Horizon 2020 Programme

SCRREEN2

This project has received funding from the European

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SCRREEN

Solutions for CRitical Raw materials - a European Expert Network

FACTSHEETS UPDATES **BASED ON THE EU FACTSHEETS 2020**

NATURAL RUBBER

AUTHOR(S):

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NATURAL RUBBER

OVERVIEW

Natural rubber is primarily harvested from the rubber tree *Hevea brasiliensis*. Although native to the Amazon region, over 90% of natural rubber is now produced in Southeast Asia. The tyre industry is the largest consumer of natural rubber, accounting for around 72% of the annual demand (in 2017). Use of natural rubber in European value chains is dominated by the tyre industry, whereas in Asia the General Rubber Goods (GRG) applications in high-tech industries play an important role. There are many uncertainties in natural rubber production for both end-user and producer given the biotic nature of the raw material.

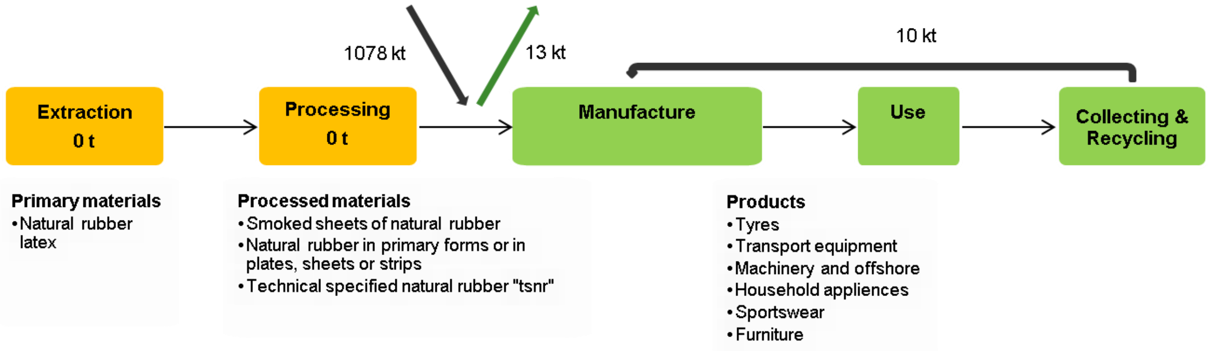

Figure 1. Simplified value chain for natural rubber in the EU[1]

Table 1. Natural rubber supply and demand in metric tonnes, 2016-2020 average

Global production	Global Producers	EU consumption	EU Share	EU Suppliers	Import reliance
15,318,712	Thailand 31% Indonesia 23% China 10% Vietnam 7% India 6%	1,160,141	7.5%	Indonesia 30% Thailand 21% Cote d'Ivoire 19% Malaysia 12% Vietnam 8%	100%

Prices: The price volatility of natural rubber is mainly influenced by shifting demand from industry and shifting supply as a result of influences from the environment (e.g. weather conditions). Current issues that impact or may impact natural rubber prices include the geopolitical tension between China and Taiwan, uncertainty caused by the Russia-Ukraine war, severe Covid-lockdowns in China, the increased strength of the US dollar and the continuing weakness in the currencies of key natural rubber-exporting countries (Jacob, 2022).

[1] JRC elaboration on multiple sources (see next sections)

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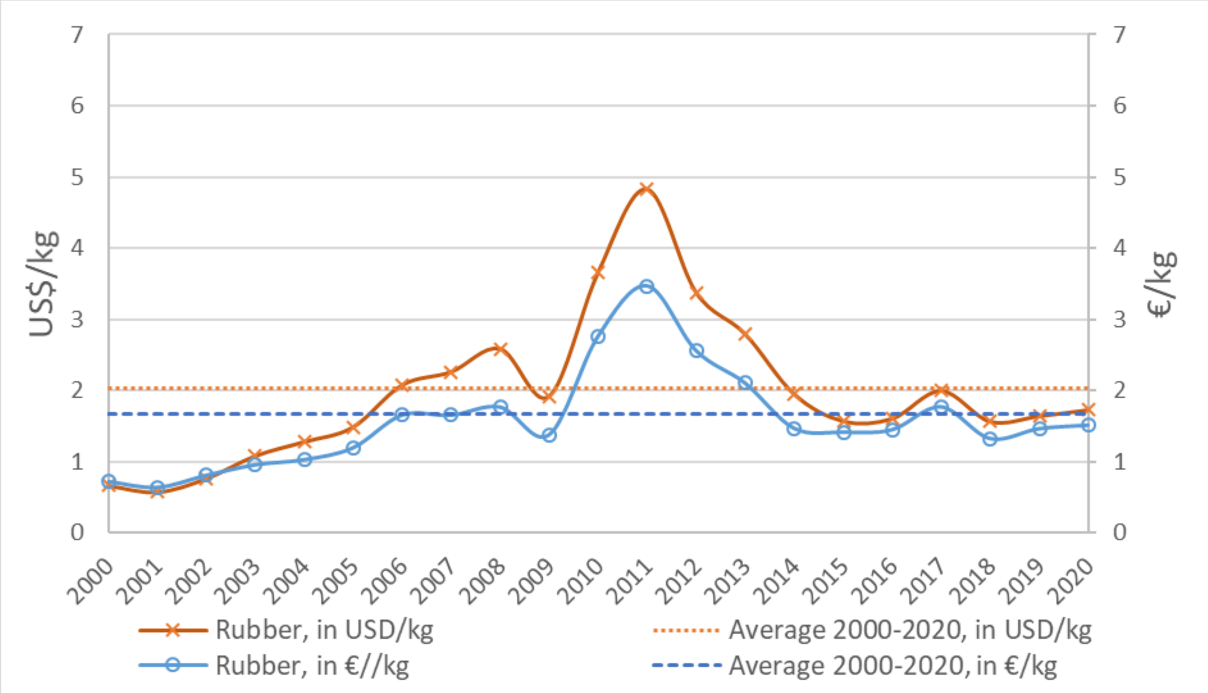

Figure 2. Annual average price of natural rubber between 2000 and 2020 (USGS, 2021)[2].

Primary supply: The global production of natural rubber in 2019 was 13600 kt (rubberstudy.org), significantly increased in comparison to the average production between 2012 and 2016 (13140 kt), dominated by Thailand and Indonesia, which account for more than 57% of global production (Figure 1). Other, organizations estimate the global production in 2019 more increased (at 14600 kt according to allindiarubber.net). There is no production of natural rubber in the EU.

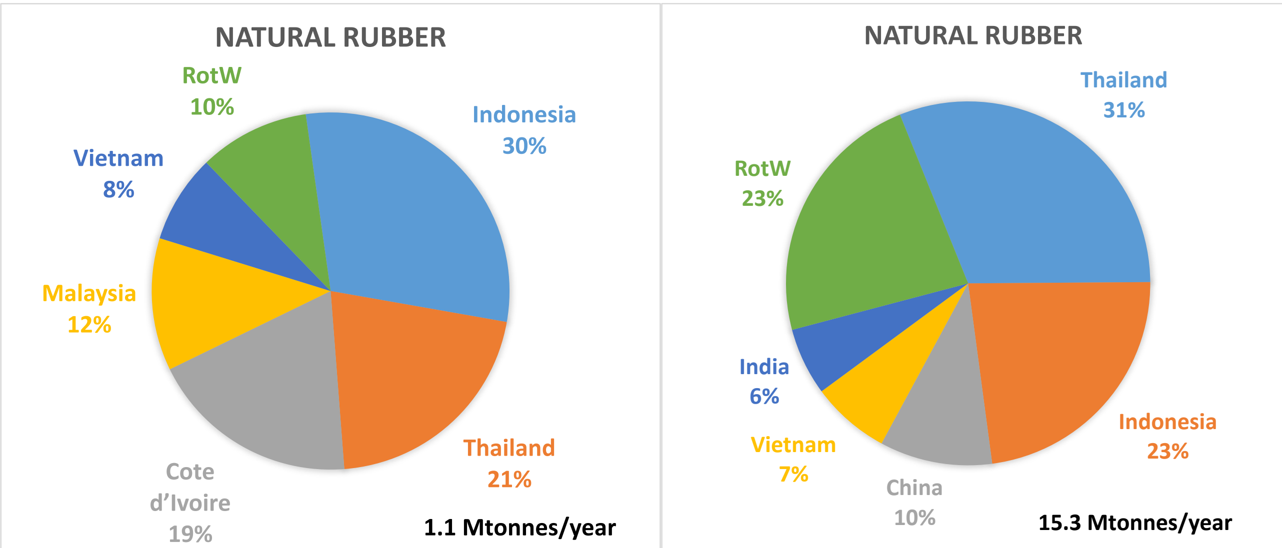

Figure 3. EU sourcing of natural rubber and global mine production (average 2016-2020)

[2] Values in €/kg are converted from original data in US$/kg by using the annual average Euro foreign exchange reference rates from the European Central Bank (https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

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Secondary supply: Natural rubber is mostly used in a mix with synthetic rubber to obtain the desired hard rubber product performances. With the available technology it is not possible to recycle rubber products and extract natural rubber from these mixtures, therefore recycling is always a mix of natural and synthetic rubbers. Since 2006, all EU member states are obliged to arrange a collection and recycling of end-of-life tyres. Collected data confirm a material recovery (recycling) rate of 56% and an energy recovery rate of 34%. An outstanding 7% is not fully accounted for. Despite the high recovery rate reached for end-of-life tyres in EU, for the criticality assessment of natural rubber, it is important to highlight that tyre recycling features an open-loop recycling, meaning that end-of-life tyres (ELT)-derived rubber granulates are mainly downcycled in other applications. With regard to recycling, near 1.5 million tonnes (1,469 kt) of ELTs are annually processed for granulation and are used in a multitude of applications

Uses: natural rubber is mainly used in tyre (83%). Second main use is in machinery for tubes, frames, ledges and profiles (11%). Only 4% is for household appliance and furniture and 1% for packaging

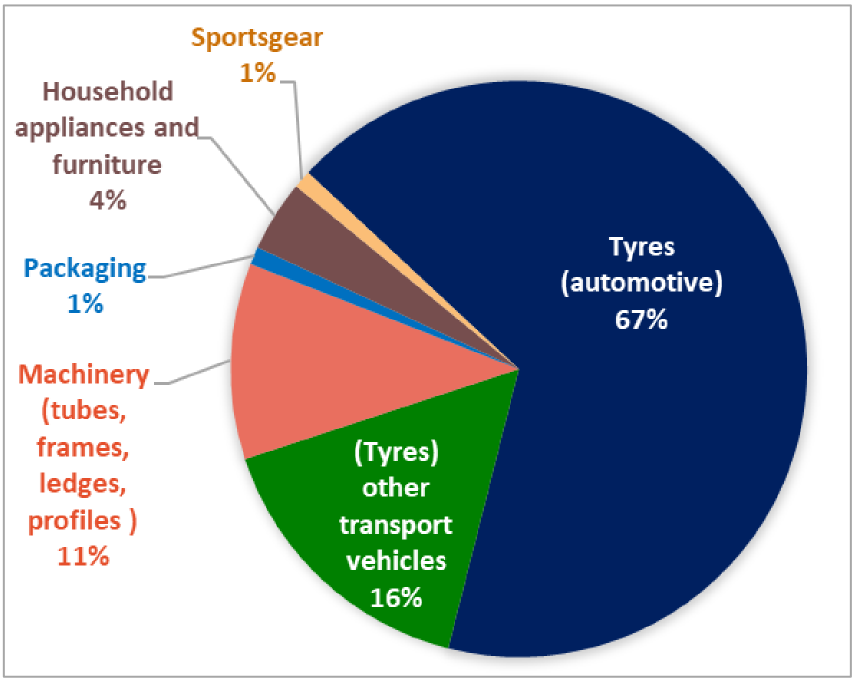

Figure 4: EU uses of natural rubber

Substitution: Regarding the substitutability of natural rubber, tyre manufacturers depend on natural rubber for its unique load bearing and abrasion-resistant qualities. European car tyres typically contain about 14% natural rubber by weight, truck tyres about 28%. Aircraft and earthmover tyres contain an even higher percentage of natural rubber. Despite decades of research, no synthetic alternative has been found for the remaining applications of natural rubber in tyres. Research is focused on developing natural rubber from alternative plant sources of latex that can grow in other geographical regions and notably in Europe.

Other issues: Occupational health thresholds are established for rubber fumes, in the EU and outside, ranging between 0.4 and 0.6 mg/m^3 of air. The Hazard Statement (H-phrases) of the European GLS classification and labelling system classify natural rubber as substance that may cause allergic skin reactions (H317), and allergy or asthma symptoms or breathing difficulties if inhaled (H334). (GESTIS 2022).

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Allergy to natural rubber latex from exposure to proteins derived from Hevea brasiliensis is observed in certain occupational and other high-risk groups, with frequent exposure to NRL products, e.g. health care workers, workers in the latex industry, and atopic individuals. (Sussmann et al. 2002). Natural rubber supply may be highly affected by Pseudocercospora Ulei (South American Leaf Blight, synonym or older form: Microcyclus Ulei), which causes a fungal disease able to destroy young rubber trees. In South and Central America, the disease destroyed the attempts made to increase the production of natural rubber. Its occurrence is still restricted to these areas, but may present a threat to Southeast Asia (ASEAN 2018) and West Africa. Being a biotic material, sustainable sourcing of natural rubber focuses on the risk of biodiversity loss, on promoting good agricultural practices and on mitigating land ownership conflicts.

Table 2. Uses and possible substitutes

Application	%*	Substitute(s)	SubShare	Cost	Performance
Tyres (automotive)	67%	Butadiene Butyl Styrene-Butadiene Rubber Ethylene-propylene	15% 15% 15% 15%	Similar or lower in all options	Reduced in all options
Tyres (other transport vehicles)	16%	Butadiene Butyl Styrene-Butadiene Rubber Ethylene-propylene	5% 5% 5% 5%	Similar or lower in all options	Reduced in all options
Machinery (tubes, frames, ledges, profiles)	11%	Chloroprene Ethylene-propylene Elastomer Polyurethanes Thermoplastic elastomers Silicones	5% 5% 5% 5% 5%	Similar or lower in all options	Reduced in all options
Household appliances & furniture	4%	All synthetic rubbers Thermoplastic elastomers	40% 40%	Similar or lower in all options	Reduced in all options
Packaging	1%	All synthetic rubbers	40%	Similar or lower	Reduced
Sportsgear	1%	All synthetic rubbers	40%	Similar or lower	Reduced

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MARKET ANALYSIS, TRADE AND PRICES

GLOBAL MARKET

Table 3: Natural Rubber (extraction) supply and demand in metric tons, 2016-2020 average

Global production	Global Producers	EU consumption	EU Share	EU Suppliers	Import reliance
15,318,712	Thailand 31% Indonesia 23% China 10% Vietnam 7% India 6%	1,160,141	7.5%	Indonesia 30% Thailand 21% Cote d'Ivoire 19% Malaysia 12% Vietnam 8%	100%

From 2016 to 2020, the global production of natural rubber achieved 15,318 kt. Natural rubber production is dominated by Thailand and Indonesia, which accounted for more than 54%. There is no production within the EU.

The major companies are Sinochem (China), Sri Trang Agro-Industry (Thailand), China Hainan Rubber (China), Von Bundit (Thailand), and Thai Rubber Latex (Thailand).

Within Europe, about 1 million tons of natural rubber is consumed yearly. The main end-use is the automotive industry, requiring performant tires (67%). Other transport vehicles require tires for 16%. Natural rubber is also used in machinery (11%), such as in tubes, frames, ledges, and profiles. Other applications include packaging (1%), household appliances and furniture (4%) and sportsgear (1%).

Substitution a major trend in the market as many discussions are happening around the substitution of natural rubber by synthetic rubber. Most synthetic rubbers in the market can be found in the form of butadiene, butyl, styrene-butadiene rubber, ethylene-propylene, elastomer polyurethanes, thermoplastic elastomers, and silicones.

The possibility of natural rubber replacement by synthetic rubber is limited in the current geopolitical context. Europe is already highly dependent on synthetic rubber coming from Russia and Ukraine and is thus impacted by the Russian-Ukraine war. Other alternatives are limited as synthetic rubber mostly come from India, China, and Saudi Arabia. The possibility of substitution is evaluated at around 2%. Meanwhile, the substitution of synthetic rubber by natural rubber might appear in the next years as major company strategies head towards more sustainable raw materials in their value chain.

EU TRADE

Natural Rubber is assessed at processing/refining stage. The following table lists relevant Eurostat CN trade codes for Natural Rubber.

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Table 4. Relevant Eurostat CN trade codes for Natural Rubber

Mining		Processing/refining	
CN trade code	**title**	**CN trade code**	**title**
-	-	**40011000**	Natural Rubber latex, whether or not prevulcanised
		40012100	Smoked sheets of natural rubber
		40012200	Technically specified natural rubber (TSNR)

Figure 5 shows the import and export trend of Natural Rubber latex, whether or not prevulcanised. The EU exports is much lower than the EU import of Natural Rubber latex. In 2021, the EU export sat at 3,366 tonnes while the import was 87,310 tonnes. The import of Natural Rubber latex fell 159,010 tonnes in 2013 to 75,839 tonnes in 2015 and it remained at this amount till 2021. Instead, the EU export seemed to maintain the same level during this period.

Figure 6 illustrates the share of import in EU for Natural Rubber latex content from various countries. The main supplier to EU in the past two decades (2000-2021) was Thailand (22% of share), followed by Malaysia, Indonesia, and Viet Nam (22%, 21%, and 11%, respectively).

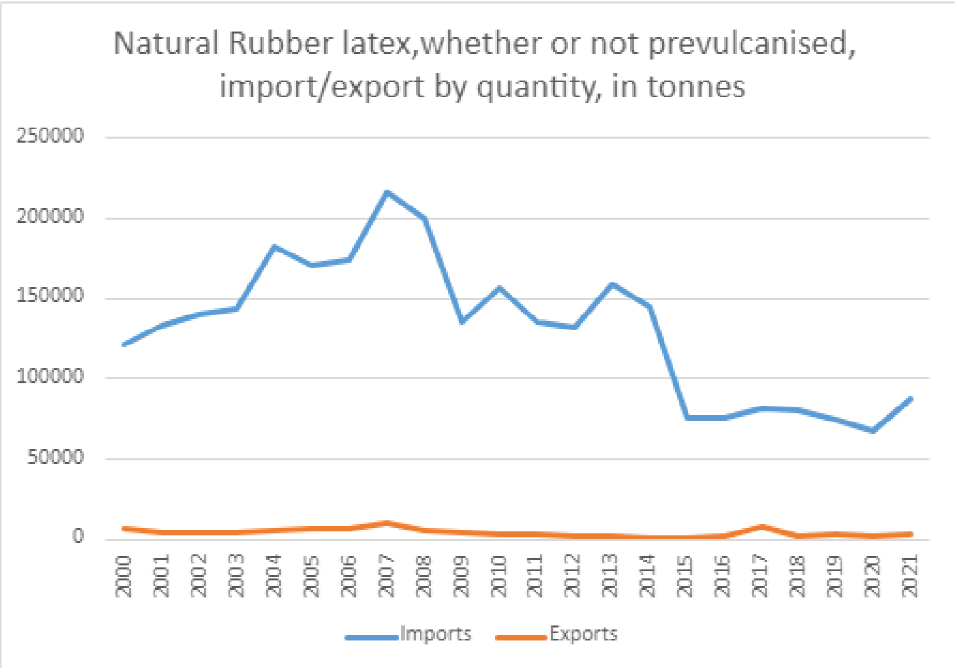

Figure 5. EU trade flows of Natural Rubber latex, whether or not prevulcanised (CN 40011000) from 2000 to 2021 (Eurostat, 2022)

Figure 7 shows the import and export trend of Smoked sheets of natural rubber (CN 40012100**)**. The export of high purity natural rubber in the past two decades (2000-2021) have been very low without any great change around 1000 tonnes. While the import continuously decreased from 248,887 tonnes in 2000 to 74,397 tonnes in 2020 and increased to 96,128 in tonnes 2021.

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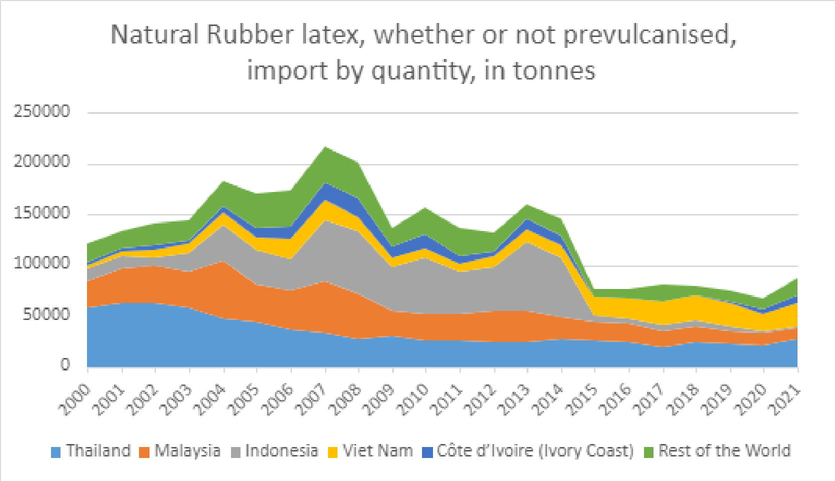

Figure 6. EU imports of Natural Rubber latex, whether or not prevulcanised (CN 40011000) from 2000 to 2021 (Eurostat, 2022)

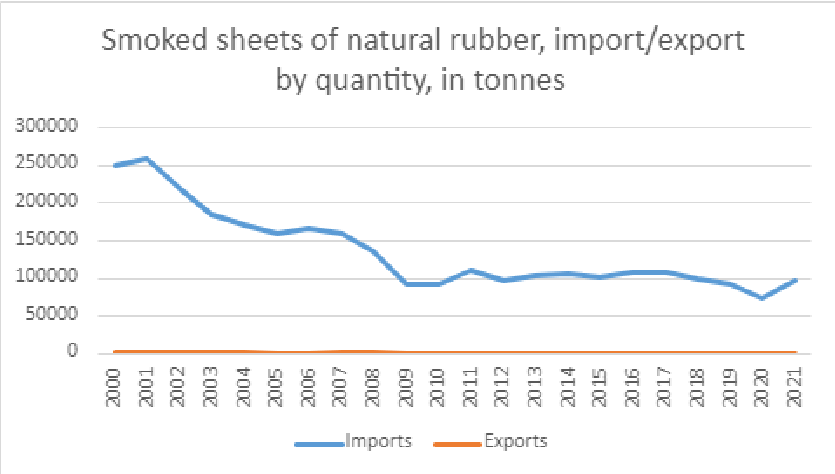

Figure 7. EU Trade flows of Smoked sheets of natural rubber (CN 40012100) from 2000 to 2021 (Eurostat, 2022)

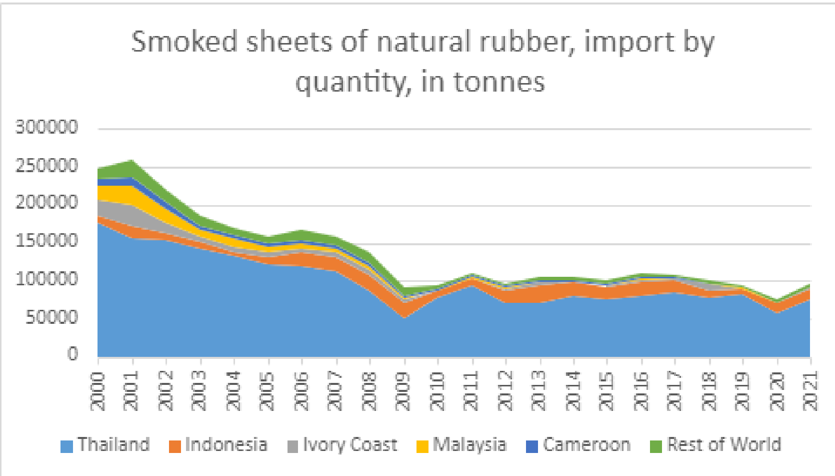

Figure 8. EU import of Smoked sheets of natural rubber (CN 40012100) from 2000 to 2021

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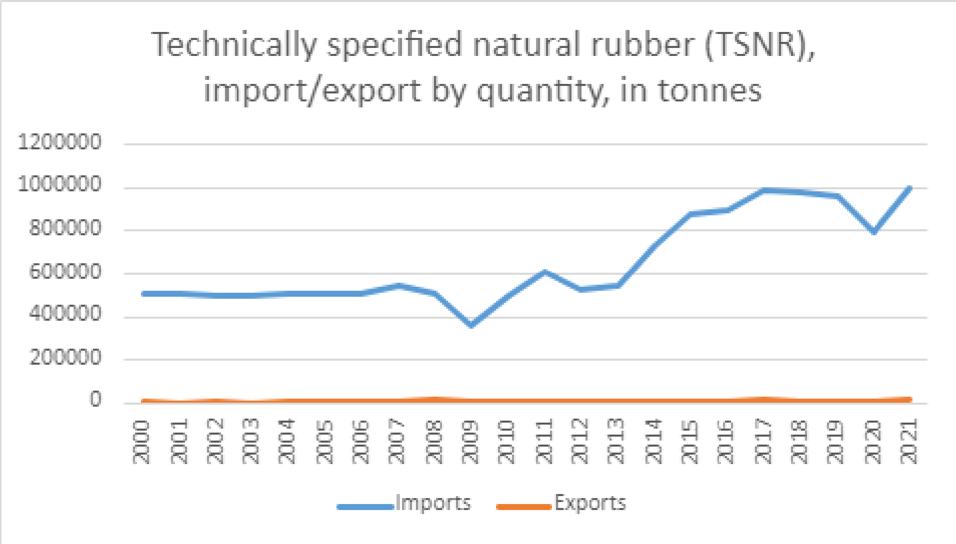

Figure 9. EU Trade flows of Technically specified natural rubber (TSNR) (CN 40012200) from 2000 to 2021 (Eurostat, 2022)

Figure 9 illustrates the share of import in EU for Technically specified natural rubber (TSNR) (CN 40012200**)** from various countries. During the year 2000-2006, the EU import showed to be relatively stable but after 2006 some fluctuations were started with a rising trend. The import of Natural Rubber latex fell 509,498 tonnes in 2008 to 355,686 tonnes in 2009 and increased again. There is another reduction between 2019-2020 that seemed COVID-19 pandemic have impacted the import.

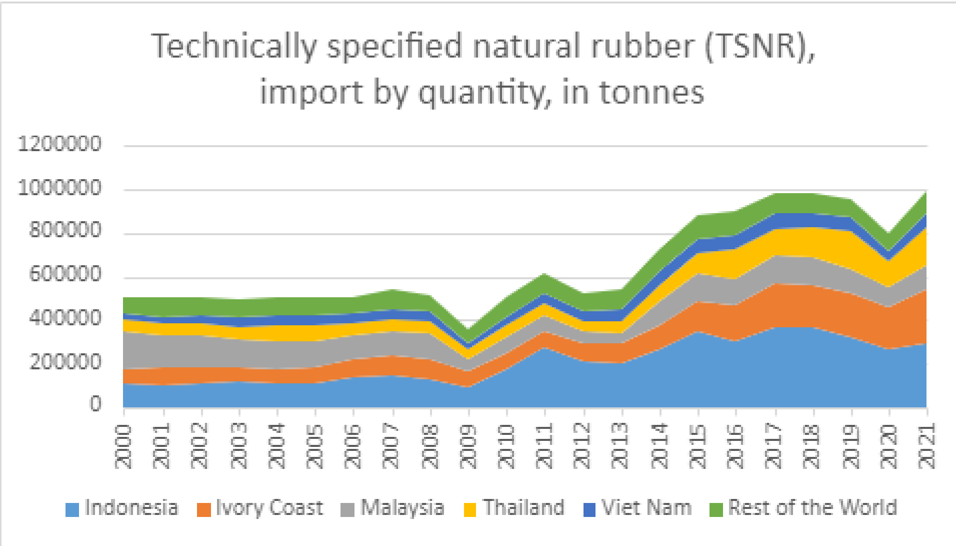

Figure 10. EU import flows of Technically specified natural rubber (TSNR) (CN 40012200) from 2000 to 2021 (Eurostat, 2022)

3.3. PRICE AND PRICE VOLATILITY

The price volatility of natural rubber is mainly influenced by shifting demand from industry and shifting supply as a result of influences from the environment (e.g. weather conditions). Current issues that impact or may

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impact natural rubber prices include the geopolitical tension between China and Taiwan, uncertainty caused by the Russia-Ukraine war, severe Covid-lockdowns in China, the increased strength of the US dollar and the continuing weakness in the currencies of key natural rubber-exporting countries (Jacob, 2022).

The price of rubber has hovered between USD 0.67 and 4.80 per kilogram over the last 20 years (2000-2020). The price of natural rubber, like all other commodities, is sensitive to periodic booms and busts. The increase in natural rubber prices started in 2005 and reached its peak in 2011 registering over 100% growth in a span of five years (Sethunath, 2016). The price reached historical highs in 2011 due to heavy rainfall which interrupted production in major producing countries of Southeast Asia such as Thailand and India. Prices were also supported by a healthy demand from the tyre industry, strong imports in China as well as the rise in crude oil prices in this period (Bureau, 2010). By 2014, prices returned to USD 2 per kilogram. An agreement by Thailand, Indonesia and Malaysia to reduce exports by 350,000 metric tons expired in 2018. This spurred concerns that more supply from these countries will hit the market just as demand was weakening at the same time as increased trade tensions between the U.S. and China (Suwannakij, 2018). By 2019-2021, there seemed to still be no relief for rubber prices. The lower demand can be attributed to the persistence of the COVID-19 pandemic which placed restrictions on mobility as well as lower vehicle sales linked to the semiconductor shortage. On the supply side, global output continued to increase. Therefore, prices remained weakened due to improved supply conditions and lower demand (Baffes & Temaj, 2021).

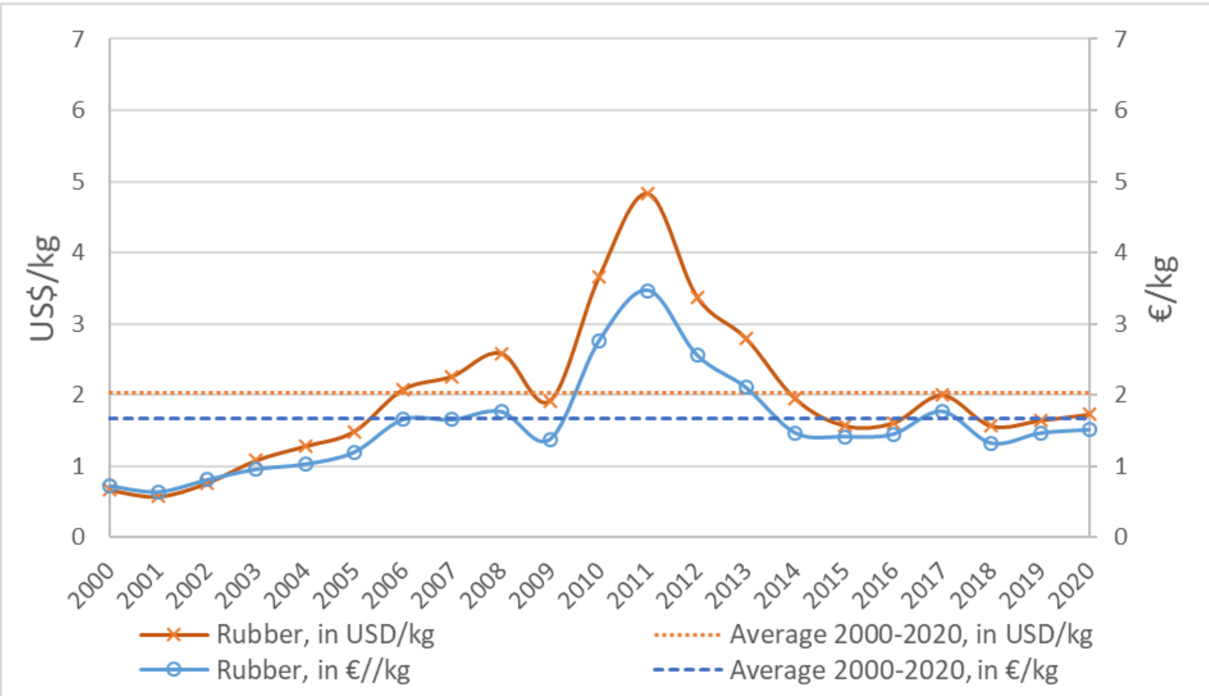

Figure 11. Annual average price of natural rubber between 2000 and 2020, in US$/kg and €/kg[3]. Dash lines indicates average price for 2000-2020 (Indexmundi, 2022)

[3] Values in €/kg are converted from original data in US$/kg by using the annual average Euro foreign exchange reference rates from the European Central Bank

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SCREEN
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OUTLOOK FOR SUPPLY AND DEMAND

The Association of Natural Rubber Producing Countries (ANRPC) forecasted a positive outlook for the global natural rubber market for the year 2022. Production is expected to grow by 2.3%. However, the impacts of climate change, labour shortage in key producing countries and the COVID-19 pandemic can negatively impact growth (Market News & Insights, 2022). Over the medium to long-term, The International Rubber Study Group (IRSG) expects supply to tighten due to the lower rate of new plantation development and re-planting compared to demand (European Rubber Journal, 2022). Although consumption is expected to register a growth of 2.2% in 2022, the demand outlook for natural rubber is dampened by the risk of the brewing economic recession (Market News & Insights, 2022). In 2022, natural rubber prices dropped by 8-15% between July 1 and August 26 across different grades and markets. Since mid-July to mid-December is peak production season, the expected monthly production is expected to surpass consumption (Jacob, 2022). Between 2023 and 2031, the IRSG anticipates an average 2.4% annual growth in rubber demand (European Rubber Journal, 2022)

DEMAND

EU DEMAND AND CONSUMPTION

Statista (2021) estimates the annual average worldwide consumption of natural rubber as about 13.3 Mtonnes for 2016-2020 whereas it is only 1.1 Mtonnes for EU.

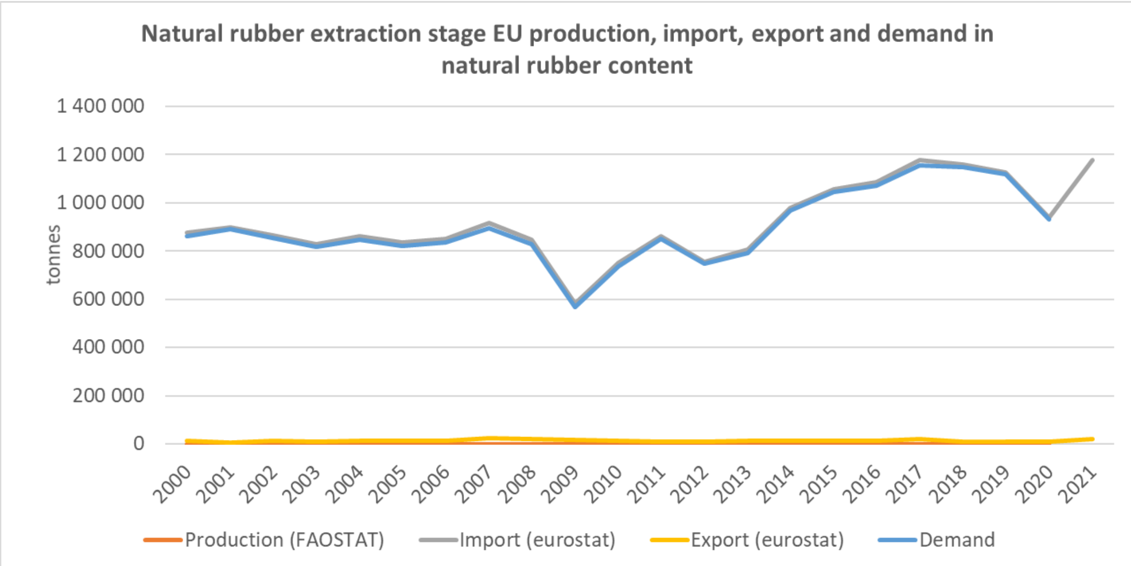

Figure 12. Natural rubber (CN 40012100, CN 40011000, CN 40012200 and CN 40012900) extraction stage apparent EU consumption. Production data is available from FAOSTAT (2022). Consumption is calculated in natural rubber content (EU production+import-export).

(https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

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Natural rubber extraction stage EU consumption is presented by HS codes CN 40012100 Smoked sheets of natural rubber, CN 40011000 Natural rubber latex, whether or not prevulcanised, CN 40012200 Technically specified natural rubber "TSNR" and 40012900 Natural rubber in primary forms or in plates, sheets or strip (excl. smoked sheets, technically specified natural rubber "TSNR" and natural rubber latex, whether or not prevulcanised). Import and export data is extracted from Eurostat (2022). Production data is extracted from FAOSTAT (2022).

Based on Eurostat (2022) and FAOSTAT (2022) average import reliance of natural rubber at extraction stage is 100 % for 2016-2020.

EU USES AND END-USES

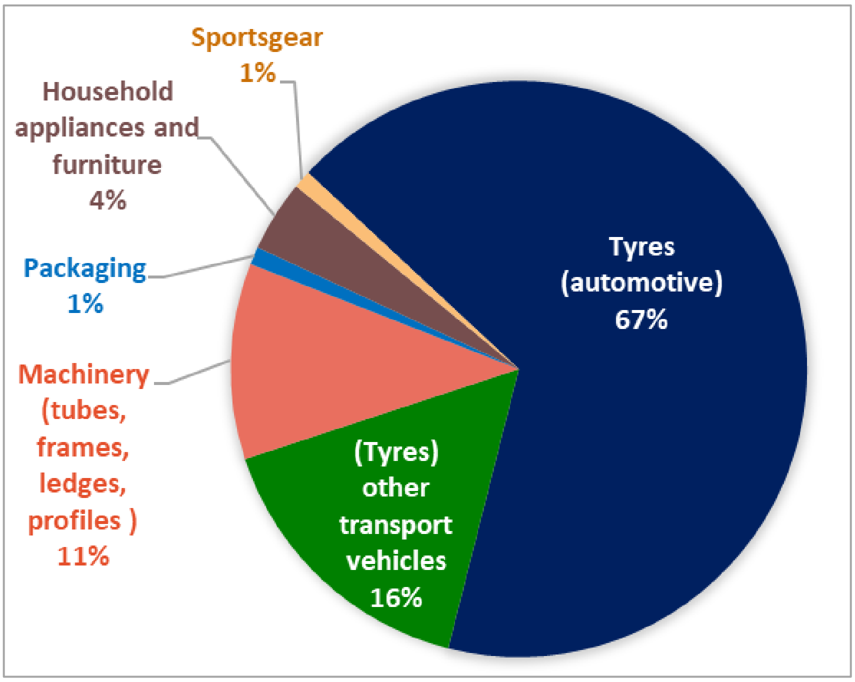

Figure 13: EU end uses for Natural Rubber (2020, validated by SCRREEN experts and EC Data sets, 2022).

APPLICATIONS OF NATURAL RUBBER IN THE EU:

TYRES (AUTOMOTIVE)

- The tyre industry uses up to 67% of natural rubber consumed in the EU, plus 3% in other automotive parts such as rubber dampers for engine mounts and suspension.
- A common car tyre contains 15% natural rubber by weight and a truck tyre will contain on average 30%. The remaining content of tyres consists, among others, of synthetic rubber, carbon black and silica as tyre fillers, steel cord and wires to provide strength, and other chemicals such as oils and zinc oxide.

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TYRES (OTHER TRANSPORT VEHICLES)

- Other transport equipment accounts for 16%, including uses in boats and motor vehicle trailers.

OTHERS (MACHINERY, PACKAGING, HOUSEHOLD PRODUCTS, SPORTGEAR)

- Natural rubber is used in many other applications, including industrial products, such as moulded and extruded products including belting, hose and tube used in machinery and offshore; in consumer products such as footwear, toys, sports and leisure goods and electrical and household items.

Table 5: Natural rubber applications, 2-digit and examples of associated 4-digit NACE sectors, and value-added per sector (Eurostat 2022).

Applications	2-digit NACE sector	Value added of NACE 2 sector (M€) 2019	4-digit CPA
Packaging	C22 - Manufacture of rubber and plastic products	94,767	22.11 Manufacture of rubber tyres and tubes; rereading and rebuilding of rubber tyres
Household appliances	C27 - Manufacture of electrical equipment	97,292	27.51 Manufacture of electric domestic appliances
Machinery and offshore	C28 - Manufacture of machinery and equipment n.e.c.	200,138*	28.13 Manufacture of other pumps and compressors
Automotive	C29 - Manufacture of motor vehicles, trailers and semi-trailers	234,398	29.10 Manufacture of motor vehicles
Other transport equipment	C30 - Manufacture of other transport equipment	49,129*	30.12 Building of pleasure and sporting boats
Sportswear	C31 - Manufacture of furniture C32 - Other manufacturing	64,377	31.02 Manufacture of kitchen furniture & 32.30 Manufacture of sports goods

** Data to 2014 only*

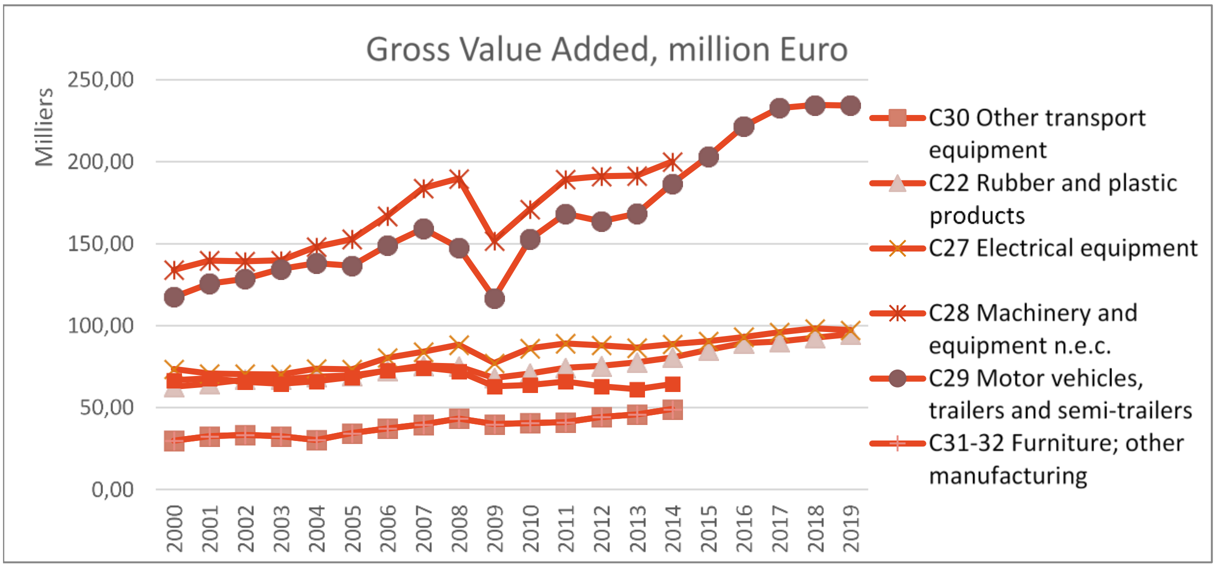

Figure 14: Value added per 2-digit NACE sector over time (Eurostat, 2022).

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SUBSTITUTION

A EU CRM study (EU CRM, 2023) validated the degree to which natural rubber can be substituted in its main applications, data shown in Table 6.

Table 6: Substitution options for manganese by application (with reference to USGS 2022, SCRREEN Experts ; EC Data 2022).

Application	%*	Substitute(s)	SubShare	Cost	Performance
Tyres (automotive)	67%	Butadiene Butyl Styrene-Butadiene Rubber Ethylene-propylene	15% 15% 15% 15%	Similar or lower in all options	Reduced in all options
Tyres (other transport vehicles)	16%	Butadiene Butyl Styrene-Butadiene Rubber Ethylene-propylene	5% 5% 5% 5%	Similar or lower in all options	Reduced in all options
Machinery (tubes, frames, ledges, profiles)	11%	Chloroprene Ethylene-propylene Elastomer Polyurethanes Thermoplastic elastomers Silicones	5% 5% 5% 5% 5%	Similar or lower in all options	Reduced in all options
Household appliances & furniture	4%	All synthetic rubbers Thermoplastic elastomers	40% 40%	Similar or lower in all options	Reduced in all options
Packaging	1%	All synthetic rubbers	40%	Similar or lower	Reduced
Sportsgear	1%	All synthetic rubbers	40%	Similar or lower	Reduced

* EU end use consumption share.

Most of the natural rubber consumed in the world comes from areas where *Hevea brasiliensis* trees can be cultivated - mainly in tropical forests, close to the equator. There is, therefore, a particular EU interest in developing additional natural sources that can grow in other geographical regions and notably in Europe.

Regarding the substitutability of natural rubber, tyre manufacturers depend on natural rubber for its unique load bearing and abrasion-resistant qualities. European car tyres typically contain about 14% natural rubber by weight, truck tyres about 28%. Aircraft and earthmover tyres contain an even higher percentage of natural rubber.

Despite decades of research, no synthetic alternative has been found for the remaining applications of natural rubber in tyres. Faced with expanding demand from developing countries (as motorisation increases) and increasing competition for land suitable for cultivation of rubber trees, tyre manufacturers are working with growers to improve yields and supply chain efficiency. (British Tyre Manufacturers' Association Ltd, 2022)

Research is focused on developing natural rubber from alternative plant sources of latex that can grow in other geographical regions and notably in Europe.

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More specifically, scientists are looking at using Parthenium argentatum (guayule) and Taraxacum koksaghyz (Russian dandelion) as alternative rubber and latex sources. These are the only other species known to produce large amounts of rubber with high molecular weight.

The EU-PEARLS (Production and Exploitation of Alternative Rubber and Latex Sources) project was a European research project that investigated the possibility of using the natural rubber from these two alternatives. The project consortium proved that the natural rubber extracted from these trees could substitute the one extracted from Hevea brasiliensis. However, there are still significant challenges to reach the industrialisation stage of these alternative natural rubber sources, any significant market change will be absent (at least) in the very short term (ETRMA, 2019a). This is particularly due to the absence of production capacity in the EU to convert the plant extract into raw rubber, which today is imported from third countries.

Most recent research in this area has been conducted on the Russian Dandelion by Continental tyres and their Dandelion Bicycle Tyre has won awards and has been in production for two years. Continental's long-term Taraxagum project will be to supply natural rubber from dandelion plants, which can be used to produce two-wheel, passenger car or commercial vehicle tyres as well as other vehicle parts made of natural rubber. Continental has already produced the first test tyres for passenger cars and trucks.

Synthetic rubber has been long used as an alternative or supplement to natural rubber, for example styrene butadiene. However, these synthetic rubbers cannot match price and performance of natural rubber (van Beilen and Poirier 2007) in tyre applications. They do not have an equally high molecular mass which defines the quality of the rubber and do not contain the non-rubber components which are found in the latex produced by rubber plants (Gronover, Wahler, and Prufer 2011). Natural rubber also exhibits greater resistance to tearing at high temperatures and builds up less heat from flexing. For this reason, truck tyres require a higher percentage of natural rubber than those for passenger cars.

The choice of elastomer is at critical for any substitution option. The elastomer presents certain mechanical property such as wear and tear resistance, stiffness, heat resistance and hysteresis. The most important synthetic rubbers are polybutadiene, butyl and halo-butyl, polyisoprene and styrene butadiene.

SUPPLY

SUPPLY FROM PRIMARY MATERIALS

Natural rubber is a biotic material which is harvested from rubber trees (*Hevea brasiliensis)*, mainly growing in tropical forests close to the equator. *Hevea brasiliensis* is a native species of the Amazon region, but has been introduced in several other regions for rubber production. At the moment, south-east Asian countries, mainly Indonesia and Thailand, are the biggest global producers and at the same time biggest suppliers of natural rubber to the EU. The Hevea tree is a tall tree, averaging 60 ft in height, and reaching as high as 120 ft and can live for more than 100 years. The Hevea is indigenous to South America, especially in the Amazon valley. However, it possible to cultivated in many tropical areas around the World such as in Southeast Asia, especially Malaysia and Indonesia. Usually, regions that are 5–10◦ latitude north or south of the equator can

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grow rubber trees. Heavy rainfall over the full year, temperatures holding between 70 and 90◦F, and elevations preferably no higher than a thousand feet above sea level are necessary for commercial growth (Semegen).

RESOURCES AND RESERVES OF NATURAL RUBBER

The overall acreage of national rubber plantations is estimated around 12 million hectares (FAO, 2019). The average yield between 2012 and 2016 was 1196 kg/ha (FAO, 2019). Rubber plantations are facing competition of other crops (palm oil, grains etc.) that together with the geographical constraints limits the flexibility to expand the total acreage of natural rubber plantations.

WORLD AND EU PRODUCTION

Global production has increased rapidly over the past 50 years. This increase has been mostly due to increased production in Thailand and Indonesia. The global production of natural rubber in 2019 was 13600 kt (rubberstudy.org), significantly increased in comparison to the average production between 2012 and 2016 (13140 kt), dominated by Thailand and Indonesia, which account for more than 57% of global production (Figure 1). Other, organizations estimate the global production in 2019 more increased (at 14600 kt according to allindiarubber.net). There is no production of natural rubber in the EU. EU average annual imported amount of natural rubber between 2016 and 2020 was 1.53 million tonnes, while the average annual exported amount at the processing stage at the same period was 360.000 tonnes (Eurostat, 2022).

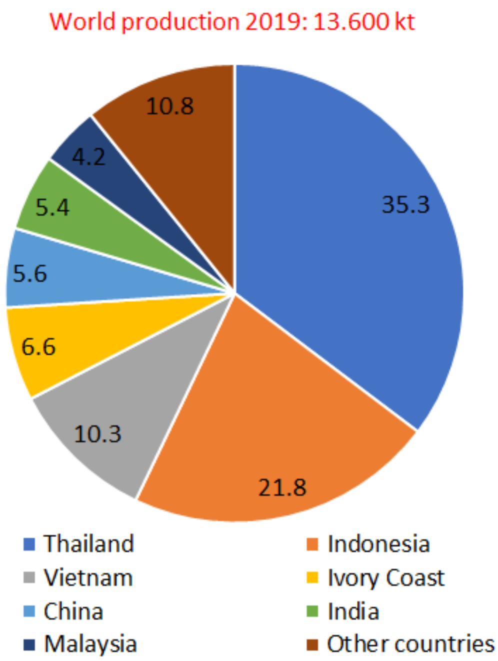

Figure 15: Global production of natural rubber by country in 2019 (www.rubberstudy.org).

The production of general rubber goods (GRG) consists a significant industrial sector in EU. About 20 large tyre manufacture companies are activated in EU plus Turkey with more than 365 thousand employees. Figure 16 shows the major tyre manufacture plants in Europe (ETRMA, 2021).

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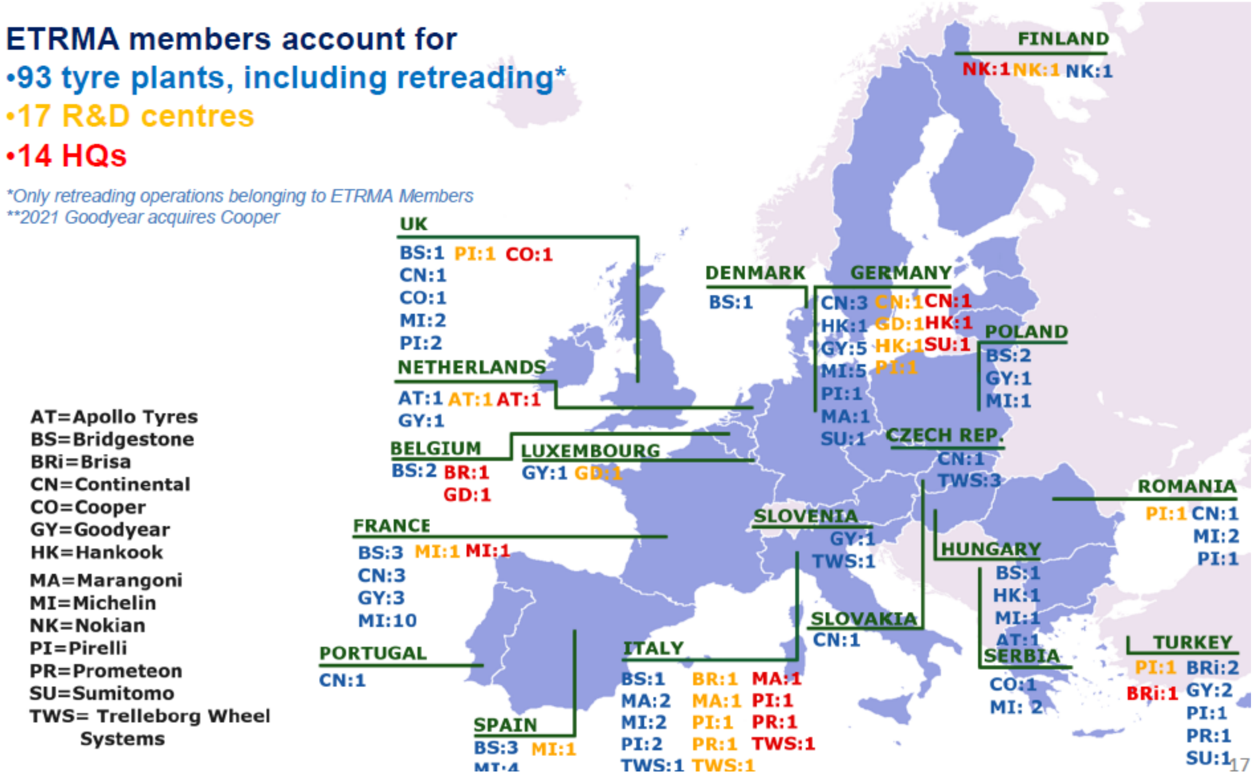

Figure 16: Major tyre manufacture plants in EU (ETRMA, 2021).

SUPPLY FROM SECONDARY MATERIALS/RECYCLING

POST-CONSUMER RECYCLING (OLD SCRAP)

In terms of recycling, biotics are to be dealt differently than the majority of the abiotic materials. For the majority of the cases, the recovered biotic the equivalent to "old scrap" simply can't be re-used in the same application or with the same properties as the original raw material due to contamination issues. Natural rubber is mostly used in a mix with synthetic rubber to obtain the desired hard rubber product performances. With the available technology it is not possible to recycle rubber products and extract natural rubber from these mixtures, therefore recycling is always a mix of natural and synthetic rubbers.

According to recent Eurostat data, the recycling rate of the primary natural rubber in EU does not exceeds 1% (Eurostat, 2022).

Figure 17 shows the EU situation for used tyres. Tyres are the main application of natural rubber in the EU, as demonstrated in the previous section.

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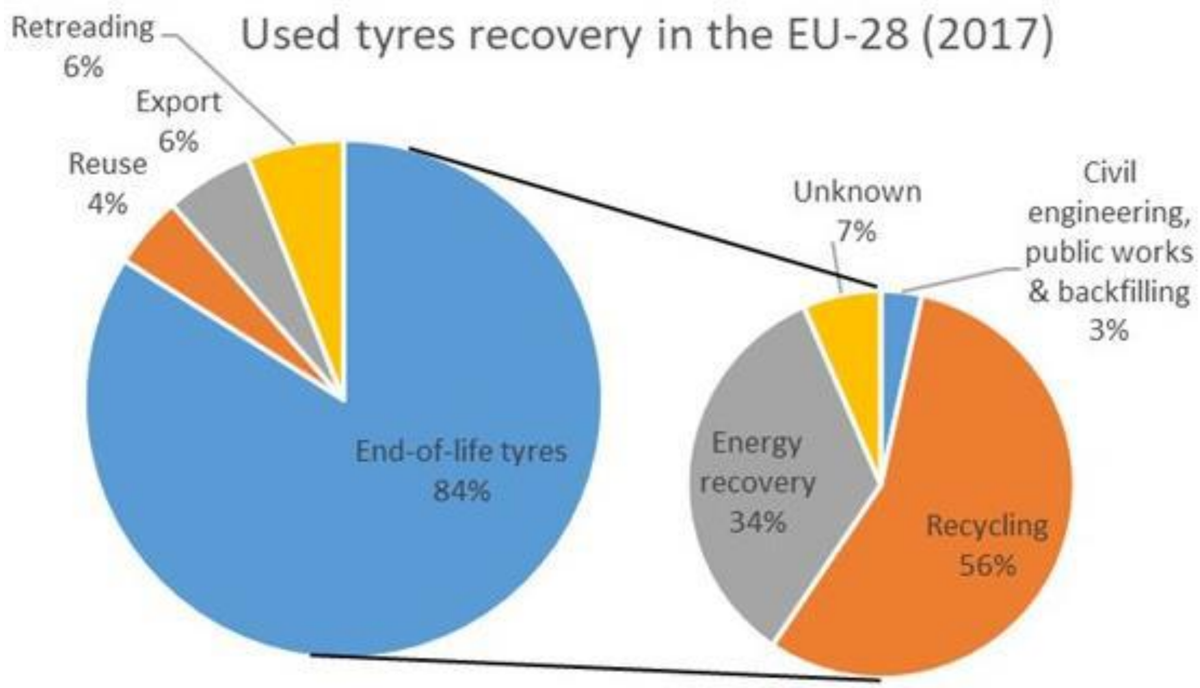

Figure 17: Used tyres recovery in the EU-28 in 2017. (ETRMA, 2017).

Since 2006, all EU member states are obliged to arrange a collection and recycling of end-of-life tyres. Collected data confirm a material recovery (recycling) rate of 56% and an energy recovery rate of 34%. An outstanding 7% is not fully accounted for.

Despite the high recovery rate reached for end-of-life tyres in EU, for the criticality assessment of natural rubber, it is important to highlight that tyre recycling features an open-loop recycling, meaning that end-of-life tyres (ELT)-derived rubber granulates are mainly downcycled in other applications than tyres as current tyre devulcanization technologies are not selective enough to get high quality devulcanization, which is requested to meet stringent technical performances imposed by EU regulation (tyre wet grip, rolling resistance, noise) as well as safety performances. Therefore, the current recycling of ELTs & End of-Life GRG products does not lead to a reduction of the natural rubber supply risk.

With regard to recycling, near 1.5 million tonnes (1,469 kt) of ELTs are annually processed for granulation and are used in a multitude of applications - such as synthetic turf, children playgrounds, sport surfaces, moulded objects, asphalt rubber, acoustic & insulation applications - substituting other raw materials than natural rubber (for example, virgin EPDM in synthetic turf, polyurethane in moulded objects).

For GRG the recycling of natural rubber products mainly occurs in a limited way, mainly due to the heterogeneity of elastomers used and the multitude of SMEs in the GRG sector making economies of scale difficult to get. End-of-life recycling of GRG products is limited either due to contamination issues (e.g. dismantling of End-of-life vehicle seals, tubes etc.) or due to the mere impossibility to recycle/collect the application (condoms, clinical gloves, etc.) (European Commission 2017).

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PROCESSING OF NATURAL RUBBER

Natural rubber is mainly harvested from the rubber tree *Hevea brasiliensis* in the form of latex, which is a white emulsion. While latex can also be sourced from other tree species, its applicability is not as straightforward as that extracted from *Hevea brasiliensis*. Latex is a colloidal dispersion of solid particles of the polymer polyisoprene in water. Polyisoprene $(C_5H_8)_n$ is the chemical substance that comprises rubber, and its content in the emulsion is about 30% (Groover, 2002). The rubber tree is a perennial crop that is harvested throughout the year. Natural rubber is extracted by making a cut in the bark of the rubber tree, commonly designated as tapping. The method of tapping involves paring away a thin slice of bark without damaging the growing layer in a series of half-spiral cuts, usually on alternate days, using a special knife. The latex then oozes from the cut and flows into a collecting cup for a period of several hours or more until it begins to coagulate and the flow ceases (Rubberstudy, 2022). The rubber can start to be harvested when the tree reaches at least 45 cm in circumference, which corresponds to a tree age of about six years. The maximum yield isreached around the fifth to the tenth year of tapping. A rubber tree is productive for 20 to 40 years, where the length of the productive period is largely determined by the tapping intensity. Afterwards replanting is required and the old tree can be harvested to provide wood for furniture.

After its collection, the latex with water amount about 70 wt.%, is taken to a processing plant, where it is submitted to sieving to remove extraneous matter, blended, coagulated, rolled into sheets and then dried in 'smokehouses' to produce 'ribbed smoked sheets' (RSS). Formic or acetic acid are used for the coagulation. Alternatively, after coagulation, it is washed, shredded and granulated under controlled conditions before being dried in deep-bed driers to form a 'block' rubber known as Technically Specified Rubber (TSR). Finally, the rubber is pressed into bales and wrapped into polythene bags for despatch. A small proportion of natural rubber is also processed and sold as latex concentrate; water is removed by centrifuging, creaming or evaporation to give a product containing around 60% rubber. (Rubberstudy, 2022). Dried natural rubber is usually vulcanised, a chemical process that involves heating and the addition of sulphur or other cross-linking additives. This process improves the elasticity and durability of the untreated natural rubber. Vulcanised rubber is then further processed into different rubber products.

Table 7: Grades and types of commercial natural rubber (Semegen, 2001)

Type	Source	Grades
Ribbed smoked sheet	Field latex	1×, 1, 2, 3, 4, 5 (thick and thin)
Pale crepe	Field latex	1×, 1, 2, 3 (thick and thin)
Estate brown crepe	High grade, natural coagulum	1×, 2×, 3× (thick and thin)
Compo crepe	Coagulum, tree scrap	1, 2, 3
Thin brown crepe	Natural coagulum, unsmoked sheets	1, 2, 3, 4
Thick blanket crepe	Natural coagulum, unsmoked sheets	2, 3, 4
Flat bark crepe	Natural coagulum, earth scrap	Standard and hard
Pure smoked	Remilled RSS or cuttings	
Blanket crepe		

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Natural rubber consists a uniform material leaving. It is the subsequent handling and processing introduce variability. Of the 35 official grades, there are really only about eight major types, which are summarized in Table 7.

OTHER CONSIDERATIONS

HEALTH AND SAFETY ISSUES RELATED TO THE NATURAL RUBBER OR SPECIFIC/RELEVANT COMPOUNDS AT ANY STAGE OF THE LIFE CYCLE

Occupational health thresholds are established for rubber fumes, in the EU and outside, ranging between 0.4 and 0.6 mg/m³ of air. The Hazard Statement (H-phrases) of the European GLS classification and labelling system classify natural rubber as substance that may cause allergic skin reactions (H317), and allergy or asthma symptoms or breathing difficulties if inhaled (H334). (GESTIS 2022).

Allergy to natural rubber latex from exposure to proteins derived from Hevea brasiliensis is observed in certain occupational and other high-risk groups, with frequent exposure to NRL products, e.g. health care workers, workers in the latex industry, and atopic individuals. (Sussmann et al. 2002).

ENVIRONMENTAL ISSUES

The rubber plantations in Southeast Asia coincide with four biodiversity hotspots (Sundaland, Indo-Burma, Wallace and the Philippines), supporting large numbers of endemic and highly threatened species. Expansion of Hevea brasiliensis rubber plantations is a resurgent driver of deforestation, carbon emissions, and biodiversity loss in Southeast Asia. Southeast Asian rubber extent is massive, with rapid further expansion predicted. Meeting global rubber demand, while minimizing biodiversity and ecosystem service losses, will be very challenging in the future (Warren-Thomas et al. 2015, 2018).

Natural rubber supply may be highly affected by Pseudocercospora Ulei (South American Leaf Blight, synonym or older form: Microcyclus Ulei), which causes a fungal disease able to destroy young rubber trees. In South and Central America, the disease destroyed the attempts made to increase the production of natural rubber. Its occurrence is still restricted to these areas, but may present a threat to Southeast Asia (ASEAN 2018) and West Africa. The low genetic variety of rubber plantations (the majority of the production comes from Brazilian tree clones, susceptible to the disease) makes them highly sensitive to this disease. If the disease would spread to Asia and West Africa, the impacts on natural rubber production could be devastating (CABI 2015).

Other biological threat that might affect supplies of natural rubber is Neofusicoccum Ribis, which causes leaf fall in natural rubber plantations in Indonesia. (ETRMA, 2019b, ANRPC 2019), and the white root disease caused by Rigidoporus microporus, which is the most serious disease in Asia and Africa.

The ongoing climate change has been affecting natural rubber production. Thailand's rubber production has been hit by droughts and flooding in recent years, with the latter also further spreading disease-causing microbes across growing regions. (BBC 2021)

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NORMATIVE REQUIREMENTS RELATED TO MINING/PRODUCTION, USE AND PROCESSING OF THE NATURAL RUBBER

There are several guidelines related to sustainable production and/or supply chains of natural rubber established by mainly individual companies and industrial sector associations, e.g. (WBCSD 2017). Guidelines on this topic are also available from Civil Society and Aid Organizations, e.g. (Suedwind 2019).

SOCIO-ECONOMIC AND ETHICAL ISSUES

ECONOMIC IMPORTANCE OF THE NATURAL RUBBER FOR EXPORTING COUNTRIES

Table 8 lists the countries for which the economic value of exports of natural rubber represent more than 0.1 % in the total value of their exports.

Table 8: Countries with highest economic shares of natural rubber exports in their total exports

Country	Export value (USD)	Share in total exports (%)
Laos People's Democratic Rep	5086886923	4.22 %
Indonesia	1,6319E+11	1.84 %
Cambodia	1,7716E+10	1.54 %
Thailand	2,3139E+11	1.52 %
Myanmar	1,6929E+10	1.30 %
Guatemala	1,1658E+10	1.25 %
Luxembourg	1,3506E+10	0.58 %
Malawi	780745038	0.47 %
Malaysia	2,3405E+11	0.33 %
Sri Lanka	1,0707E+10	0.30 %
Viet nam	2,8144E+11	0.28 %
Philippines	6,5214E+10	0.15 %

Source: COMTRADE (2022), based on data for 2020

For Laos People's Democratic Republic (4.22 %), Indonesia (1.84 %), Cambodia (1.54 %), Thailand (1.52 %), Myanmar (1.30 %) and Guatemala (1.25 %), the value of natural rubber exports represents more than 1% of the total value of their exports.

Luxembourg (0.58 %), Malawi (0.47 %), Malaysia (0.33 %), Sri Lanka (0.30 %), Viet nam (0.28 %) and Philippines (0.15 %) export natural rubber, whose value still accounts for more than 0.1 % of their total exports.

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For all other exporting countries, this share is below 0.1 %.

SOCIAL AND ETHICAL ASPECTS

Being a biotic material, sustainable sourcing of natural rubber focuses on the risk of biodiversity loss, on promoting good agricultural practices and on mitigating land ownership conflicts. Natural rubber is mainly produced by smallholders in South East Asia. It is estimated that up to 20 million families are fully or partially dependent on rubber cultivation for their basic source of livelihood (ETRMA, 2020). At the same time, rubber plantations can threaten the livelihood of indigenous communities. They can be subject to physical displacement and resettlement as in the case of the Orang Rimba community in the provinces of Jambi, Riau and South Sumatra, in Indonesia (EJ Atlas 2019). Other similar cases are reported as well from other regions (WRF 2019).

As for other materials, initiatives and due diligence approaches (Table 9) are in place and they require ensuring decent working conditions and the respect of human rights along the value chain.

Table 9: Examples of initiatives and organizations related to sustainable natural rubber production

Gobal Platform for Sustainable Natural Rubber (GPSRN 2022)	Multi-stakeholder initiative	Platform to bring together companies, smallholders, academia and civil society for a **sustainable**, **equitable** and **fair** natural rubber supply chain**.**
Tire Industry Project (TIP) (WBSCD Tires 2018)	Industry	Global CEO-led initiative of 11 tire companies to lead research and establish frameworks for deeper understanding of the tire industry's environmental and human health impacts to proactively contribute to a more sustainable future
Sustainability Palm Oil Transparency and Toolkit (SPOTT 2022)	Civil Society/NGO	Free online platform assessing commodity producers, processors and traders on their public disclosure regarding their organisation, policies, and practices related to environmental, social and governance (ESG) issues.

Note: The above listing is not exhaustive but exemplary and does not reflect any evaluation or opinion about the mentioned initiatives and organizations.

RESEARCH AND DEVELOPMENT TRENDS

RESEARCH AND DEVELOPMENT TRENDS FOR LOW-CARBON AND GREEN TECHNOLOGIES

- GreenRubber[4] - Sustainable Production of Natural Rubber Using Yeast (2023 – 2024)

  To become self-sufficient in natural rubber, there is an urgent need to establish environmentally friendly methods for the synthesis of natural rubber. To meet this demand, an interdisciplinary approach will be applied to develop a yeast-based cell factory to produce high-quality natural rubber from cheap and readily renewable materials like sugar.

[4] C.f. https://cordis.europa.eu/project/id/101067117

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- Sustainable Development of Natural Rubber and Their Environmentally Friendly Composites (Boonmahitthisud 2021)

  Natural rubber (NR) is well-known as renewable bio-based polymer that has been widely used in a wide variety of applications ranging from ordinary household to aerospace products. In order to meet the complete concept of green growth and sustainable development, the uses of non-toxic chemicals and green fillers alternating to conventional fillers are necessary to be concerned. In this article, we provide up-to-date information on the sustainable development of NR including NR latex production with low ammonia/non ammonia system and the usage of effective curing activator and bio-based processing oil. Moreover, the issue of the environmentally friendly green NR composites is described here with using renewable biomass organic fillers derived from plants and animals such as cellulose and chitin.

OTHER RESEARCH AND DEVELOPMENT TRENDS

- Air: Aeroponic Inulin and Rubber[5] (2018 – 2020)
  Taraxacum Koksaghyz (TKS) was identified in other projects as the most promising alternative rubber crop. However, this wild plant is small and does not produce sufficient rubber to be economically profitable. Rubber production can be increased by plant breeding and by improving the growing conditions. “AIR” will apply cutting edge technologies of both fields, hosted by KeyGene, a forerunner SME in development of the TKS rubber production chain. Pre-breeding material developed by KeyGene by interspecific crosses between TKS and large common dandelions. Pre-breeding material true-breeding will be made by introgression of apomixis traits. Apomixis is clonal reproduction by seeds and holds great potential for agriculture. Production of rubber dandelions under artificial growth conditions will be optimized, such as hydroponical cultivation, variable light spectra by LEDs, salt and mechanical stress. Plants will be digitally phenotyped and gene expression will be monitored. Based on the experiences from the research phase, a 3D farming growth experiment will be conducted and its economics will be calculated.

- Drive4EU[6]: Dandelion rubber and inulin valorization and exploitation for Europe (2014 - 2018)

  For its natural rubber supply, Europe fully relies on imports. Considering the future market developments and related sustainability issues, European rubber manufacturers are urgently looking for resource diversification. Natural rubber can be produced from rubber dandelion (Taraxacum koksaghyz, TKS) which contains around 40 % of inulin in its root biomass, an excellent resource for furan type chemicals and polymers. The main objective of DRIVE4EU was to turn TKS production into a valid business case by developing concepts for valorising rubber and inulin. The goal has been reached, showing the success of the DRIVE4EU consortium and the opportunity for Rubber dandelion as new sustainable rubber and inulin crop for Europe.

[5] C.f. CORDIS EU research results: https://cordis.europa.eu/project/id/752921
[6] C.f. CORDIS EU research results: https://cordis.europa.eu/project/id/613697

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