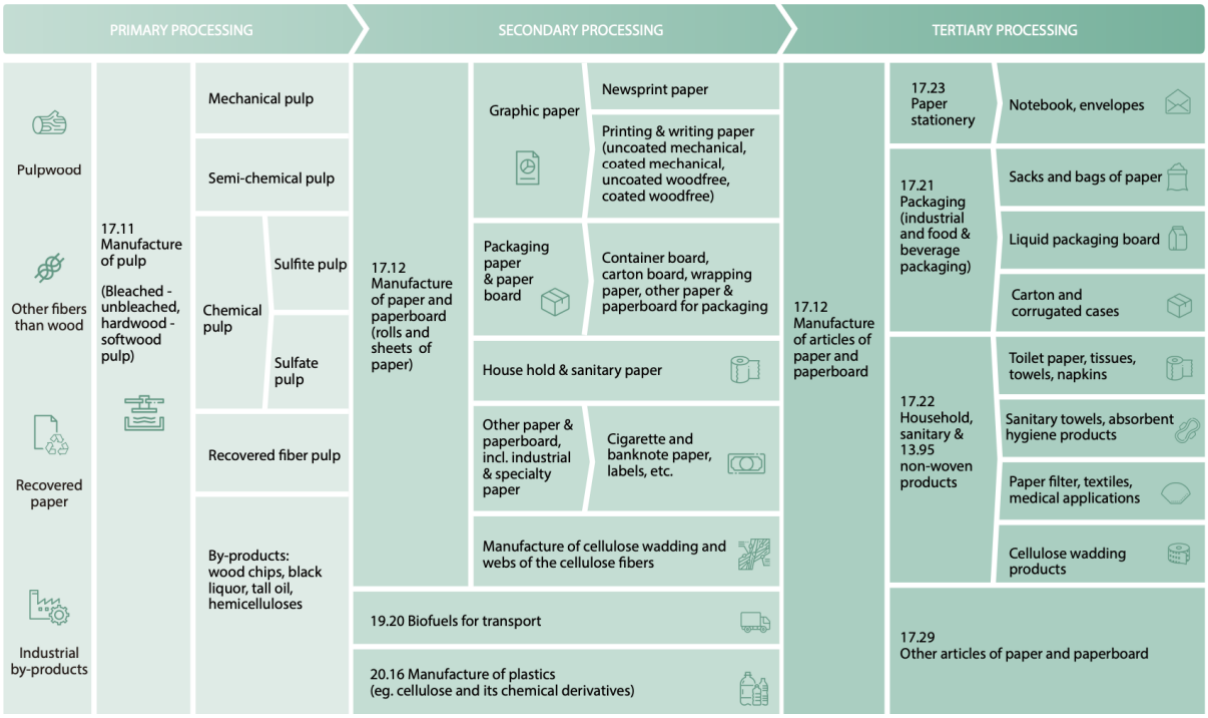
The industry's primary sources of raw materials are wood (coniferous, deciduous) and non-woody plant species (straw, miscanthus, sorghum, sugar cane). Depending on the type of wood, deciduous, coniferous, and eucalyptus pulp are distinguished. Various primary fiber types are obtained from wood pulp, cellulose, and semi-cellulose. Cellulose is a biopolymer widely used to produce paper, cardboard, and other products such as cellophane, celluloid, viscose, etc. Various types of cellulose are used in the production of paper and cardboard: nano-cellulose (high technology, pharmacology, etc.), micro cellulose (pharmacology), and viscose cellulose (textile industry).

The papermaking process is highly resource-demanding. After wood pulp, the two most significant resources are water and energy. Circularity improvement in the pulp and paper industry can include reusing water and energy. Modern technologies allow water reuse ten times or more before it is discharged[57].

In European countries, pulp and paper enterprises are also energy suppliers. Pulp and paper mills install steam turbines for cogeneration, generating electricity and heat from paper and paperboard production. Such a system allows businesses to operate independently of the public electricity grid, and excess energy can be sold or used to supply nearby areas.

[57] https://www.afandpa.org/sites/default/files/2021-07/2020_AF-PA-Sustainability-Report.pdf

Figure 18. Data regarding the paper process cycle



Source: UNECE/FAO, adapted from Rivera León et al. (2016)

4.2.2. Observation of paper making process

The structure of wood fiber can be compared with reinforced concrete: cellulose microfibrils are close to reinforcement in their strength properties, and lignin, which has high compressive strength, is close to concrete. Lignin is a mixture of natural polymers, a non-hydrolyzable part of the wood. Hardwood wood contains 18-24% lignin and 27-30% coniferous. During cellulose production, sulfate, sulfite lignin, and lignosulfonate acids can be used as waste products. Lignin can be used as a synthetic rubber enhancer and a plasticizer in ceramic production, and lignin can also be used in particle boards and plastics production. Sludge-lignin can be used to obtain high-quality drilling fluids. Lignosulphonic acids are used as cheap fasteners

and binders in the foundry industry, which additives the charge in cement production.

There are several types of cellulose and wood pulp, depending on the production technology and raw materials used:

1. Sulphated cellulose - cellulose obtained from thermochemical treatment of wood chips with a solution of sodium hydroxide and sodium sulphide. Kraft pulp has higher paper-forming properties than sulphite pulp. With the sulphate method of production. Cellulose uses sodium sulphide, so hydrogen sulphide's main component pollutes the atmosphere.

2. Sulphite cellulose is obtained by cooking raw materials in a liquor containing sulphurous acid, salts of sulphurous acid, or mixtures as the main components.

3. Wood pulp is a fibrous semi-finished product for manufacturing paper, which is obtained by mechanical grinding wood in an aquatic environment. At the same time, it is split into micro- and macroscopic particles of various shapes. The wood pulp contains cellulose and lignin. There are several types of mechanical wood pulp: refined wood pulp, thermomechanical wood pulp, chemical thermomechanical pulp, bleached chemical thermomechanical pulp, etc.

4. Semi cellulose is a fibrous semi-finished product that differs from cellulose. The final separation of the raw material into fibers is carried out under the action of its grinding in disc mills. The yield of semi-cellulose is 65-75% by weight of dehydrated raw materials (neutral sulphite method).

5. Cellulose from non-wood raw materials is cellulose obtained from annual plants, primarily cereals, by alkaline methods.

The process of obtaining primary fiber begins at the pulp and paper mill with wood processing. The trunk of a fallen tree is cleared of branches and separated from the root base. These parts become biofuel. Round timber is obtained from such trunks by transverse division. The next step is debarking. Trunks are crushed into chips under pressure to produce wood pulp or boiled with various reagents, depending on which pulp is to be obtained (sulphate, sulphite, neutral sulphite methods). The last step is drying.

Many facilities improve the circularity of their production by sustainably used energy. There are a few ways to do it: creating side energy streams from woody biomass, sustainable using of heat, and using wastewater and solid waste as the resource for biogas production. For example, the Swedish paper production facility Fiskeby uses its own steam from the drying process one more time. They use modern technology to exchange outgoing and incoming air and water. Fiskeby created a biogas facility to treat wastewater from the paper production process, using heat from the production mill to provide optimal temperature to the microorganisms in the tank[58].

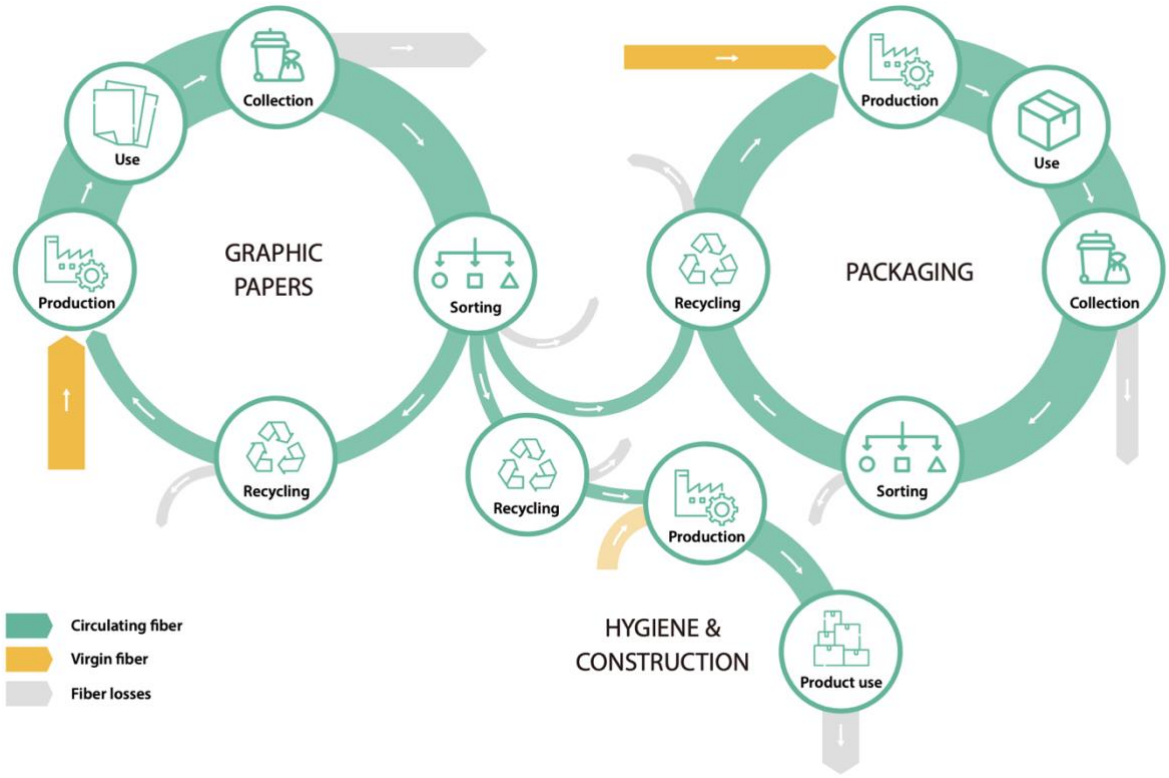
Another opportunity to use subproducts of the papermaking process is black liquor gasification. Black liquor is a mixture of lignin, hemicellulose, and inorganic

[58] https://www.fiskeby.com/sustainability/energy/?lang=en

chemical components like sodium hydroxide and sodium sulfide. It is an environmentally dangerous substance that paper mills did not know how to handle until the early 20th century and just through to the waterways. It was one of the reasons for the bad reputation of paper mills. But now, many paper mills use recovery boilers to reuse the inorganic chemicals and obtain energy from the pulping contaminants[59]. Next decades some of the boilers should be replaced, so during the process of replacement, new technology could be implemented to produce not only steam and electricity but fuels and chemicals through gasification. Black liquor could be used as a resource for energy supply. Ash from black liquor could be used as fertilizer for potassium sulfate. It can reduce the industry's dependence on hydrocarbons.

[59] Black liquor gasification

Figure 19. The cellulose-based fibers life cycle and losses



Source: UNECE/FAO, adapted from WEF (2016).

The circular economy concept is highly realized in the paper industry because the material could be recycled 5-7 times without downcycles from paper to paper and around 30 times with downcycle from piece to molded fiber. Wastepaper is the used paper or paper that is not fit for use. Wastepaper is used mainly as a raw material for producing paper and cardboard. Less often, it is used for creating other products, such as asphalt supplements. Some types of paper and cardboard cannot be returned to the cycle. For instance, contaminated or impregnated types of cardboard and paper are not recyclable. So, non-recyclable types of paper and cardboard include bitumen paper, sanitary ware, photographic paper, wallpaper, construction paper waste, etc.

Circularity could be improved at this stage. There is the option to incinerate waste during the paper production process. For example, already mentioned Swedish paper recycling mill Fiskeby can recycle even composite materials, such as tetra pack or elopack, etc., because they have separation capacities and incinerator that put back the energy from the incineration to the production cycle[60].

The process of wastepaper collection starts from the retailers, factories that produce paper, cardboard products, packaging, printing houses, waste sorting stations, households, and other commercial and municipal properties. The accumulation of wastepaper occurs either in container yards or special rooms at the facility. Further, the wastepaper is removed and transported to the place of processing (sorting, pressing, boiling). In the processed form, wastepaper enters the plant.

Wastepaper cannot be stored for a long time because it begins to rot and deteriorate during long-term storage. In this regard, the accumulation of stocks of wastepaper for more than one month is impossible.

Recycling of wastepaper is carried out according to the technology of wet defibration and includes five main stages:

- Dissolution of wastepaper.
- Purification of wastepaper from impurities.
- Thermomechanical processing.

[60] https://www.fiskeby.com/sustainability/energy/?lang=en

- Additional dissolution of wastepaper mass.
- Cleaning of wastepaper mass.

The wastepaper mass is cleaned from heavy and light impurities in the second stage. Water is supplied in all types of cleaning equipment to reduce the loss of wastepaper. Heavy impurities are sand, glass, and paper clips. Firstly, they are cleaned with special equipment, which is a cyclone. Then they are deposited in the dirt collector and periodically removed. Light impurities are polymer film and various pieces of wastepaper. They are removed using a slotted vibrating screen.

The thermomechanical processing step is optional. However, it is necessary if products with a complex composition, including bitumen, wax, paraffin, glue, and other substances, are used as raw materials. They contaminate equipment, clog nets and felts of paper and board machines, and stick to the surface of drying cylinders. Thermomechanical processing is the dispersion process, i.e., grinding solids or liquids, resulting in mechanical destruction.

The fiber value from wood and wastepaper is determined by its paper-forming properties (strength, deformation, etc.), which depend on its length.

The paper-forming properties of wood pulp are lower than cellulose since it contains lignin and fiber. In any case, the primary thread is the most valuable. The structure of the fibers consists of OH - bonds intertwined with each other. With each processing cycle, the structural bonds are getting destroyed. The mechanical properties of the paper are reduced, and the strength deteriorates.

In addition to recycling cycles, fiber degradation is affected by a rather expensive cleaning process concerning wastepaper. Various reagents and biocides are added to the contaminated wastepaper in the pulper, which lead to the destruction of structural bonds.

Paper is an excellent material for recycling, but as already said, it can be recycled from paper to paper only five-seven times (Figure 19). Fibers lose their paper-forming properties during recovery, collection, and sorting. For example, it has been counted that only 38 % of paper products are made from recycling, the rest is made from raw material[61]. Even with the high level of circularity, the pulp and paper sector in the European Union produces 11 million tons of waste yearly. It has been found that 25-40% of municipal solid waste generated each year worldwide is paper-related[62].

4.3. Opportunities to improve circularity in the pulp and paper industry

For resource-dependent countries that rely on the supply of hydrocarbons, such as Sweden, could be an excellent solution to develop biofuel production[63]. The policy could stimulate the use of organic waste to produce biofuels.

A meaningful way to increase circularity and sustainability in the papermaking industry relates to sourcing raw materials. Policymakers and businesses should

[61] Van Ewijk, S., Stegemann, J.A., Ekins, P., 2018. Global Life Cycle Paper Flows, Recycling Metrics, and Material Efficiency. Journal of Industrial Ecology 22, 686-693.
[62] New market niches for the Pulp and Paper Industry waste based on circular economy approaches
[63] https://smartcitysweden.com/focus-areas/mobility/biofuels/

secure that virgin fibers used for production come from sustainably managed forests domestically and internationally.

One of the areas with the potential to improve circularity in the pulp and paper industry is bioenergy production. There are a few ways to do it: creating side energy streams from woody biomass, sustainable using of heat, and using wastewater and solid waste as the resource for biogas production. Policies can stimulate the implementation of new technologies. For example, the state could subsidize the installation of new equipment.

One more avenue to improve circularity in the paper production process is to lessen the use of chemicals like ink, glue, and dye. There is a special technological process of deinking, but it also destroys fiber easily. The chemistry industry developed a lot during the last decades, so producers get the opportunity to use many different types of inks. More than 6000 chemicals are used in modern ink. Because of the variety and quality of chemicals, it is not easy to completely vanish them from the paper.

So, it could be suggested to limit the use of chemicals, especially ink, by policies. It can improve circularity from the point of sustainable design but could be painful for the chemistry industry. For example, Chinese dairy giant brand Yili decided to be more sustainable and created milk packaging without ink[64]. The same practice exists in Japan.

[64] https://www.dairyreporter.com/Article/2022/06/14/how-yili-is-targeting-the-low-carbon-consumption-trend-from-no-ink-packaging-to-china-s-first-carbon-neutral-yogurt

5. Discussion

Following the current deglobalization trend, the circular economy concept should be clarified and changed. A circular economy should rely on local energy sources and best practices and follow bioeconomy trends.

Energy efficiency in the circular economy theoretical approach is mainly connected with material efficiency. Gilbert explains material efficiency as providing services with less material production and processing[65]. The main idea is to reduce energy use in the process of production. As well, scientists connect energy efficiency with decreasing greenhouse gas emissions. But on the other hand, renewables could stimulate the increase of the different carbon-emitting activities[66]. Renewables have become a trendy topic of theoretical discussion from the aspects of life-cycle emissions and raw metal consumption[67].

One of the conditions for implementing the circular economy worldwide is the stabilization of global demand for the volume and composition of products. But energy policies regulate the supply chain in the paradigm of the linear economy, when there is a need to minimize the financial and environmental costs, but in a «take-make-dispose» system.

[65] Gilbert, P., Wilson, P., Walsh, C. and Hodgson, P. (2017). «The role of material efficiency to reduce CO2 emissions during ship manufacture: A life cycle approach», Marine Policy (2017), pp.227-237

[67] Parrique T., Barth J., Briens F., Kerschner, C., Kraus-Polk, A., Kuokkanen A., Spangenberg, J.H. (2019). Decoupling Debunked: Evidence and Arguments Against Green Growth as a Sole Strategy For Sustainability, European Environmental Bureau

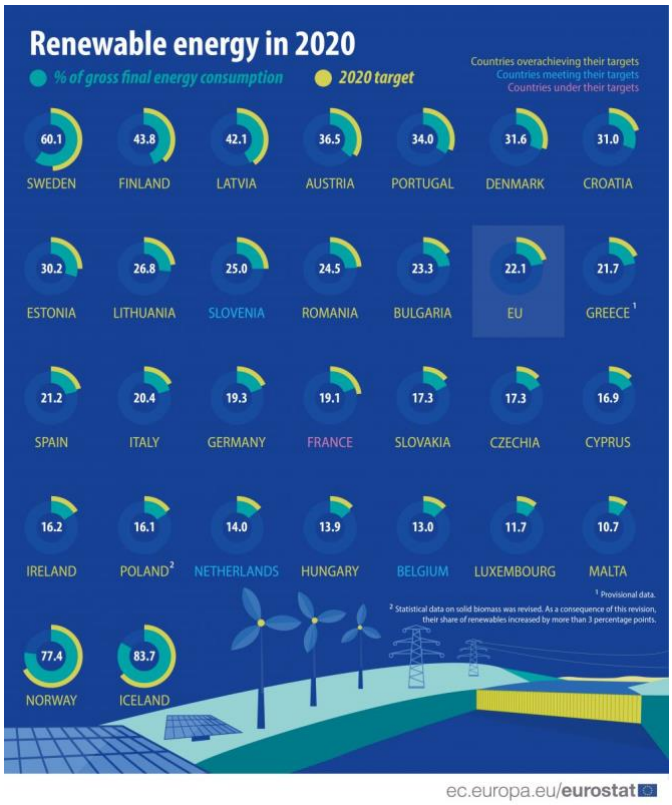
As well, European energy policies try to stimulate decarbonization. But decarbonization does not consider the energy source and the country of origin as essential for analysis. The circular economy, as represented in current policies, is regarded as an alternative way for decarbonization through non-energy means[68].

On the other hand, there is a reason why the circular economy is not strict regarding energy policy. First, there is a significant difference in conditions between energy-demanded countries and those with enough natural resources. So, energy-demanded countries orient their policies on those aspects that are more predictable and controllable. There is no unique solution in European Union regarding energy transition. Renewables cover 21.1 % of the total energy supply in Europe (Figure 20). Countries still argue regarding nuclear power generation, could it be considered «green» or not[69]? It means that European Union still should rely on suppliers for at least the nearest years.

[68] Incentivizing Decarbonization through the Circular Economy. Enel Foundation. Oxford Institute for Energy Studies, pp. 7, 27. ISBN 978-1-78467-174-7

[69] Germany needs to stop imposing its failed energy policies on the rest of the EU. Brussels report, January 4, 2022

Figure 20. Renewable energy in Europe (2020)



Source: Eurostat

There is no technical possibility of switching from hydrocarbons to renewables totally and simultaneously. The modern economy relies on hydrocarbons because industry should use energy to produce goods and provide employment and social stability. Infrastructure for transporting hydrocarbons is very developed. It means alternative power sources do not yet develop to include them in the circular system. But on the other hand, even United Nations started to post information about the possibility of combining the circular economy approach and energy policies for

better results[70]. It means that more and more organizations understand the role of energy in the circular economy.

[70] https://climatechampions.unfccc.int/3-ways-the-circular-economy-is-vital-for-the-energy-transition/

6. Conclusions

Regarding 1st objective of the thesis: to show which aspects of circular economy are becoming missing and dysfunctional in deglobalizing world.

Policy observation and analyses of the interviews with paper recyclers showed that nowadays the circular economy is mostly connected with the waste management. Policymakers and professionals are still not aware enough about energy sources in production cycle, there is a gap between theoretical and practical understanding of the circular economy approach in Europe and Russia. Observation of European policies regarding circular economy showed that circular economy is far from energy policies. The inability of Europe to implement the transition to green energy and its dependence on Russian hydrocarbons presents an urgent need to review the concept of circular economy and its implementation in the face of new realities. As interviews showed, the Russian paper recycling industry creates circular solutions, but sustainable professionals are mostly skeptical regarding the circular economy and its implementations. It means that the theory and practice of the circular economy concept in Russia also differ. To cover this gap, it should be political will and request from the professional community to implement circular economy solutions continually and explain them to the broader public.

The international waste trade concept should be renovated as well. Since deglobalization tends to continue, the best way is to learn how to handle waste locally without transporting it to other jurisdictions that could be less strict with environmental regulations. Otherwise, countries become not only energy-depended

but also dependent on waste management, creating potential ecological misbehavior in countries that rely on waste trade.

These days the attractive idea of circularity, how it is defined now in European government policies and NGO papers, can no longer match the current geopolitical circumstances. Prevention of waste production, extended producer responsibility, 3R, and even 9R concepts are not enough to implement a circular economy. Considering the start of the production process and energy sources is necessary. A combination of the circular economy concept and energy transition policy could be fruitful for policymaking because of the resource efficiency and more conscious approach to importing hydrocarbons, especially right now, when the highly globalized world has started to divide into clusters.

Regarding 2nd objective of the study: to show the fate of the pulp and paper industry as a successful traditional example of circular economy implementation under new conditions.

As showed in case study the pulp and paper industry already uses modern technologies to produce biogas, create and use biomass as fuel, tackle waste as an energy resource, and progressive in wastewater treatment. Paper as the material is highly recyclable and quickly biodegradable.

As interviews showed the professionals from paper recycling industry are optimistic about possibility to supplement single-use plastic, at least in packaging, with paper material. It could decrease the need for crude oil used for single-use plastic

production. Trees could be planted again. The pulp and paper industry could produce biofuel. With sustainably managed forests, it can successfully continue reducing CO2 production.

Case study showed that pulp and paper production is a successful example of circularity among other industries. It could be a role model for different industries and an instance of a bioeconomy as an extension of the circular economy, especially for those countries that are energy dependent.

The 3rd objective of the thesis: to propose biomass-based solutions as a resource for the energy-dependent regions to continue implementing the circular economy approach in the pulp and paper industry under new circumstances.

Based on the case study, the idea of the circular economy can be developed like the bio-based economy model. The bio-based economy relies on bioenergy production and renewable resources that could be recovered quicker than depleted. An essential part of a bio-based economy is biomass production. Biomass can be used to generate heat and energy that substitutes fossil fuels and reduces the emissions of greenhouse gases. Currently, one of the reasons for the use of biomass is the high price of fossil fuels, it could be continued. Biomass can be used to generate heat and energy that substitutes fossil fuels and reduces the emissions of greenhouse gases. The bio-based economy could be a fruitful solution for energy-depended countries to tackle deglobalization issues with a shortage of hydrocarbons supply.

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