Ministry of Environment and Gender Equality
Environmental Protection Agency

Analysis of the treatment of end-of-life tyres regarding environment, market, economy, and system

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Engelsksproget version
Title: Analysis of the treatment of end-of-life tyres regarding environment, mar-ket, economy, and system
Purpose:
The aim of this study is to investigate how these challenges affect the Danish End-of-Life tyre (ELT) system, investigate potential solutions and provide recommendations for the Danish Envi-ronmental Protection Agency on how these challenges can be met. The assessment will include collecting information of the current Danish Tyre system, neighbor check of five countries, identi-fication of the current problems, drivers, and potential solutions for the Danish ELT system and assessment of the potential costs and economic impacts of the identified solutions, to the extent data is available.

Prepared by: Viegand Maagøe
Prepared for: The Danish Environmental Protection Agency
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Editors:
Mette Rames, Viegand Maagøe
Nanna Fredsted, Viegand Maagøe
Astrid Enemark, Viegand Maagøe
Mariana Jordão, Viegand Maagøe
Felice Alfieri, Viegand Maagøe

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Summary

The Danish end-of-life tyre system
The Danish Regulation on a fee and subsidy system for handling of End-of-Life Tyres (ELT) were first put in place in 1994[1] with the goal of getting the tyre producers to take responsibility of the tyres at end of life through paying a fee to place them on the market in Denmark. The regulation is based on the Danish Environmental Protection Regulation[2] and from the start focused on proper disposal of tyres, by giving a subsidy for collecting and sending worn out tyres to recycling. Despite continuous changes to the regulation over the years, it is currently faced with a number of challenges of both technical, legal and economic nature.

The continued objective of the regulation should be to treat ELTs in Denmark on as high a level in the waste hierarchy as possible, meaning a continued focus on high recycling rates. Furthermore, this study broadens the scope and also look into potential support of reuse through re-treading[3].

The study investigated the flows of ELTs, and costs of the current system through interviews and questionnaires with actors in the Danish ELT system, and a baseline outlook for the Danish ELT market until 2035 was made. This showed an increasing trend in tyre sales, both on the replacement market and with new vehicles. An increased share for noise-cancelling tyres (NCT) is also expected, especially driven by the increased sales on Electric passenger cars. In the baseline a continued low market share of re-treaded truck tyres is expected. Regarding end-of-life scenarios, a continues high share of material recycling is expected, and the infill ban from EU[4] is expected to have very limited effect on the Danish tyre recycling, since only 10-15% of rubber granulate is currently used for this purpose[5]. However, the derived effect of surplus ELT rubber granulate from other countries, previously being used for this purpose, has not been taken into account.

The main conclusions from the assessment of the current Danish system and market- and technological development showed that:

- Economically there is a deficit in the system of 38 million DKK in 2023, which arises from increasing gate fees due to increased processing costs driven mainly by energy prices, since both the transport of ELTs and the recycling process are energy intensive. There are only to companies in Denmark that collectors can send the ELTs to, to get the subsidy payout, which poses the risk of inflated gate fees.
- This imbalance is increased by the fact that tyres on new vehicles do not contribute to the system, as they are exempted from fees.
- The re-treading market is declining (from 48% of the truck tyre market in 2000 to 20% in 2023) due to especially price-sensitivity due to cheap tyres imported from outside

[1] https://www.retsinformation.dk/eli/lta/1995/144

[2] https://www.retsinformation.dk/eli/lta/2024/1093

[3] Direct reuse of tyres (without re-treading) may have negative side-effects, even if considered high in the waste hierarchy. This is elaborated in the report.

[4] https://www.estc.info/is-synthetic-turf-being-banned/#:~:text=Under%20the%20European%20Union%20Registration,will%20be%20banned%20from%202031.

[5] According to Genan, no inputs from Imdex.

Europe, and the current system does not incentivise re-treading other than exempting re-treaded tyres (from Danish casings) from the fee.

- New tyre technologies are emerging in the market which cannot be recycled with the current dominant technologies, and new recycling technologies are not ready to be operated on commercial scale yet.

Comparison of end-of-life Tyre systems in Neighbour check

To gather experiences from similar systems in neighbouring countries, interviews were held with representatives of ELT systems from five selected countries: Sweden, Germany, Italy, Portugal, and The Netherlands. Most of these have Extended Producer Responsibility (EPR) schemes (except from Germany) with a fee for new tyres on par with that of the Danish system. The Danish system has many similarities to the EPR systems, except it is centred around waste handling (through the Environmental Protection Regulation).

The different systems regulate the fees with different mechanisms, for example Sweden and Portugal do an internal analysis on a need-basis, while the Netherlands have a third party make a total cost report every second to third years.

All the systems cover tyres for all types of cars, trucks and busses, and farming/construction tyres, except for the Dutch system, which only covers Passenger car tyres. On the other hand, only the Portuguese system covers tyres sold with new cars. For all the countries with an ERP system (Italy, Sweden, Netherlands, Portugal), the end-users can dispose of their tyres free of charge, and they are collected free of charge, since it is the Producer Responsibility Organisation (PRO) that pays the collectors, on behalf of the producers with the eco fees paid for new tyres. In Germany, where there is a free market, the tyres may get collected for free or for a small fee, and in Denmark it has become the norm after the regulation change in 2023, that waste producers pay the collectors a remuneration to cover the costs of the collection.

The collection rates in all five countries as well as Denmark exceeds 100% in 2023 when calculated as tyres sold vs. collected in the same year. However, in Denmark, the collection rate is usually calculated as collection potential (average sales over the past three years) vs. tyres collected in the current year, yielding a collection rate of 95% for 2023. At the same time, Denmark has by far the highest material recycling rate of 96% (calculated as per cent of collected tyres send to recycling, but accounting for the recycling rate at the recyclers). The next highest recycling rats found in the neighbour check was for Netherlands (73%) and Portugal (70%), whereas for the remaining countries it was less than 50%.

The Dutch system Stands out by having very high direct reuse rates, which is mostly achieved through export of used (but still usable) tyres to countries inside EU, UK, Africa, and Latin America (the latter two account for approximately 50%). According to RecyBem they achieve this through high sorting requirements for the collectors.

Proposed solutions

Based on the findings of the study, experiences from the Neighbour check and interviews with Danish actors in the ELT value chain, it is recommended to implement the following options (option numbers are based on FIGURE 1):

1A	Include tyres sold with new cars, so they pay their share of the ELT system, and the overall economy of the system is increased.
2A	Include re-treading as an option for subsidy. This incentivises an end-of-life scenario higher in the waste hierarchy and increases competition for recyclers. There is an

	economic challenge since a truck tyre re-treaded two times, would then pay only one fee, and get subsidy two times for re-treading, and once for recycling. It is necessary to ensure that this can be covered by the system.
2B	To be able to subsidise sending casings to re-treading, an approval process for re-treaders needs to be put in place, similar to that of recyclers in the current system.
3A	It is recommended to incur a higher fee for Noise Cancelling Tyres (NCTs) and Self-Sealing Tyres (SSTs) placed on the market than for normal tyres of the respective group they belong to, because they pose a problem in the current recycling system, and incurs higher costs for the actors who handle them due to the way they are designed. A barrier to this can be that there is no official classification of tyres as NCTs or SSTs, but it depends solely on the appraisals used by the manufacturer. Hence a technical based definition would need to be developed. It also faces other difficulties related to the type of regulation, because the payment of subsidy is bounded to recycling of those types of tyres the fee originally is charged for.
3B	Even though NCTs and SSTs cannot be recycled using the current material recycling processes, it is suggested to pay a small subsidy for collectors, for collecting and correctly sorting these tyres, even though they currently go to incineration. This is to prepare the system for future recycling technologies for these tyres and incentivise their correct handling.
3C	The increased fees for the NCTs and SSTs should be used to cover research into recycling technologies that can handle these tyre types. Optimally, this could be done in collaboration with other actors in the EU, for example the Azur network, or SDAB, who are already funding research in tyre recycling.
4A	In general, the fees in the system should be increased enough to cover the handling fees the collectors charge (approx. 285 DKK/ton). This corresponds to a 3.00 DKK/tyre increase in all the fees if solution 1A is implemented, and 3.7 DKK/tyres if it is not. Even with this increase the general annual indexation should still be maintained.
4B	It is recommended to reinstate the principle of remuneration-free collection of tyres form waste producers, as the opening of charging a handling fee has given rise to a lot of complaints from especially waste producers and end users. To ensure remuneration-free collection, however, the fees need to be increased according to option 4A.
4C	A cost assessment report could be used as a one-off option to determine the adequate increase in fees for option 4A. It is not necessarily the same type of cost assessment as used in the Dutch Producer Responsibility organisation, but at least a more in-depth economic analysis than what has been possible to conduct in this study.

It is not recommended to implement option 2C and 3D.

2C	It is not recommended to set specific sorting requirements to collectors, due to the assumed administrative burden for both the collectors, and the Danish EPA to enforce the requirement. Instead, it is suggested to follow the other options (2A, 2B, 3A, 3B) for incentivising better sorting of ELTs.
3D	As with option 2C, it is not suggested to set a hard requirement to collectors to pick up all tyres, but instead rely on the incentives (Option 3B) to ensure all tyres are collected. Furthermore, the study has shown no apparent problem with dumping of tyres, because they are not collected.

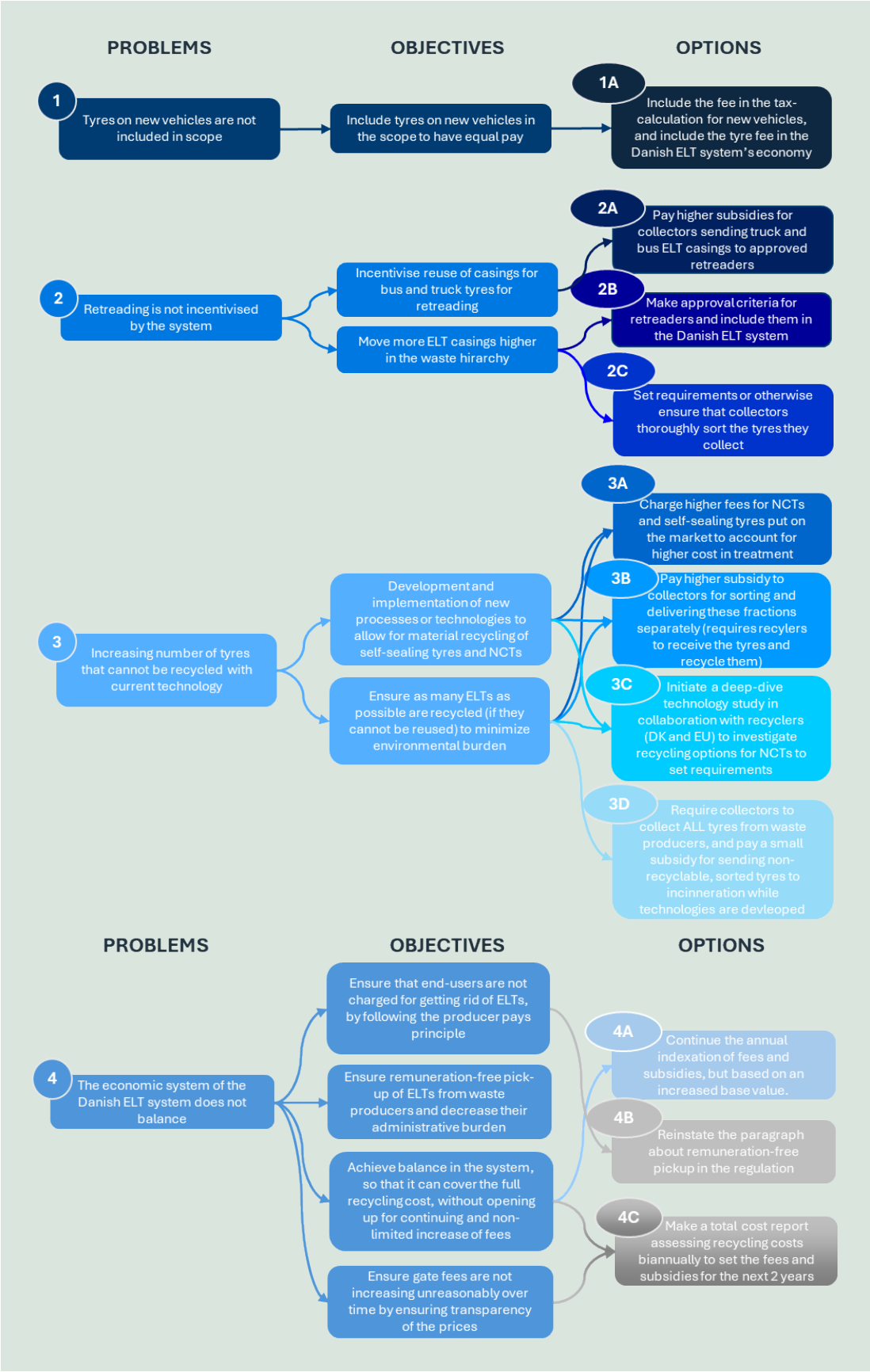

FIGURE 1. For each of the identified problems 1-4, possible solutions were identified (options), which is shown here as a "solution tree". ELT (End-of-Life Tyre), NCT (Noise-Cancelling Tyre).

Appropriateness of Extended Producer Responsibility for tyres in Denmark and legal clarifications

In this study, the mechanisms of the Danish ELT system were analysed, and improvement options suggested purely based on the objective of improving environmental performance at appropriate costs. However, the proposed options are more principles than final regulatory proposals, and some of them requires the Danish ELT regulation to be based on another authorisation than the Environmental Protection Regulation. This also leaves the final choice between a modified version of the current regulation and an actual EPR scheme. While this is a political decision, this study shows no need to implement an EPR scheme:

- The Danish system is already very similar to an EPR scheme, and can be tailored to include all the same principles and mechanisms, even though this would require a legal basis with a broader scope than just waste.
- The EPRs are controlled by Producer Responsibility Organisations (PRO), and all the control is laid out to them, meaning that the environmental ministries are only scarcely involved (usually only to receive annual reports from the PROs), and thus have less control over the EPR schemes compared to the current involvement of the Danish EPA in the current Danish system. The PROs often consist of actors form the tyre production- or ELT value chains.
- There is no direct connection between having and EPR scheme and having higher recycling percentages. Denmark, with its fee/subsidy system, has one of the highest recycling rates (of approximately 96%), whereas Sweden, with an EPR scheme, had as low as 27% recycling before the most recent changes to their scheme[6].
- While it was not possible to gather completely comparable data on administration costs for all the countries, the Danish system seems to be quite lean and low-cost, (total cost around 2.2 million DKK in administration (see TABLE 1), compared to the EPR schemes, also based on the impressions of the interviewed stakeholders and PROs.
- The biggest risk of not implementing an EPR scheme for tyres in Denmark, is if the EU decides to make it mandatory at some point. There is, however, no indication of this happening in the near future, especially with Germany, being a very large player in the EU, wanting to stick with their current free market system.

[6] These percentages are based on the amount of tyres sent to recycling facilities out of the total collected amount, and does not reflect the actual usage of recycled material.

Contents

1. Background

A fee and subsidy scheme on tyres was introduced in Denmark to promote the recycling of tyres, by ensuring their collection and processing through economic incentives. This fee and subsidy scheme is currently regulated by the executive order BEK no 1660 of 13/11/2020[7]. However, the suitability of the current system is compromised due to changes in the market, which poses a challenge for the system as it is now:

1. **Regulatory changes from European Commission:** The European Union's decision to phase out rubber granules as infill material in synthetic pitches over the next 8 years due to the presence of potentially harmful chemicals and microplastic pollution[8] introduces a major disruption to the market, since this is one of the most widely used ways of recycling rubber from End-of-Life Tyres (ELTs)[9,10,11]. Danish tyre recycling companies relies only partially on this market, and less so than other EU countries, and the reduced demand will thus have limited direct effect, but may change the entire rubber granulate market and its prices due to this disappearing demand. The timeline for this transition is set, but identifying and establishing new markets for these materials remains an uncertain and challenging effort. Vulcanised rubber (as in the tread of car Tyres) is by nature difficult to recycle, as rubber cannot be re-melted as for example plastic.

2. **Complexities in processing special tyres:** The industry is facing difficulties in processing the increasing amounts of specialized tyres, such as Noise Cancelling Tyres (NCTs), Self-Sealing Tyres (SSTs), solid rubber rings, and coloured tyres, due to their material composition. The NCTs and SSTs are especially difficult to recycle, as they cannot be treated via the current material recycling technologies. These tyres incur fees under the current executive order[12], but do not receive recycling subsidies due to processing challenges given their unique compositions and properties.

3. **Rising processing costs:** Due to fluctuating market conditions, energy prices, and prevailing economic uncertainty caused by the increasingly complex material composition of tyres and future regulatory changes in the EU, the expenses associated with converting tyres into granules have risen. This increase in

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[7] BEK no 1660 of 13/11/2020 (https://www.retsinformation.dk/eli/lta/2020/1660). In this report the executive order will be referred to as “the Danish tyre regulation” or the “Danish ELT system” and “the scheme”, all referring to this legislation.

[8] https://echa.europa.eu/hot-topics/granules-mulches-on-pitches-playgrounds

[9] Kole et. al., *Tyre granulate on the loose; How much escapes the turf? A systematic literature review*, 2023 (https://www.sciencedirect.com/science/arti-cle/pii/S0048969723048465)

[10] EuRIC, *EuRIC urgently demands the European Commission to halt the export and incineration of Tyres collected in Europe outside its borders*, 2023 (https://euric.org/images/EuRIC_MTR_-_Position_paper_-_EuRIC_urgently_demands_the_EC_to_halt_the_export_and_incineration_of_Tyres_collected_in_Europe_outside_its_borders.pdf)

[11] ECHA, *An evaluation of the possible health risks of recycled rubber granules used as infill in synthetic turf sports fields*, 2017 (https://echa.eu-ropa.eu/documents/10162/17220/annex-xv_report_rubber_granules_en.pdf/dbcb4ee6-1c65-af35-7a18-f6ac1ac29fe4)

[12] As for all tyres, fees apply only to tyres sold as replacement, not tyres sold on new vehicles, which is currently how most of these special tyres enter the market.

processing costs places additional financial strain on actors in the ELT value chain, as cost are passed through the chain, ultimately being paid by the end users, who with the current set-up must pay both a fee for new tyres they purchase as well as a fee for getting rid of their used tyres, which together cover the full recycling costs.

4. **End-of-life tyres for re-treading are not covered**: Re-treaded tyres constitute an important part of the European market for C3 tyres commonly found on trucks and buses. This process allows for the reuse of up to 70% of the original tyre, effectively extending its lifespan and contributing to circular economy goals, such as waste reduction[8,9]. However, the current Danish ELT regulation, does not subsidise tyres sent for re-treading. Additionally, re-treaded tyres in the EU currently lack labelling requirements, which could impact their market competitiveness. While the Delegated Regulation (EU) 2021/2139 outlines specific criteria under the European Taxonomy framework, it does not require public producers to exclusively purchase the highest energy class tyres. Instead, it serves primarily as a classification system to differentiate between sustainable and unsustainable activities. Nonetheless, failure to comply with the "Do No Significant Harm" (DNSH) criteria means public procurers cannot use European funds from the Recovery and Resilience Fund for such purchases[13], further limiting the competitiveness of re-treaded tyres against new ones. This situation is expected to persist only until 2026, marking the end of the Recovery Fund initiative. However, the recast of the Energy Efficiency Directive (EED) introduces another challenge, mandating that public procurers purchase only tyres with the highest fuel efficiency class[14], which applies to all public procurement activities. Since the re-treaded tyres are exempt from the tyre labelling regulation, they have no fuel efficiency class, and cannot adhere to this requirement. The European Commission is, however, working on developing a tyre label for re-treaded C3 (truck) tyres.

Collectively, these factors highlight a period of significant transformation and uncertainty for the Danish tyre recycling and refurbishing sector, which require adaptive strategies and innovative solutions to navigate the evolving landscape.

1.1 Study aim

The aim of this study is to investigate how these challenges affect the Danish End-of-Life tyre (ELT) system, investigate potential solutions and provide recommendations for the Danish Environmental Protection Agency on how these challenges can be met. The assessment will include the following steps:

- Collecting information of the current Danish Tyre system through desk research, surveys, and interviews with stakeholders in the value chain for ELTs in Denmark
- Selecting five neighbouring countries and make a literature study and interviews with representatives of ELT systems in these selected countries
- Identification of the current problems, drivers, and potential solutions for the Danish ELT system, including assessment of the appropriateness of an EPR scheme in the Danish context

[13] Denmark usually does not use these funds, but other EU countries do. However, if any public procurement activities involve transportation, they may also opt to use the EU Taxonomy as criteria for the transport service they purchase, thus including the tyre label.

[14] https://commission.europa.eu/news/new-tyre-labelling-rules-apply-1-may-2021-2021-04-29_en

- Assessment of the potential costs and economic impacts of the identified solutions, to the extent data is available

To investigate the current challenges and potential legal measures to be taken to solve them, the study will analyse the current systems' flow of ELTs and associated economy. Based on these findings a baseline / Business as Usual scenario for development in the tyre market and system economy will be defined. To the extent that it is possible, the proposed solutions will also be followed up with a calculation of the expected change to this baseline. The goal is to investigate how the system can best support the most environmentally beneficial methods for tyre recycling and treatment.

The study is conducted through several approaches, including:

- Desk research and literature search,
- A survey in the form of a questionnaire conducted in relation to the study, targeting collectors and waste producers,
- Interviews with actors in the Danish ELT system
- A neighbour check to gather experiences from other ELT systems in five selected countries with different systems.

These approaches are explained in detail in Appendix 1.

2. Current system in Denmark

Denmark introduced a fee and subsidy system on ELTs in 1995 under the resort of the Ministry of Environment, in which economic incentives are given to ensure worn out tyres are collected and sent to recycling[7]. The purpose of the system is to ensure the proper management of ELT tyres by prioritizing recycling, reducing waste, and minimising environmental impact through sustainable handling and resource recovery. The system is operating by collecting fees paid by tyre producers / importers for tyres sold on the Danish market, to fund subsidies to collect ELTs who bring them to recycling, as well as cover the administrative costs incurred by the Ministry of Environment, the DBMF (Dæk Branchens Miljø Fond / The Tyre Industry Environmental Fund) and the Danish Tax Authority.
This subsidy system charges a fixed fee on all tyres introduced into the Danish market. The Danish Tax Authority collects fees on behalf of the Danish EPA. Funds are transferred on request to a public fund where the Executive order on fees and subsidies for tyre recycling establishes the requirements for allocating the funds to private collectors of ELTs. The organisation DBMF is responsible for paying the subsidies to the collectors and generally monitoring the system in collaboration with the Danish EPA.
The authorisation of the regulation is based on the Danish Environmental Protection Regulation (Bekendtgørelse af lov om miljøbeskyttelse[15]), and the avoidance of dumping of ELT-tyres in nature. The regulation is thus formed as a recycling system and can as such only include tyres defined as waste for recycling in scope. Therefore, the regulation does not cover direct reuse. To ensure that ELTs are handled in accordance with the waste hierarchy (aside from reuse), one of the key principles of the Regulation is that ELTs should be sent to recycling to be eligible for subsidy. To further increase incentive for recycling, the subsidy is adjusted based on the recycling rates of the recycler they are sent to.
A tyre in Denmark is defined end-of-life when it no longer meets the legal requirements for safety and performance. This includes having a tread depth below the minimum threshold of 1.6 mm, or showing signs of severe wear or damage, such as cracks or bulges, which could compromise driving performance and safety. Dumping of tyres is illegal in Denmark under European Directive 1999/31/EC, and ELTs must instead be recycled or used for energy recovery, depending on their condition. Garages, tyre dealers, or recycling centres – referred to as waste producers – are responsible for handing over tyres that can no longer be used in Denmark to collectors.

Collectors handling discarded tyres must be registered with the Danish Environmental Protection Agency through the DBMF. Registration requires providing the company name, address, CVR number, an inventory of discarded tyres dated at the time of application, details on planned recycling or recovery methods, and a list of the regions where collection activities are intended. This applies regardless of whether the company applies for subsidies directly or transfers the collected tyres to another registered tyre collection company. In 2024, 110 collectors were registered in Denmark, with Helstrup Dæk collecting over 50% of the country's ELTs16. Collectors typically do not pay waste producers for discarded tyres; however, with the amendment BEK no. 1264 of 27/10/2023, they are now allowed to charge a handling fee for ELTs, aimed at securing collection and recycling after increased gate fees at recycling facilities.

[15] https://www.retsinformation.dk/eli/lta/2019/1218

[16] Interview with Helstrup Dæk

2.1 Structure of the current system

Several actors participate in the ELT value chain in Denmark. FIGURE 2 outlines the principles of the system and the actors involved. This section will describe the flow of tyres and cash flows between actors in more detail.

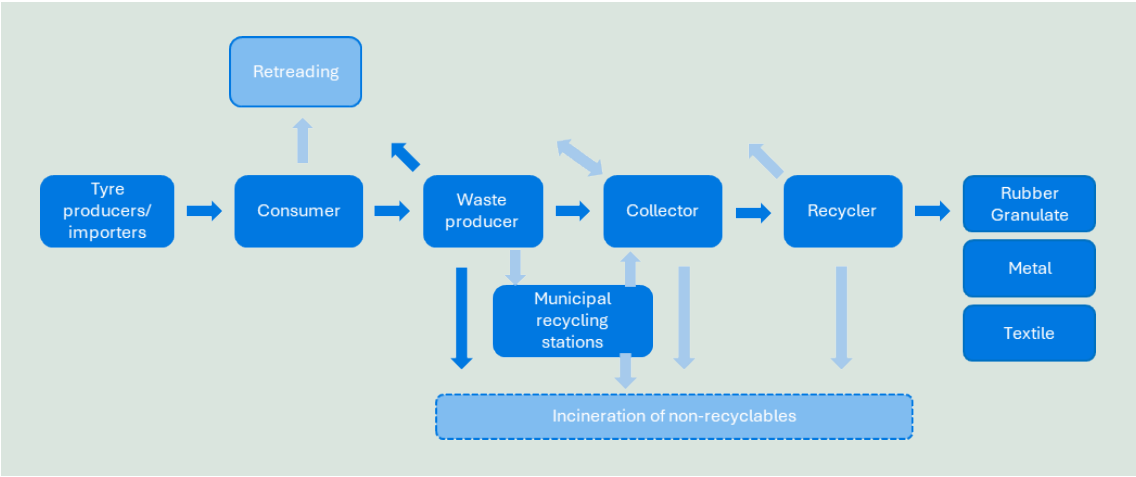

FIGURE 2. Schematic overview of the current Danish end-of-life tyre system, dark blue arrows showing the main flows of tyres and end-of-life tyres (including casings for re-treading) and the light blue arrows showing the minor flows.

The ELT system consists of three main categories of actors: Waste producers, Collectors and Recyclers:

1. **Waste producers:** Waste producers include car workshops, tyre centres, municipal waste collection sites, and car wreckers. The waste producers are the link between the actual users of the tyres (consumers) and the ELT system.

    a. The waste producers get the ELTs from the consumers (end users) when they are worn out and changed to new tyres. They often have individual contracts with collectors about picking up the tyres, or small waste producers may drive them to the municipal recycling stations themselves and pay a waste fee to deliver them there.

    b. The waste producers (car workshops or tyre centres) can also be importers / place the tyres on the market and thus the ones paying the tyre fee.

2. **Collectors:** There are currently over 150 individual companies acting as collectors in the Danish ELT system. The collectors collect the tyres at the waste producers, often they have contracts determining the pick-up interval, fee etc. The subsidy is paid to the collectors. To receive the subsidy, they must be registered with the Danish EPA[87], have documentation for where the tyres were collected, and to which of the approved recyclers they were sent.

3. **Recyclers:** There are only two recycling companies recognised by the Danish EPA that accept ELTs: Genan A/S and Imdex A/S[17]. These companies convert the ELTs into rubber granulate, steel for recycling and textile scraps through a shredding process. No recognised recycling companies are currently using pyrolysis as

[17] https://www.daekbranchens-miljoefond.dk/#vbid-18d69057-aaoxjbjl

converting technology. Collectors can only receive the subsidy if tyres are delivered to one of these approved recyclers.

Tyre collection companies involved in tyre recovery, including recycling, can receive subsidies to fully or partially cover the costs of collecting ELTs. The subsidy amount per kilogram of tyre is specified in the Danish Tyre Executive Order and is only paid to the collector upon presenting an approved financial statement from one of the two authorized processing companies, Genan A/S or Imdex A/S. Approval of the processing company is contingent upon its operational status, processing of ELTs through granulation or pyrolysis, and processing of all received tyres eligible for subsidies. Additionally, the total recycling rate must be at least 50%, and the products from the processing must meet recycling requirements. The company must also have an environmental permit, either recycle the products from the processing themselves, or sell the products for recycling purposes[18].The subsidies are described in more detail in section 2.3.2.

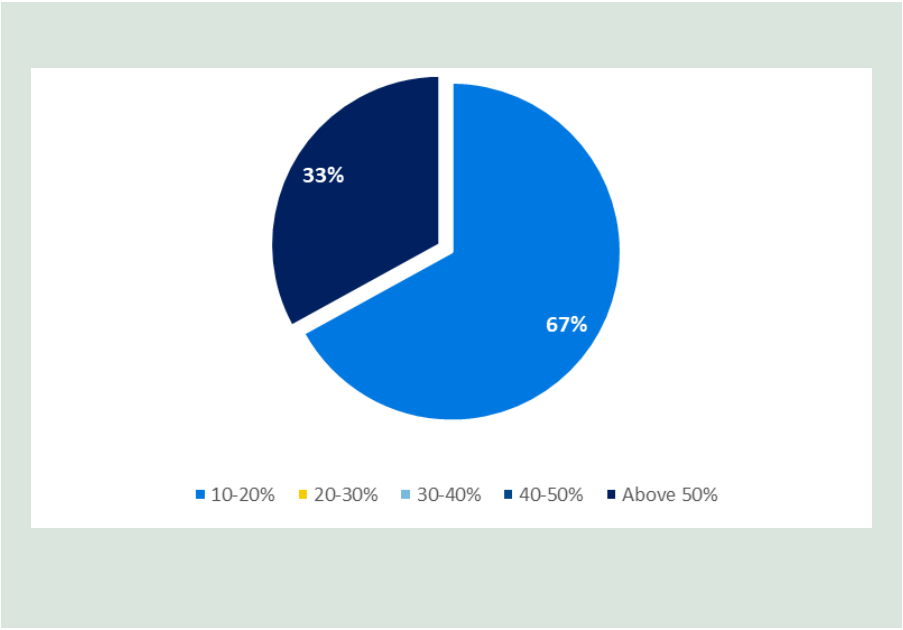

FIGURE 3. Dependency of collecting tyres in business. The percentages indicate the share of the collectors' business that depends on tyre collection.

The collectors are depending on the subsidy, especially the 33% of collectors who rely on tyre collection for more than half of their business, as shown in FIGURE 3. The remaining 67% of collectors report that only 10-20% of their business relies on tyre collection. According to the survey made with collectors for this study, most collectors (around 54%) retrieve tyres from auto repair shops, agricultural businesses, and transport companies, while approximately 15% also collect from other waste producers. The remaining collections are made from sources such as car dismantlers, scrap dealers, and recycling centres.

The collectors transport the ELTs to one of the two approved processing companies, Genan A/S or Imdex A/S.

Genan A/S is the world's largest ELT recycler, operating six plants (five in Europe and one in the USA), including one in Viborg. Genan A/S specializes in breaking down worn tyres from vehicles such as cars, trucks, and industrial machinery into their original components: rubber, steel, and textile. These materials are processed into high-purity rubber granulates and

[18] https://www.daekbranchens-miljoefond.dk/#vbid-18d69057-aaoxjbjl

powders. The process involves multiple stages: cleaning, granulating, separating, sifting and packaging the materials. The output from Genan's activities is 75% rubber granules and powder, 15% steel and 10% textile fibres.

Imdex A/S is another key player in Denmark's ELT recycling sector. They specialize in breaking down tyres into various sizes for reuse in multiple industries. The outputs of Imdex's activities are 67 % rubber granules, 18% steel and 14% textile fibres. Recycled materials can be used in various applications. Rubber granules are used in asphalt and bitumen, new tyres, artificial grass pitches, running tracks, playgrounds, industrial products like shoe soles and conveyor belts. It can also be mixed with other materials, for example rubber powder is used in the automotive coatings industry and for mixing into plastic compounds. Steel is transported to recycling plants, where it is converted into new steel products. Although the textile fibres have good insulation properties, there are still few practical applications for these.

Other actors in the chain are the Municipal recycling stations and the re-treaders:

The municipal recycling stations receive tyres from consumers directly, from smaller car workshops, and in some cases from collectors, when they have collected tyres that are not eligible for recycling. However, the collectors also pick up the tyres for recycling form the municipal recycling stations. It is thus unclear which actor is primarily responsible for sending none-recyclable tyres to incineration. It has not been possible to find any data on this flow of ELTs.

The re-treaders, mostly buy worn out truck tyres directly from end users (truck owners), sort them in casings eligible for re-treading, and have collectors collect those that cannot be re-treaded, and sent to recycling. While re-treading is not part of the current Executive order, as casings for re-treading is currently not considered ELTs, according to the Danish Environmental Protection regulation[19], they are included in this study, which looks beyond the current regulatory scope. The flow of casings for bus and truck tyres for re-treading is not monitored in the ELT system, but by the Danish re-treading association (FFRD[20]).

2.2 Requirements of the Danish Tyre Executive Order

The following section outlines the main provisions of the Danish Tyre Executive Order, including provisions on fees, subsidies, recycling rate requirements, and recent amendments to the order. The Danish Tyre Executive Order establishes the legal framework and economic mechanisms governing how fees are collected from tyre importers and how subsidies are distributed to tyre collectors for recycling purposes.

The Danish tyre system is funded through the Finance Act. In 2024 with an allocation of 61.1 million DKK. Revenue from fees contributes 50.6 million DKK, while the administration of the scheme costs 2.2 million DKK, and subsidies amount to 58.9 million DKK. Additionally, operational funds from the Danish EPA's main account provide approximately 2 million DKK for the administration of the system[21]. Furthermore, the VAT of the subsidy is refunded to the system. TABLE 1 lists the overall system revenue and expenses.

TABLE 1. Costs of the Danish Tyre System (million DKK).

2024	Revenue / expenses (mill. DKK)

[19] https://www.retsinformation.dk/eli/lta/2024/123

[20] Fabrikant Foreningen for Regummierede Dæk: https://ffrd.dk/

[21] [1] 23-miljoeministeriet.pdf

2024	Revenue / expenses (mill. DKK)
Subsidy	50.6
Fee	-58.9
Administration	-2.2
VAT refund	11.0
Total	0.5

Note: the administration costs cover the administration of the scheme within Ministry of Environment, the DBMF (Dæk Branchens Miljø Fond / The Tyre Industry Environmental Fund) and the Danish Tax Authority.

2.2.1 Fee

According to the current provisions in Executive Order BEK no. 1660 of 13/11/2020, "any individual who manufactures or re-treads tyres commercially, or who receives tyres or re-treaded tyres with a section width of at least 5.00 inches or a rim diameter of at least 8 inches, or solid rubber rings, must pay a fee to the Danish Environmental Protection Agency."

Additionally, the Executive Order provides exemptions from fees when placing tyres on the Danish market for the following categories:

- Tyres, including spare tyres, mounted on vehicles imported from abroad.
- Tyres, including spare tyres, used for fitting during the manufacture of new vehicles.
- ELTs imported directly for processing by a Danish EPA approved processing company.
- Re-treaded tyres, where documentation proves that the original ELTs were collected in Denmark.
- Tyres reused by the holder through re-treading, whether performed in Denmark or abroad - re-treading companies in Denmark must maintain a separate record of the number of carcasses imported and exported in Denmark. If there is a net surplus of imported carcasses, a fee must be paid corresponding to the number of re-treaded tyres produced from this surplus

The fees are structured according to specific tyre groups (see TABLE 21 in Appendix 4), as illustrated in
TABLE 2.

TABLE 2. Fee rates per tyre group from the Danish Executive order (2024 prices).

Tyre type	DKK/tyre
Group 1-2	12.53
Group 3-4	29.23
Group 5-6	87.70
Group 7-8	261.00

Note: See TABLE 21 in Appendix 4 for tyre group specifications.

Companies that produce or import tyres and place them on the Danish market are responsible for paying fees and registering with the Danish Business Authority via *virk.dk*. Since there are no domestic tyre manufacturers in Denmark, all companies paying these fees are distributors. These distributors are not always direct importers; major global brands like Apollo Vredestein, Bridgestone, Continental, Goodyear, Michelin, Pirelli, and Yokohama are often represented by

third-party actors. These include tyre centres, auto repair shops, or other dealers and retailers who import and distribute the tyres locally.[22]. Companies are required to issue invoices in at least two copies for every delivery of fee-liable tyres. The invoice must include information of the issue date, names and addresses of the supplier and recipient, product type and description, and the number of fee-liable tyres.

The fees are adjusted annually on January 1 according to the general price and wage index set by the Ministry of Finance. The fee is not a tax; therefore, the funds collected are exclusively earmarked to cover the administrative costs of the system and subsidies. The aim is full cost coverage, with any significant imbalances between revenue and expenses intended to be evened out within a maximum of four years. Additionally, contributions from over- or under-recoveries to the cumulative balance of previous years' imbalances are excluded from this adjustment.[23]

2.2.2 Subsidy

According to the Danish Tyre Executive Order, subsidies are provided to companies participating in tyre recovery schemes for recycling The purpose of the subsidy is to incentivise sustainable solutions for handling tyres. Subsidies are only granted for tyres collected in Denmark and are conditional on the tyre's section width being a minimum of 5.00 inches, a rim diameter of at least 8 inches, or if they are solid rubber rings.

Subsidies are disbursed on a monthly basis. From the system's inception in 1995 until 2017, the subsidy rates were fixed, regardless of the processing company receiving the tyres. In 2017, maximum subsidy rates were introduced, which are adjusted based on the recycling rate achieved by processing companies, calculated through an energy- and mass balance for the process and intended application.

The tyre collector is responsible for documentation, which includes a record of collected tyres in kilograms and details on the origin of the collected tyres, identifying the waste producer and any company that delivered the collected tyres. Additionally, documentation must include a report from a recycling company on the amount of tyres received, measured in kilograms, unless the processing company sends a monthly report of received tyres directly to DBMF. Applications for subsidy must be submitted to DBMF no later than four weeks after the end of the month in question.

The subsidy rate is adjusted according to the recycling rate that each processing company can document, calculated using the following formula:

$$G = N_{GA}/Tyre_{tot}$$

G= Recycling rate in percent

N_{GA} = Mass of tyre material recycled in kg

$Dæk_{tot}$ = Total mass of processed tyres in kg

X % recycling rate = X % subsidy

As of 1 January 2024, the maximum subsidy is 1.66 DKK per kg (including VAT) for tyres with a rim diameter less than 24 inches, corresponding to passenger car and truck tyres, and a maximum of 2.30 DKK per kg (including VAT) for tyres with a rim diameter of 24 inches or more, corresponding to large agricultural tyres. FIGURE 4 below shows the maximum possible subsidy per kg of tyres (i.e. if the recycling rate was 100%), for PV/LV (same subsidy per kg) and OTR, over the past 10 years. As seen in the graph the maximum achievable

[22] Registered on Virk – Danish Business Authority

[23] Budgetvejledning 2021

subsidy per kg fell from 2.1 DKK/kg in 2019 to 1.98 DKK/kg in 2020, due to a change in the executive order (13/11 2020) which was criticized by collectors, because the gate fees were increasing at the same time.

The maximum achievable subsidies are not what is actually paid out to collectors, but this subsidy is scaled according to the recycling rate of the recycler the send it to. In 2024, Genan A/S achieved a recycling rate of 90.6%, and Imdex A/S achieved a recycling rate of 86%.

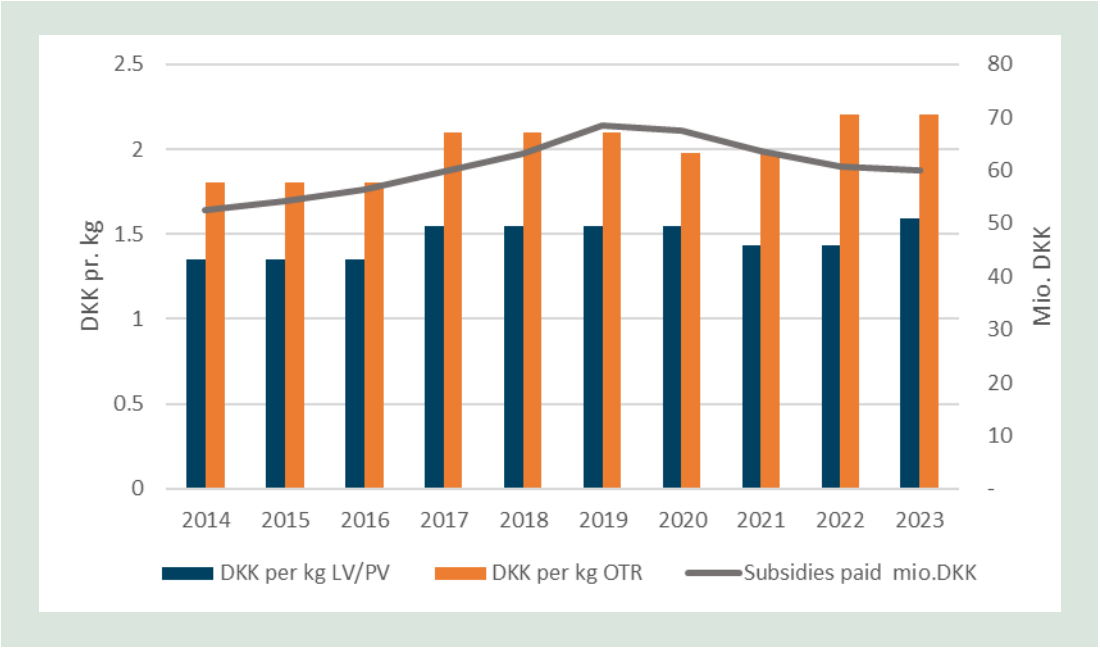

FIGURE 4. Total subsidies paid per year and maximum subsidy rates (DKK/kg) defined in the Executive order. Note: Source: DBMF(Dæk Branchens Miljø Fond / The Tyre Industry Environmental Fund). The amounts include VAT. The changes in the rates are due to changes in the executive order, where the subsidy rate used is dependent on the recycling rate of the recyclers. See TABLE 21 in Appendix 4 for tyre group specifications.

The Danish tyre regulation has been changed over time, with some of the more recent changes described here.

2.2.3 2023: Cancellation of free collection

Originally, the Danish ELT regulation was intended to ensure collection of ELTs free of charge for the waste producers, and the subsidy was intended to cover the costs of collecting the tyres and sending them to recycling. However, while the subsidy received by collectors stayed constant, the tyre recyclers increased the gate fee for collectors to deliver tyres for recycling, due to increased recycling costs. This resulted in tyre collectors losing profit, as the collectors were not permitted to charge waste producers for collection of tyres. The Danish Tyre Executive Order was amended in October 2023 to allow collectors to charge handling fees for tyre collection to ensure an economically viable operation for the collectors.[24]

[24] Executive Order amending the Executive Order on Fees and Subsidies for Tyre Recovery

2.2.4 2017: Exemption of re-treaded tyres from the fees

The 2017 amendment exempted re-treaded tyres from the fee, provided it could be documented that the casings were collected and re-treaded in Denmark. This exemption was implemented to promote the circular economy and encourage domestic re-treading as a sustainable alternative to new tyre production.

However, re-treaded tyres that do not have documentation proving that their casings were collected and retreaded within the country are subject to the same fees as new tyres of equivalent dimensions. This policy ensures that all tyres, whether new or re-treaded without proper documentation, contribute equally to environmental management efforts.

2.2.5 2017: Change in Load Index for group 1 tyres

Before 2017, the fee rates were primarily determined based on the tyre's dimensions and usage. With Executive Order No. 1347 of November 21, 2016, which came into effect on January 1, 2017, the Load Index (LI) was introduced as a central factor in the classification of tyres, specifically for Group 1 tyres. This indexing system indicates how much weight a tyre is designed to carry. The consequence of this change was that tyres which would previously have belonged to Group 3, now belonged to Group 1 instead.

2.3 Main flow of the tyres

This section provides an overview of the flow of tyres in the Danish ELT system and summarise the data found in the study. As shown in FIGURE 5, the main flow of ELTs is collected by approved collectors, who send them to either Genan or Imdex for processing and material recycling, where they are processed into rubber, metal, and textile fractions. In addition to this main flow, there are side streams where ELTs are directed for re-treading, export, or incineration at various stages in the supply chain. FIGURE 5 illustrates all pathways for tyres, including both the main flow and side flows. Data for FIGURE 5 is based on data collected from DBMF, such as the number of tyres collected (45,444 tonnes) and recycled (43,477 tonnes) in 2023. Data for re-treaded tyres is from FFRD (Fabrikantforeningen for Regummierede dæk[25]). The remaining data is based on interviews with stakeholders and assumptions.

Of the tyres not collected, the vast majority is expected to be truck and bus tyres for re-treading, and according to FFRD, this amounts to around 3 million tyres per year (assumed to be 80% of the re-treads that entered the market in 2023, based on sales data from FFRD).

[25] https://ffrd.dk/

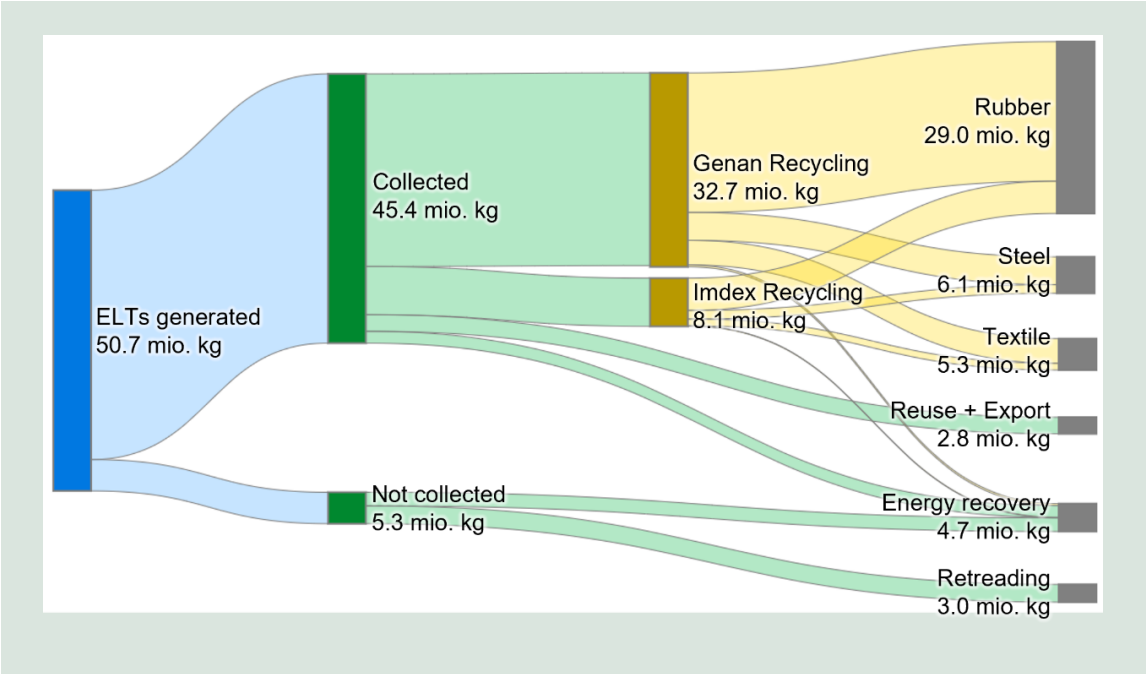

FIGURE 5. Flows of tyres in the end-of-life tyre system, 2023. Various sources, mainly DBMF (Dæk Branchens Miljø Fond / The Tyre Industry Environmental Fund) data. The share of tyres going to Genan vs Imdex for recycling is estimated to be split as 80%/20%. The material output from the recycling process is based on the data in
TABLE **3**. The residues are assumed to be incinerated with energy recovery.

TABLE 3. Outputs from recycling process of Genan and Imdex. Sources: Genan: LCA of waste tyre treatments: Material recycling vs. co-incineration in cement kilns (2020). Imdex: https://imdex.dk/baeredygtighed.

Material	Genan	Imdex
Rubber	72.5%	67%
Steel	14.7%	18%
Textile	12.4%	14%
Residues	0.4%	1%

The share of tyres going to reuse was reported to be up to 15% of collected tyres from specific collectors who apply sorting of their tyres, and down to less than 1% by others.

The remaining amount of collected tyres is assumed to be incinerated with energy recovery, as described by DBMF, as they cannot be either recycled reused nor re-treaded. This is estimated to be around 2-4%, which fits with the fact that around 3% of the tyres collected are non-recyclable technologies (like NCT and SSTs described later) according to stakeholders.

2.3.1 Data on collected tyres

FIGURE 6 illustrates the collected tyres recorded by collectors each year compared to the collection potential over the past 10 years. The collection potential is defined by DBMF as being the annual average tyre sales of fee-liable tyres for the past three years. Since the potential, according to this definition is based only on fee-liable tyres, the collected tyres surpass the potential many years assumed to be due to tyres sold with new cars not being included in the potential calculation. In 2023, 45,444 tons of tyres were collected compared with the potential of 47,843 tons. Other years, the collection exceeded the potential, and over

a 10-year period this surplus amounts to ca 13,000 tons of tyres, which were collected in the system, but not paid for.

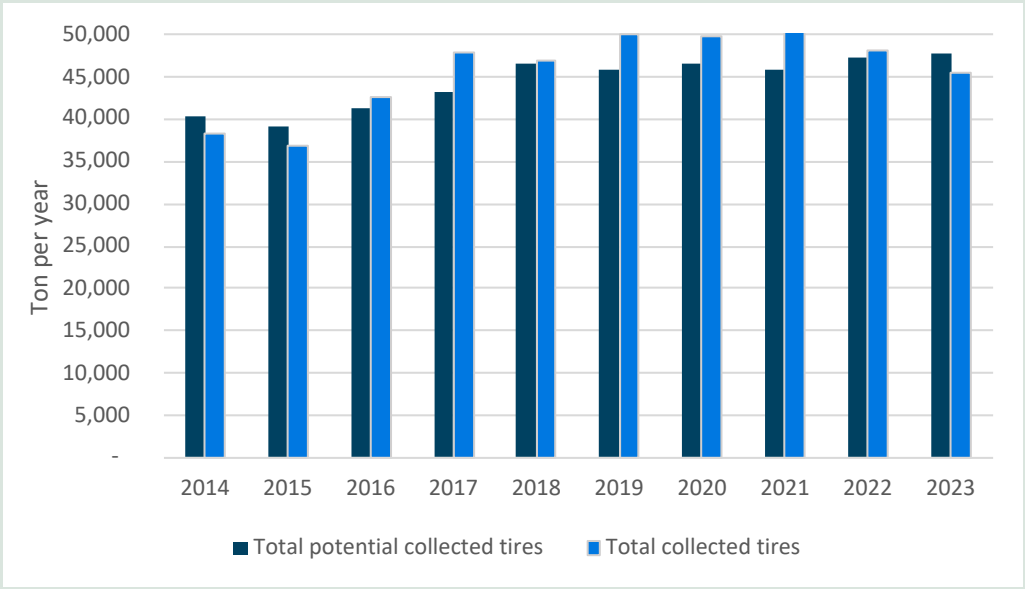

FIGURE 6. Total collected tyres compared to the total potential collection calculated from Fee-liable tyre sales.

As seen in FIGURE 7, where the same numbers are broken down per tyre type, the collection rate is also equally high across all tyre types, indicating that there is an equal incentive for collecting all tyre types, and no immediate issues with the system for one specific type.

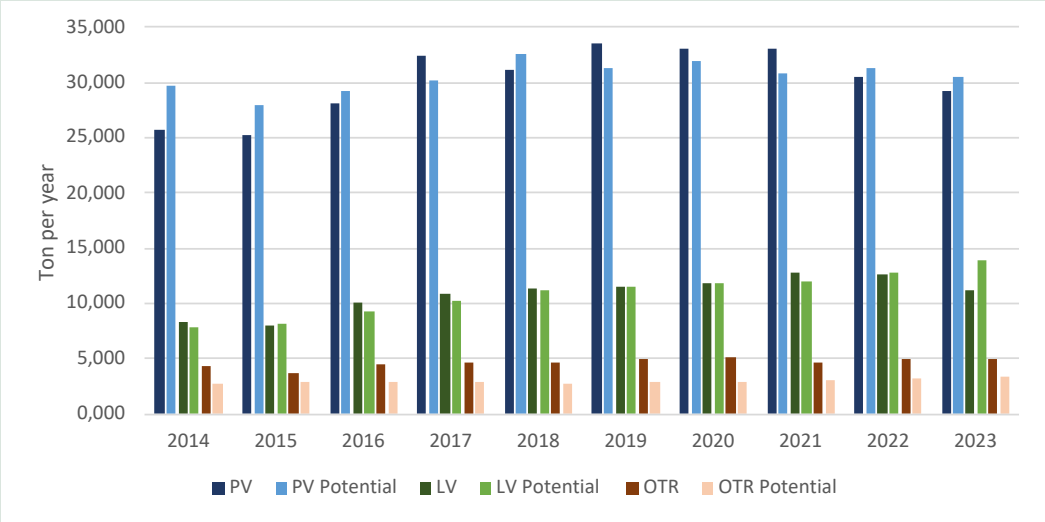

FIGURE 7. Tyres collected: collected volume vs collection potential (tons) categorized per tyre type. See TABLE 21 in Appendix 4 for tyre group specifications.

Of the 45,444 tons tyres collected in 2023, 43,466 were sent to Genan or Imdex, as seen in FIGURE 8, and are thus counted as recycled, and liable for subsidy pay-out.

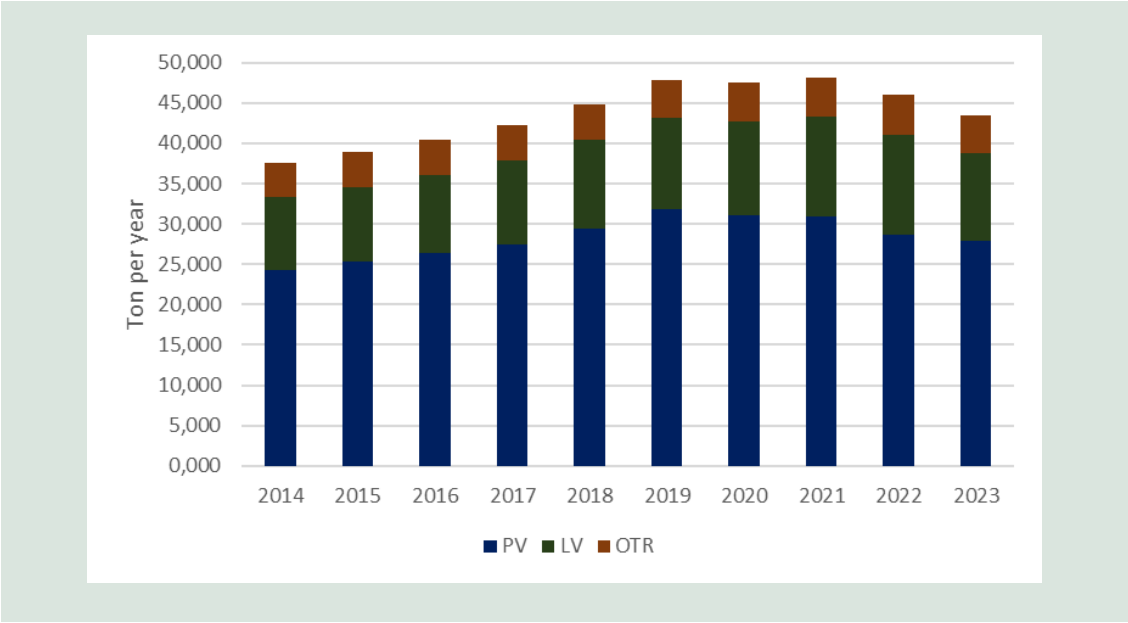

FIGURE 8. Tyres reprocessed: subsidised volume delivered to approved recyclers (tons). See Table 21 in Appendix 4 for tyre group specifications.

Overall, the collection and recycling flows results in the graphs in FIGURE 9. The graphs illustrate the flow of tyres in tons, tracking annual quantities sold, collected, and recycled from 2000 to 2023. Since 2018, approximately 95-96% of collected tyres have been delivered for recycling, demonstrating high efficiency of the system in collecting and recycling worn out tyres. The trends show that the number of tyres collected closely follows sales, though slightly lower, indicating that most fee-liable tyres sold eventually enter the collection system. The total number of tyres placed on the Danish market is, however, higher than reported, as for example private imports of tyres, tyres and spare tyres on new vehicles are exempt from the fee requirement and therefore not accounted for.

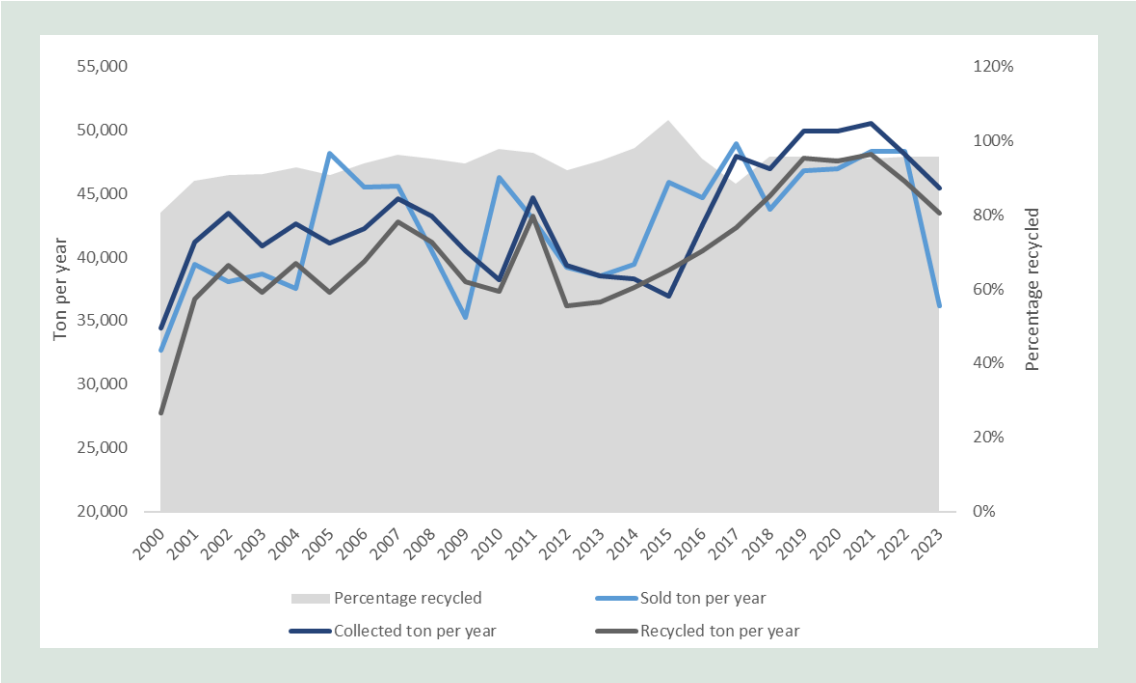

FIGURE 9. Flow of tyres (ton). Source: DBMF (Dæk Branchens Miljø Fond / The Tyre Industry Environmental Fund)'s calculation of the quantified tyres sold, collected and recycled.

Of the tyres registered as collected but not sent to recycling (approximately 2,000 tons), collectors reported in the survey the majority are sent for incineration (42%, ca 840 tons), while a substantial portion goes to municipal recycling centres (33%, ca 660 tons). The remaining 500 tons are assumed to be exported for direct reuse.

Furthermore, the results from the survey made for this study, indicates that there is a number of tyres not registered as collected, which are exported for reuse, since survey responses show that between 5-15%[26] of tyres are exported to countries like Poland, France, Spain, Germany, and various African countries. There is no central collection of this data, but it is estimated to amount to around 2,000 tons in total, primarily tyres for PVs and LVs.

It is also worth noting that the Danish system may have certain weaknesses in terms of export controls, potentially allowing collectors to obtain unjustified subsidies. This could occur if companies illegally export ELTs from Denmark and replace them with equivalent quantities of ELTs, impacting both cash flow and the financial structure for the affected collectors.

It should also be noted that not all tyres delivered to Genan or Imdex ends up being recycled. In an interview, Genan stated that they dispose of approximately 10 tons of sorted waste from collectors' containers each month. They identified that most of this waste originates from municipal recycling centres, where consumers mistakenly place non-ELT rubber in the containers. This waste represents 0.3% of the total monthly received tyres (3,500 tons), suggesting that collectors are effective at delivering clean ELT fractions, likely supported by the fine structure.

[26] Estimated based on answers In the survey, where 36% of respondents indicated they export tyres abroad, with 27% estimating exports at around 5% of their total collected tyres, and some indicating 15% or above.

2.3.2 Data on uncollected tyres

As shown in the Sankey diagram in FIGURE 5, approximately 5,300 tons of tyres are not collected for recycling, approximately 3,000 of which are sent to re-treading. There are multiple stages in the tyre collection chain—among waste producers, collectors, and processors—where tyres do not move toward recycling.

In the questionnaire conducted for this study with waste producers, they estimated that uncollected tyres account for about 5% of the total collected volume, approximately 5,300 tons based on a collection of 45,444 tons. Most uncollected tyres are sent for incineration, delivered to municipal recycling stations, or given to the end user, who will likely drop them off at a municipal recycling station as well. Some waste producers also report that these tyres accumulate in storage or are disposed of, though this represents only a very small portion (2%), indicating that the Danish tyre system helps reduce incentives for illegal disposal of ELTs.

While collectors are not required to pick up all tyres, approximately 73% of the waste producers from the study rarely or never experience that collectors are not willing to pick up all tyres, while 16% often or always experience that they leave some tyres uncollected. This is particularly common for self-sealing (SST) and Noise cancelling (NCT) tyres (33% of answers), truck and agricultural tyres (15% of answers), and tyres with algae (15% of answers). The main reason for this is that these types of tyres cannot currently be processed with existing technology at processing facilities, making it unprofitable for collectors to take them, as they yield no subsidy pay-out.

2.4 Review of Cost Levels of Current System

The following section elaborates on costs and monetary flows in the different stages in the tyre flow, from the collection of fees when tyres are placed on the Danish market to the various identified options once a tyre reaches end-of-life in Denmark. To map this cash flow, a survey was conducted among waste producers and collectors (see Appendix 1), along with interviews with relevant stakeholders.

As summarised in TABLE 4 a total of 75 respondents answered the survey, which was sent to 411 waste producers and industry organizations (Based on the CVR register). Several recipients subsequently indicated that they did not consider themselves as target group for the survey, and 15 emails were inaccessible, resulting in a response rate of approximately 20%. For the collectors, 20 responses were received of 139 sent surveys. As with the waste producers, some recipients found themselves outside of the relevant target group for the survey, and 14 emails were inaccessible, yielding a response rate of about 15%. Response rates of 20% and 15%, respectively, pose a challenge, as the low participation increases the uncertainty of the estimated cost levels in the analysis.

TABLE 4. Survey respondents.

	Survey	
	Waste producers	Collectors
No of respondents the survey was sent to	411	139
Responses received	75	20
Inaccessible	15	14
Final response rate	20%	15%

The collection market is dominated by Helstrup Dæk, who has a significant market share in the collection market of over 50%, as well as a number of smaller actors. The response from

Helstrup Dæk therefore represents a significant part of the actual costs. Nevertheless, the responses should be viewed as a random sample rather than a representative reflection of the entire industry.

2.4.1 Collecting tyres and handling fee

The collection of ELTs involves a variety of pricing agreements between collectors and waste producers. These agreements differ significantly in terms of contract conditions, with some being based on unit price and others on weight. Notably, these contracts operate outside the framework of the subsidy system and are not regulated, leading to diverse approaches and potential discrepancies in cost allocation. FIGURE 10 illustrates the pricing structure for the handling fee that collectors may charge waste producers, showing that most pay a fixed price per ton of tyres to get them collected.

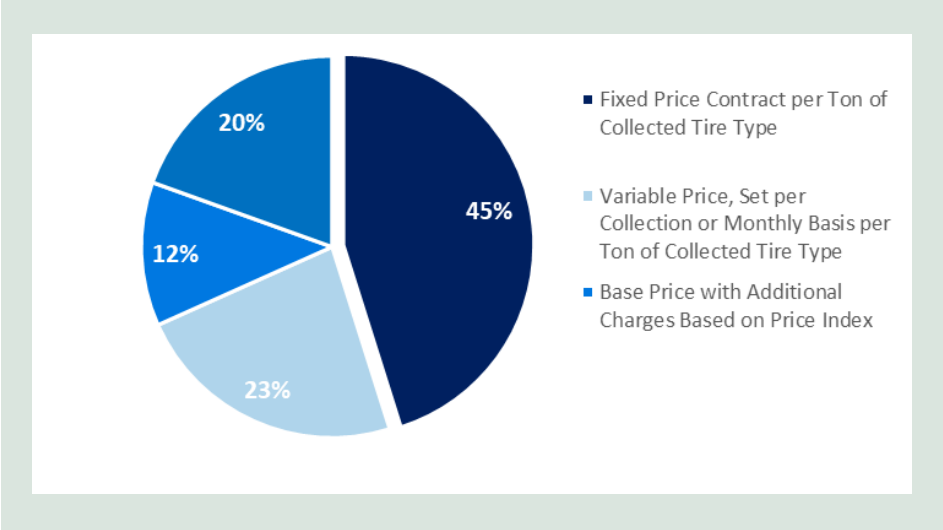

FIGURE 10. Contract condition between waste producers and collectors.

To get an idea of the size of the handling fee, both waste producers and collectors were asked to indicate (with a pre-determined interval) the handling fee per ton of ELTs. The chart in FIGURE 11 illustrates the distribution of collection fees for three tyre categories: Passenger cars (blue), big vans (green), and truck and agriculture (orange). The data is based on responses from the survey with collectors (light-coloured bars) on what they charge, and answers from waste producers (dark-coloured bars) on what they pay.

FIGURE 11. Answers on handling fee between waste producers and collectors per ton tyres. The graph shows the percentage of respondents assigning each interval of costs they pay/receive for per ton of tyres, for each tyre type. For example, 25% of waste producers answer that they pay between 200-300 DKK/ton PV tyres. See TABLE 21 in Appendix 4 for tyre group specifications.

Results from the survey with waste producers:

PVs: The waste producers (dark-coloured charts) state that they on average pay 262 DKK per ton for collection of passenger car tyres. 44 % of the respondents pay between 200-400 DKK per ton, while 10 % are either not charged or receive payment for their tyres.

LVs: The average price for collection of van and truck tyres is 257 DKK per ton, with 42% of respondents paying between 200-400 DKK per ton, and 21% paying over 400 DKK per ton. There is no upper limit on the response option of "> 400 DKK per ton", therefore the average price may be conservatively estimated.

OTR: For large truck tyres and farm/construction tyres, the average price for collection is 315 DKK per ton, with 35% of respondents paying under 600 DKK per ton and 3% paying over 1100 DKK per ton. However, more than 56% of the waste producers did not have this type of tyres.

Results from the survey with collectors:

PVs: The average price reported by collectors (light-coloured chart) for collection of passenger car tyres is 290 DKK per ton, weighted across the survey intervals. There is significant variation in the prices reported, with 35% charging over 400 DKK per ton, while 40% charge less than 300 DKK per ton.

LVs: The average price for van and truck tyres is 277 DKK per ton, with 30% charging over 400 DKK per ton, while around 30% charge between 100-300 DKK per ton.

OTR: The average price for truck and agricultural tyres is 582 DKK per ton, with 16% charging over 1100 DKK per ton and 26% charging under 300 DKK per ton, illustrating significant variation. Additionally, over 42% of respondents reported not collecting truck or agricultural tyres.

The average collection fee variates between the waste producers and the collectors with 30 DKK per ton for passenger car tyres, 20 DKK per ton for van tyres, and 266 DKK per ton for

truck and agricultural tyres. The greatest variation in average fees is found in the truck and agricultural tyre category, which can be due to various reasons, including:

- Small sample size (almost half of the respondents did not have/collect these tyres). Hence the larger uncertainty and discrepancy in answers.
- Size variations in the tyres can result in the very large agricultural tyres being more expensive per ton to collect due to difficult handling.

For all the responses there is also the overall uncertainty that the answers presented here are not weighted according to the size of waste producer / collector and the amount of tyres they handle.

The overall average handling fees are illustrated in the TABLE 5 below, broken down by tyre category and calculated as an average across collectors and waste producers weighted by the distribution of collected tyre types.

TABLE 5. The average handling fee between waste producers and collectors.

		Tyre type			
Type	**Unit**	**PV**	**LV**	**OTR**	**Total**
Price	DKK	276	267	448	**285**
Percentage collected 2023	%	62%	31%	7%	**100%**

Note: The handling fee between waste producers and collectors is not regulated within the subsidy system. The executive order BEK no. 1660 of 13/11/2020 allows for the payment of subsidies to collectors regardless of whether a handling fee is charged to the waste producer. See TABLE 21 in Appendix 4 for tyre group specifications.

2.4.2 Administrative costs for waste producers, collectors, and recyclers

All the actors in the ELT supply chain have administrative costs related to the Danish Tyre System. Based on the survey conducted for the study, this administrative cost was estimated based on average time in hours spent on registration, accounting, and reporting. The average cost is estimated using an average hourly wage of 413 DKK for the sector Mechanical work[27].

Of the waste collectors, 40% indicated that they have obligations within Danish Tyre System, which entails administrative costs for registration with the Danish Business Authority, maintaining financial records, and reporting the number of fee-liable tyres to the Danish Tax Agency.

TABLE 6 outlines the annual administrative costs for fee-liable waste producers related to registration and reporting requirements distributed over the number of hours based on the hourly rate. Respondents who indicated 0 hours are assumed to be waste producers not subject to fee obligations and not registered as tyre importers with the Danish Business Authority (and thus not included in the average).

[27] Statistics Denmark, Wage statistics for the private sector (LONS20). The average wage is used from the sector “723 mechanical work" with an average hourly wage in 2023 of 413 DKK, including overhead costs, which are standard expenses beyond direct labour costs.

TABLE 6. Administrative costs for waste producers.

	Average no. hours	Hourly wage (DKK per hour)	Frequency	Total average cost per year (DKK)
Registration as waste producer	1.3	413.31	One-time registration	551
Accounting and handling of tyres in connection with fee payments	9.8	413.31	Quarterly	4,058
Total average cost annually				**16,232**

Waste producers spend between 0-2 hours on registration with the Danish Business Authority, where the majority 67% spend 0-1 hour, resulting in an average annual cost of 551 DKK. For quarterly accounting and reporting, a large share 64% of the waste producers indicates spending 1-8 hours per quarter, and 36% that they spend more than 20 hours. On average this results in an average annual cost of 16,232 DKK. On top of this the waste producers also reported spending time on invoicing and planning indicating that the administrative cost of 16,232 DKK is a conservative estimate.

TABLE 7 likewise display the average administrative cost of collectors. The collectors spend between 1 and 7 hours registering as a collector with the Danish Environmental Protection Agency, with 67% spending 1-2 hours and 33% spending 5-7 hours. The estimated cost level is monetized using an average hourly wage of 413 DKK[28] resulting in an average cost of 1,239 DK[29].

The administrative costs associated with applying for subsidies are measured based on the average number of hours spent per year. Collectors spend between 0 and 80 hours on this process, where the majority spend between 20-30 hours with the total average cost estimated at approximately 12,730 DKK. Additionally, collectors report that they incur costs related to tyre cleaning, rim removal, and environmental reporting, which form an integral part of their daily operational expenses as tyre collectors, where the cost of 15,912 DKK is a conservative estimate.

TABLE 7. Administrative costs for collectors.

Activity	Average no. hours	Hourly wage (DKK per hour)	Frequency	Total average cost per year (DKK)
Registration at Danish EPA	3.4	413.31	One-time registration	1,240
Application for subsidy	38.5	413.31	Annually	15,912

Recyclers participating in the Danish tyre management system face a range of costs associated with compliance and operational requirements, which are listed in TABLE 8[30].

[28] Statistics Denmark, Wage statistics for the private sector (LONS20). The average wage is used from the sector “723 mechanical work" with an average hourly wage in 2023 of 413 DKK, including overhead costs, which are standard expenses beyond direct labour costs.

[29] Antagelse og procedure foreskrevet i Erhvervsministeriets erhvervsøkonomiske vejledning er benyttet VEJLEDNING OM ERHVERVSØKONOMISKE KONSEKVENSVURDERINGER

[30] Based on information from Genan A/S

TABLE 8. Estimated administrative costs of recyclers related to the Danish end-of-life tyre system. DBMF (Dæk Branchens Miljø Fond / The Tyre Industry Environmental Fund).

Activity	Indicated annual costs (DKK)
Meetings with Danish EPA about the system	90,000
Collaboration with DBMF	60,000
Reporting to the Danish EPA	10,000
Recalculation of recycling rate	25,000
Product tests otherwise not used in the industry	15,000
Accountant declaration	45,000
Filling out forms, consultancy services, Membership of the Danish Recycling Industry Association	115,000
Total	**360,000**

2.4.3 Gate fee

When collectors deliver tyres to processors, they pay a gate fee, which covers part of the recycling costs. The average gate fee is estimated to be 925 DKK per ton. However, it is important to note that the survey data reveal a wide range in responses, with prices varying from 100 DKK per ton to 1350 DKK per ton. This spread suggests that gate fees are not standardized in the market and can variate based on the specific circumstances and bargaining power of individual actors. Furthermore, the average was not weighted based on size of collectors, or how many tyres they pay which fee for.

Overall, the average of 718 DKK per ton should be interpreted with caution, as it encompasses a broad range of factors such as the frequency of collections, the quality of delivered tyres, and total volume playing a key role. Due to this, the question asked was “How much do you pay on average to deliver ELTs for processing per tyre type in DKK per ton,” where it could have been interpreted as an average price of delivering the tyres to both incineration, recycling, reuse etc.

In an interview, Genan explained that they adjust the gate fee quarterly, based on an index reflecting their production's kWh consumption, energy prices, inflation, and other factors. Genan has indicated that the range of 900–1350 DKK is a more realistic reflection of gate fees, despite some collectors reporting lower values. Additionally, more expensive to process due to the lack of material recovery income. As a result, the average gate fee derived from collector responses has been adjusted to 1125 DKK in the more realistic range of 900–1350 DKK. This adjustment assumes that the reported range of 100–250 DKK reflects the cost of delivering tyres for purposes other than full-scale recycling.

For an accurate understanding of Genan’s market prices and processing costs, several contextual factors should be considered. Factors like seasonal fluctuations, product purity, and homogeneity significantly impact the economics of tyre recycling. In this industry, the "landed price", which includes transport costs, is critical, especially given the limited domestic market in Denmark and Scandinavia, making transport cost developments a key factor in the overall cost structure.

The industry also incurs high fixed costs due to substantial investments in facilities that comply with environmental and industrial standards, as well as Environment, Social and Governance (ESG), Life Cycle Assessment (LCA), and Quality, Health, Safety and Environment (QHSE) requirements. Additional costs arise from marketing, innovation, regulatory compliance, and quality control processes. Therefore, while processing costs are

important, they form only part of the overall cost structure, with compliance and market adaptation representing significant challenges.

Further complicating the market, there is an oversupply of ELT rubber granulate internationally, influenced by concerns around polycyclic aromatic hydrocarbon (PAH) content, potential health risks, and the recent “infill ban.” These factors, combined with increased transport costs to reach distant markets, have limited demand for tyre-derived products in Scandinavia. Given these dynamics, addressing the challenges of local market demand, regulatory compliance, and transport logistics will be essential for sustainable tyre recycling in Denmark.

The gate fee serves as a mechanism for recycling companies to adjust their pricing structure in response to prevailing market conditions including international price setting and demand creation. By setting the gate fee, recyclers can offset fluctuations in the costs associated with processing and transporting materials, aligning their revenue with external factors such as energy prices, labour costs, and transport expenses. This adjustment allows the company to remain economically viable by accounting for changes in demand, input costs, and shifts in end-market prices for recycled materials.[31]

2.4.4 Costs of additional end-of-life tyre flow

Waste producers incur costs when handling uncollected tyres. Incineration costs range from 420 DKK to 2,000 DKK per ton, and when waste producers deliver tyres to municipal recycling centres, there is typically a waste fee varying between 300 DKK and 1,225 DKK per ton. One respondent mentioned paying collectors an additional 900 DKK per ton for handling tyres that cannot be recycled.

Using the average distribution of uncollected ELTs and average prices for each category, the estimated average cost for a waste producer to handle uncollected tyres is 440 DKK per ton, as seen in TABLE 9. This average should be interpreted with caution, as the wide range of prices in different categories indicates that costs can vary significantly based on individual agreements, regional differences, and dynamic pricing, creating substantial variation in actual costs for waste producers. Additionally, differences in fees for commercial versus private delivery to recycling centres can skew the average.

TABLE 9. Additional end-of-life tyre flow and costs followed for waste producers and collectors.

	Waste producers		Collectors	
Alternative route	**% answers**	**DKK**	**% answers**	**DKK**
Incineration	29%	420-2,000	42%	0-2,000
Recycling centres	27%	300-1,225	33%	0-2,000
Storage	8%	0-900	>1%	0-2,000
Export			8%	0
Average cost pr. ton DKK		433		925

In the survey, waste producers were asked what it would take for them to avoid sending tyres for incineration. Based on the responses, it can generally be concluded that waste producers prefer a solution where the collection of ELTs is free, as this is highlighted as a key factor in preventing tyres from being sent for incineration. Many emphasize that collectors should be obligated to take all types of tyres, regardless of their recycling potential, to ensure proper and

[31] Based on interview with Genan A/S

environmentally friendly handling. Some respondents note that clear rules and incentives for recycling instead of incineration are necessary, along with increased monitoring of how tyres are managed after collection. Additionally, there is a desire for a "zero-cost" solution, where the fee paid by customers covers both collection and recycling[32]. A few also suggest that problematic tyre types, such as " Self-sealing tyres," should be banned.

Collectors emphasize that tyres are only sent for incineration when recyclers refuse to accept them, such as Self-sealing (SSTs) and Noise cancelling tyres (NCTs) tyres or severely deteriorated ones, and suggest that technical advancements are needed to make these tyre types recyclable. This aligns with the fact that 25% of collectors reported that they often or always pay fines to processors like Genan A/S or Imdex A/S if they deliver tyres that cannot be processed. Costs for delivering tyres to other places than recyclers range from 0 DKK to 2,000 DKK per ton, with a weighted average of 925 DKK per ton. They highlight the need for financial incentives, like subsidies, to support proper handling and recycling. Many collectors already prioritize environmentally friendly routes but stress the importance of clear, consistent agreements to avoid logistical burdens. They also argue that incineration is sometimes the only feasible option for unusable tyres.

This view contrasts with waste producers, who primarily want free collection and argue that collectors should be obligated to take all tyre types, regardless of their recyclability. Waste producers also expect increased control and transparency over tyre handling. The divergence lies in waste producers' focus on broad obligations for collectors and cost-free solutions, while collectors stress the technical and financial limitations of managing certain tyre types.

2.4.5 The economic balance of the current system

The monetary flow within the current system is essential for its functionality. The previous imbalance with increasing gate fees and constant subsidies, pressuring especially collectors, was also the reason for the 2023 change to the executive order, opening for collectors to charge a handling fee to fully cover their costs.

Therefore, the questionnaire made for this study included questions for both collectors and waste producers regarding their costs and income per ton of tyres, as presented in the sections above. To summarise on these gathered data, the balance in cost/revenue for collectors are shown in FIGURE 12. Worst case and best case are seen from the perspective of the Collectors.

The income streams are:

- **Subsidy** payout calculated as average over tyre types for 2024, and the weighted average recycling rate for Genan and Imdex (assuming they recycle a 80/20 share respectively), yielding 1,492 DKK/ton
- **Handling fees** based on survey results ranging from 266 DKK/ton (worst case) to 448 DKK/ton (best case), with an average of 285 DKK/ton

The cost streams are:

- **Gate fee** based on survey and inputs from Genan ranging from 925 DKK/ton (best case) to 1,125 DKK/ton (worst case) with an average of 1,025 DKK/ton.
- **Operational costs** based on the survey 669 DKK/ton, which strictly related to transport and sorting of tyres and documentation for the collection

[32] The current legal basis for the executive order does not allow recycling to be part of the system.

- **Cost of unrecyclable tyres** relates to handling difficult tyre types, such as SSTs and NCTs, which require specialized and costly solutions. This is calculated as 44 kg unrecycled tyres per ton of recycled tyres, with a cost per ton ranging from 13.2 DKK/ton (best case) to 88 DKK/ton (worst case), with an average of 40.7 DKK/ton.

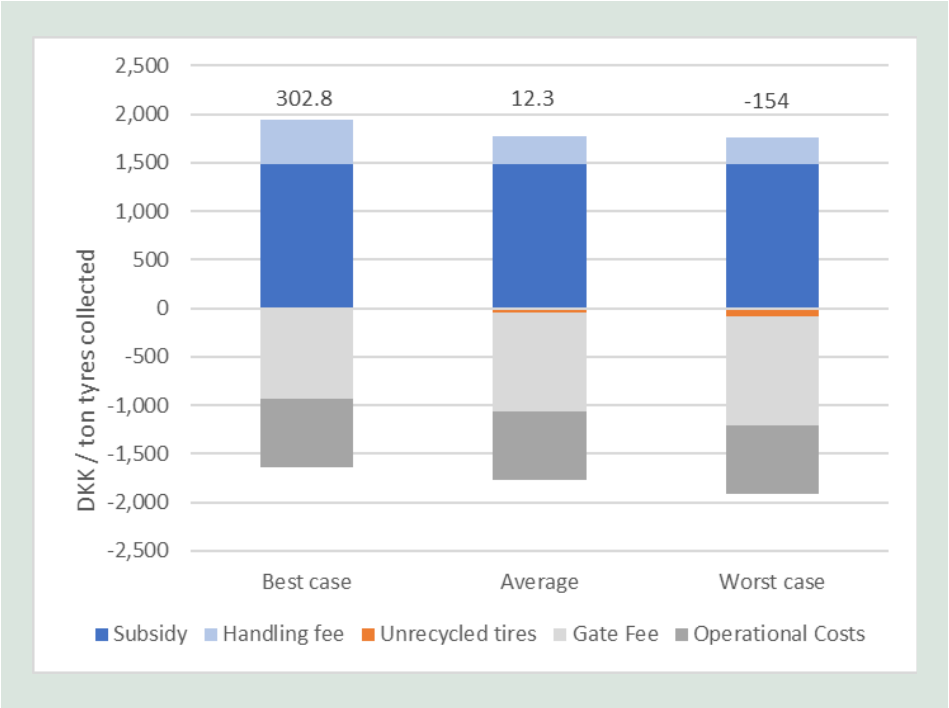

FIGURE 12. Balance between costs and revenues per ton of tyres collected for Collectors. Based on survey results and average subsidy payouts (with 2024 rates).

As seen from FIGURE 12, the economic balance for collectors per ton of tyres they handle, is quite uncertain from the numbers collected in this study. It should also be noted that additional expenses exist for collectors, which are not included here. In the survey they themselves mention the following activities: tyre cleaning, rim removal, and preparing environmental reports. Salaries and general business operations are not included either. Indirect costs, such as compliance with environmental regulations and investments in new technologies, add to the financial pressure but remain unquantified within the current system.

Collectors find themselves in a cross-pressure situation, reporting that they cannot pass the rising costs directly onto waste producers without risking poor collaboration and strained relations. However, without the ability to charge for collection, many collectors fear they would need to close their businesses.

For waste producers, the financial burden of having their ELTs collected is primarily connected to administrative costs related to invoicing, planning, and reporting. Adding to this challenge, they experience a frustration from customers who feel unfairly charged both an environmental fee on new tyres and a separate collection fee when the tyres reach the end of their life. This payment through two fees, which end users see as a double charge, has left the waste producers with an explanation task, they do not feel fully equipped to handle. Furthermore, waste producers often encounter challenges in handling complex tyre types, such as SSTs, which create bottlenecks in the system. These inefficiencies leave waste producers advocating for higher subsidies or a "zero-sum system" where fees fully cover the

cost of tyre collection and recycling, reducing administrative burdens and customer dissatisfaction.

Recyclers, such as Genan and Imdex, face additional challenges in maintaining viable market conditions. With fluctuating demand for recycled tyre products, and market that is generally characterised by a surplus of rubber granulate, they rely on gate fees. Beyond basic processing costs, they incur substantial fixed costs for compliance with environmental and industrial standards and innovation. Additionally, the lack of a local market for recycled materials in Denmark and Scandinavia, combined with high transport costs to distant markets, exacerbates their financial strain. Global overcapacity in ELT granulates and restrictive policies like the "infill ban" further limit market opportunities. They argue, that lowering the fees from the collectors is not a feasible solution, as they are critical for recyclers to cover the seasonal fluctuations in demand and the need to ensure the purity and homogeneity of recycled fractions require substantial energy and resources.

3. Technologies

3.1 Tyre technologies

In this section an overview is given of the main technological developments in the tyres sold in Denmark, focusing primarily on the emerging tyre types, which are foreseen to increase significantly in market share over the next 10 years.

3.1.1 Self-sealing tyres

Self-sealing tyres (SSTs) are specially designed to automatically seal small punctures, usually up to around 5 mm in diameter, in the tread area without losing air pressure[36]. These tyres are designed to help prevent air from leaking out and allows drivers to continue driving to the nearest workshop without the need for immediate repair[62]. Well-known tyre manufacturers like Continental[33], Michelin[34] and Pirelli[35], are at the forefront of the development of SSTs.

SSTs are being marketed as environmentally friendly, despite not being able to be handled at the end-of-life. Although Continental argues that SSTs can be recycled with other types of tyres, they acknowledge that it is more challenging to recycle than conventional tyres[36]. As a result, the company is examining how to remove the sealing layer in the tyre before the material goes through the recycling process[36]. Some argue that this tyre should cost more to put on the market because it is more difficult to recycle.

Genan reports challenges with handling these tyres: they require a sealing compound which complicates its recycling. At Genan, these tyres have triggered fires in the machinery and, as a result, it no longer accepts SSTs[36]. Nevertheless, 2 to 3% of tyres received at Genan's six facilities are SSTs, leading to significant sorting costs. In order to mitigate this issue, Genan in Germany has implemented fines of €25 per SST wrongly delivered and customers must take the tyres back with them[36]. As a result, they receive very few of these tyres.

There are currently no recycling opportunities for SSTs and in Denmark these tyres cannot be sent to energy recovery, making it difficult to deal with these types of tyres at the end-of-life. Additionally, because only a small share of the tyres handled daily are SSTs, it is not feasible for recyclers like Genan to develop a production line to handle these tyres[36].

3.1.2 Noise cancelling tyres

Noise Cancelling tyres (NCTs) are specially designed to reduce road noise inside and outside the vehicle, significantly improving the comfort while driving. These tyres typically made of a polyurethane foam[37], which absorbs vibrations and reduced the sound produced by the tyres' contact with the road. In the tyre manufacturing process, a thick layer of foam insulation is

[33] https://www.continental-tyres.com/products/b2c/car/continental-tyre-technologies/contiseal/

[34] https://www.michelinman.com/auto/why-michelin/technological-innovations/michelin-selfseal-technology

[35] https://www.pirelli.com/tyres/en-us/car/tech-and-knowledge/seal-inside

[36] https://ctwatch.dk/nyheder/milj_teknik/article14297068.ece

[37] https://www.continental-tyres.com/products/b2c/car/continental-tyre-technologies/contisilent/

applied to the inner lining of the tyre[38]. However, some manufacturers are also designing new tread patterns, which also help reduce the noise[39]. While some tyre manufacturers claim that these tyres can reduce noise inside the vehicle by around 20%[39], others claim that it can reduce it by half[40] or by 9 dB[37].

NCTs are gaining popularity and some well-known tyre manufacturers like Michelin[39], Continental[37] and Pirelli[40] are offering different technologies. Genan anticipates an increase in NCT tyres, projecting that within 3-5 years, they may constitute a similar proportion as electric vehicles in the car fleet.

However, managing these types of tyres at their end-of-life presents several challenges. Genan describes the foam contained in NCT tyres as a significant technical challenge because it mixes with the textile and rubber fractions, making it difficult to separate, ultimately degrading the quality of the final product. Additionally, they report that these tyres have a poor incineration value, as gas emissions during combustion with household waste are difficult to control, resulting in lower energy output.

3.1.3 Other tyre technologies

While NCTs and SSTs are currently the most prominent tyre technologies entering the Danish market, other innovative tyre types are gaining momentum globally. These include electric vehicle (EV) tyres, airless tyres, and smart tyres.

Electric vehicle tyres

Electric vehicle tyres are designed to meet the unique demands of EVs, such as heavier weights, immediate torque delivery, less noise during operation and higher lifespan. As a result, EV tyres are designed to address these demands, while optimizing performance, safety and efficiency.

EVs are typically heavier than ICE vehicles meaning EV tyres must be able to withstand the added weight. In addition, EVs provide high instant torque, which can lead to increased wear and tear[41]. To deal with these issues, EV tyres are designed with reinforced sidewalls and robust internal structures, as well as good grip and low rolling resistance[41].

Since EVs do not have an engine and operate more quietly than conventional vehicles, road noise becomes more noticeable. As a result, and as mentioned above, many EVs use noise-cancelling tyres to reduce the noise inside the vehicle.

Due to the increased torque and power, EV tyres have a shorter lifespan than conventional tyres, which typically last 4 to 5 years[68]. Consequently, EVs may require more frequent tyre replacements and, as a result, more tyres throughout their life cycle when compared to an ICE vehicle.

[38] https://www.tyrerack.com/upgrade-garage/what-is-noise-reducing-tyre-technology?srsltid=AfmBOoqVQw50MvtASUmxfSJnGKz32jkK6vIhqrwkSfjJIxflMxmb-MoQ

[39] https://www.michelinman.com/auto/why-michelin/technological-innovations/acoustic-technology

[40] https://www.pirelli.com/tyres/en-ww/car/tech-and-knowledge/pncs

[41] https://www.continental-tyres.com/products/b2c/tyre-knowledge/electric-vehicle-tyres/

In Denmark, tyres that cannot be reprocessed are rejected at weigh-in[42]. Additionally, these tyres are currently incinerated or sent to disposal[42].

Airless tyres

Airless tyres, also known as solid tyres, are inherently puncture-proof, since they do not rely on air pressure. This quality, combined with their durability, often gives them a longer lifespan than conventional tyres. Airless tyres are designed to support the weight of a vehicle, effectively eliminating the need to periodically refill the tyres with air[45]. By eliminating the need for air, these tyres do not require regulation pressure checks and other routine maintenance.

Most airless tyres on the market today are made from solid rubber or plastic and are typically used in vehicles operating in construction and outdoor settings, such as trailers and lawnmowers. However, tyre manufacturers like Bridgestone[43] and Michelin[44] are developing airless tyres for passenger vehicles, which would remove concerns over flat tyres and eliminate the need for a spare. This shift could offer added storage space and reduce vehicle weight, leading to higher efficiency[43]. In addition, the production of these tyres can potentially be conducted by means of 3D-printing[45].

Airless tyres for passenger cars can be made of a combination of rubber, aluminium for the wheel and a flexible load-bearing structure made from glass fibre reinforced plastic[44].

Despite these advantages, the development of this technology is facing several challenges: manufacturers need to prevent debris from getting trapped within the spokes, ensure even weight distribution, and maintain reliable load transmission[44]. Furthermore, the durability of these tyres at high speed is not yet proved to be sufficient[45]. Due to these complexities, many believe this technology may still be a decade or more away from coming into the market.

Smart tyres

Smart tyres are equipped with built-in sensors that not only monitor tyre pressure but also detect abnormal temperatures and minor punctures[46]. In addition, these tyres will be able to predict potential hazards and warn drivers before damage occurs[46]. There is a growing market for these tyres, as it can help reduce wear and tear, fuel consumption and accident risks.

So far, these tyres are beginning to be used in industrial applications, where they can report wear and temperature data and alert operators of problems ahead of potential accidents[47].

These tyres are part of the growing trend toward connected and intelligent vehicle systems, designed to enhance safety, efficiency, and overall driving experience by providing data that can be analysed and acted upon by drivers or vehicle systems.

These tyres are high-end and expensive and are especially popular in electric vehicles (EVs) and luxury cars, where reducing noise is a top priority.

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[42] Email correspondence with Dækbranchens Miljøfond

[43] https://www.bridgestonetyre.com/learn/tyre-technology/airless-concept-tyres/#

[44] https://www.michelin.co.uk/michelin-uptis-prototype

[45] https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1536650&dswid=-3562

[46] https://www.continental.com/en/career/what-we-are-working-on/smart-tyres/

[47] https://www.motortrend.com/features/future-tyre-technology/

3.2 End-of-life technologies

The technologies to handle and treat tyres at end-of-life is constantly evolving. In this section both the well-established technologies and the evolving technologies are described. While the Waste Framework Directive sets the basic concepts for waste management, including a waste hierarchy that prioritizes methods for handling and disposing of waste (illustrated in FIGURE 13), the environmental impacts of these different methods are not very well known for tyres specifically.

Even though the waste hierarchy gives a general guideline for how waste management should first prioritize prevention and then preparing for reuse, recycling, recovery and disposal, recycling and reuse can entail different technologies which have different environmental impacts. The environmental impact depends not only on the technology itself, but also on the market, supply and demand for e.g. recycled materials, their quality, demand for re-treaded tyres etc.

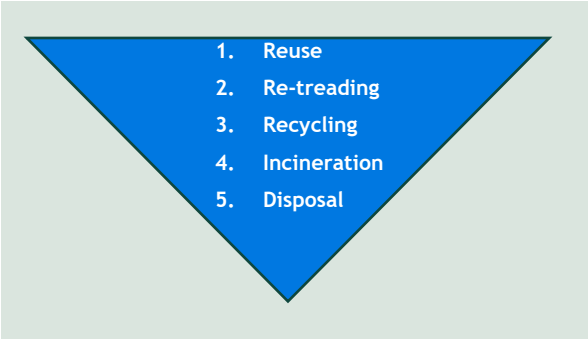

FIGURE 13. Waste hierarchy for tyres, adopted from the general waste hierarchy from the European Commission.

Today, most of the ELTs in Europe are either reused, re-treaded, recycled or incinerated with energy recovery. According to ETRMA, in 2019, 95% of ELTs in Europe were collected and processed for material and energy recovery, 52% of which went to recycling (including re-treading) and 40% to incineration with energy recovery[48]. The remaining 5% are unknown or stocks and 3% are used in civil engineering. The end-of-life technologies currently in use and expected to enter the market in the future are described below according to the waste hierarchy.

The development of recycling technologies over the next 10 years, seems to be characterised by evolving technologies, especially pyrolysis. In Germany around 50% of ELTs used to be incinerated around year 2000, today the share is closer to 25%, and the German Environmental ministry expect it to lower to around 10%. Most stakeholders from countries included in the Neighbour check, expect the direct incineration of ELTs for the cement industry and general waste incineration for urban heating to slowly decrease. Only tyres that cannot be recycled, for example NCTs and SSTs will be incinerated in the future, and in Netherlands, like in Denmark, this is already the case.

On the other hand, pyrolysis which is vaporisation without oxygen is likely to increase, as several facilities are being built all over Europe, with collective capacities above 1 million

[48] https://www.etrma.org/wp-content/uploads/2021/05/20210520_ETRMA_PRESS-RELEASE_ELT-2019.pdf

tonnes per year[49], and ambitions for more. This requires the tyres to be granulated first, and expected material outputs are Carbon Black, steel, oil and gas that will go to energy recovery. The research, however, still has some way to go to produce good or even high-quality materials, for example the Carbon black quality is not yet good enough to be used in new tyres.

Several stakeholders including RecyBem, Svensk Däckåtervinning AB (SDAB), Genan and Germany (Azur network) all believe that the infill ban will not have any major effects on the market for rubber granulate. Even today the share reported to be used in synthetic turfs, is very low (e.g. around 4-5,000 tons in Germany out of around 500,000 tonnes collected ELTs, i.e. around 1%), and most is used for a vast variety of other products. No recycler or EPR operator can point to one specific use of the rubber granulate, but agree that it is the number of different applications (flooring, construction, noise insulation, different consumer products, etc.) that ensures there is a market. A concern is therefore that Registration, Evaluation, Authorisation and Restriction of Chemical substances (REACH) or other regulation on hazardous substances could restrict the use of ELT rubber granulate, which could potentially have an effect. Here recyclers like Genan are reliant on testing the tyres for various substances to ensure safety.

Some countries export tyres to outside Europe (often Morocco or India), for example in Germany, a share that cannot be accounted for in the statistics are assumed to go outside Europe, and in the Netherlands the export to outside Europe is limited to 30% by law.

3.2.1 Reuse – Direct

Direct reuse of ELTs refers to the repurposing of old tyres to the same function, without the need for extensive processing. However, the main challenge with direct reuse is the fact that the tyres must be in a condition which allows for immediate reuse. If tyres have enough tread and structural integrity they can be directly reused.

While some European countries, like the Netherlands[108], have achieve high rates of reuse due to high quality sorting, most nations struggle to reuse tyres domestically, due to strict regulations on tread depth. To qualify for reuse, tyres must be in good condition to meet a minimum tread depth requirement. As a result, many European countries export a portion of their ELTs that are still in good condition to regions such as Africa and Latin America, where tyre regulations are less strict.

However, the benefit of reusing tyres depends on how many kilometres are left in their service life – if very few kilometres are left and the tread cannot hold long distances, they are therefore discarded. This means that the burden on the end-of-life of the tyres is passed on to those who import the tyres. In case these tyres are exported to countries with poor waste management systems, such as those in Africa and Latin America, the environmental impact of reusing the tyres is then larger than if the tyres were directly recycled or incinerated.

When direct reuse in vehicles is not possible, the tyres can be reused for other purposes, such as agriculture, construction, gardening, decoration, playgrounds.

It has not been possible to get data for the reuse rate in Denmark, but according to all information gathered, it is very low, most likely less than 2%.

[49] in Sweden (72.000 tons P/A), Northern Netherlands (180.000 tons P/A), UK (120-200.000 tons P/A), Germany and others (180.000 tons P/A), Estonia (oil slate combination 300.000 tons P/A) and with ambitions of further almost 1 million tons P/A

3.2.2 Preparing for reuse – re-treading

Re-treading is the process of renewing a used tyre by replacing its worn-out tread with a new layer, extending the tyre's lifespan, reducing the need for resources to produce new tyres and minimizing waste.

The re-treading market has faced significant pressure in recent decades, largely due to the influx of cheap tyre imports. Once a viable option, particularly for C1 tyres for passenger cars until the 1990s, re-treading has struggled to compete as the availability of low-cost new tyres has shifted consumer demand away from re-treaded options. Today, re-treading is mostly limited to niche sectors, serving specialized markets such as off-road, rally racing, classic sports cars, and other specialty vehicles where unique performance requirements can justify the choice[50].

Technological barriers have also impacted re-treading, especially within the C1 passenger tyre market, due to the vast range of tyre dimensions required for passenger vehicles today[51]. The need to change moulds for every size makes production costly and time-consuming, limiting the practicality of re-treading. Streamlining re-treading to a smaller range of dimensions (ideally 2-5[51]) could improve efficiency. However, this would require a sufficiently large market demand for each dimension, which is an ongoing challenge given current market trends. Another reason is the user perception of re-treaded tyres as less safe or of poorer quality.

Up until the 1990s, there was a viable market for re-treaded C1 tyres. However, increasing preference for new tyres, along with stringent regulations on re-treading, has caused the market to shift away from C1 tyre re-treading[108], becoming nearly non-existent in countries like Germany[52]. However, other segments continue to find re-treading valuable. Agricultural tyres, for instance, retain a high rate of re-treading, as their casings are expensive to replace, making re-treading an economical and sustainable choice.

Today, re-treading is commonly done on C3 tyres, such as those used in trucks and buses. However, cheaper imports are also putting pressure on this market. Despite these barriers, re-treading remains a valuable process in the tyre lifecycle, extending tyre longevity and reducing waste[117]. As a result, there is potential in this treatment method.

Since 2012, there has been a decline in the amount of re-treaded truck tyres in the Danish market, accompanied by an increase in new truck tyres entering the market. This shift is largely attributed to the rising availability of inexpensive imported tyres and consumer preference for new tyres over re-treaded. In addition, although some cheap imported tyres have good quality, there are usually lower quality ones that cannot be re-treaded[64].

Currently, there are two re-treading facilities in Denmark, which manage collection and processing of used tyres domestically[64]. The FFRD believes there is a substantial potential for increasing the amount of re-treaded tyres in Denmark in the coming years, similar to the levels seen over a decade ago, as there is an established infrastructure for re-treading. However, there are currently too many tyre dimensions to be able to do large-scale re-treading[64].

[50] Interview with RecyBEM on 03.10.2024

[51] Interview with BRV on 04.10.2024

[52] Interview with WDK and Azur on 15.10.2024

Some major new tyre manufacturers are now investing in re-treading, including for C1 tyres, though these work in closed systems64. This trend suggests the industry's growing recognition of re-treading as a valuable process in the ELT management systems.

3.2.3 Recycling – Granulation

Mechanical recycling is one of the most established and widely used methods for recycling ELTs. It involves breaking down tyres through shredding, grinding, and granulation, ultimately transforming ELTs into valuable materials like rubber chips and granulate. The recycling process begins by shredding tyres into smaller pieces, often requiring multiple rounds to achieve the desired size. After shredding, materials such as rubber, steel, and synthetic fibres are separated, the rubber is then granulated into finer particles or powder and screened for uniformity, producing a consistent product suitable for various applications.

Today, the core focus remains on recycling, as rubber holds substantial added value[117].

Granulated rubber finds diverse applications, commonly used in playground surfaces, sports pitches, asphalt, and flooring. Steel recovered from tyres is typically recycled, while synthetic fibres are frequently utilized for energy recovery. Notably, incorporating rubber granulates into concrete production has shown potential to enhance both the technical properties and environmental performance of cement.

Despite the benefits of mechanical recycling, only a small proportion of recycled materials are used in the production of new tyres, apart from the metals. This is largely due to challenges posed by impurities within the rubber, as well as the complex cross-linked structure of vulcanized rubber, which often contains heavy metals. These factors complicate the recycling and reintroduction of rubber materials into new tyre production, thus limiting the circularity within the industry.

Cement companies have historically played a complementary role in the tyre recycling ecosystem by using the steel from tyres in the clinker manufacturing process[117], which recaptures some material value from ELTs. Furthermore, the addition of rubber granulates to the production of concrete slabs has been shown to improve their technical properties and the environmental performance of cement[53]. Nevertheless, the cement industry is facing increasing pressure to reduce its carbon footprint, and as such, the long-term use of rubber in this sector is uncertain, with plans to electrify operations and transition toward bio-based materials in the coming years[55].

Although synthetic turfs remain uncommon in some regions, like Germany, rubber granulate continues to gain traction in flooring and insulation applications. Asphalt applications have also become popular for rubber powder, though its use in cement production has seen a sharp decline – from over 250,000 tonnes annually to around 100,000 tonnes[52]. Within 5 years, it is foreseen that this number could further decrease to only 60,000 tonnes[52], underscoring an evolving market dynamic for recycled tyre materials.

In some countries (e.g. the USA), asphalt mixed with rubber granules is widespread, as it is said to counteract cracking. However, rubber granules in asphalt are not yet widespread in Denmark[62].

The market for rubber granules has been declining[117], leading the exploration of alternative applications. One solution involves using granules in ways that reduce surface exposure, thereby minimizing wear that releases polymers into rivers and oceans and contributes to

[53] https://www.sciencedirect.com/science/article/pii/S0921344923003890

microplastics. Although there are currently no viable alternatives to granules for synthetic turf fields, they remain the only practical option. However, granules can be applied beneath the artificial turf as an underlayer, where they are less exposed and less prone to degradation[117]. Since synthetic fields will continue to be used, finding sustainable applications for granules is essential.

As previously mentioned, the outputs of recycling ELTs at Genan are 75% rubber granules and powder, 15% steel and 10% textile fibres. On the other hand, the outputs at Imdex are 67 % rubber granules, 18% steel and 14% textile fibres.

The ban on rubber infill in artificial pitches in Europe from 2031 has further influenced the market and will continue to do so in the next years. Even though large Danish recyclers such as Genan does not sell large parts of their rubber granulate for this purpose, the general market for rubber granulate is expected to be significantly affected by this ban, due to decreased demand and continued high supply of material, most likely leading to decreased price points for rubber granulate.

3.2.4 Recycling – Cryogenic grinding

Cryogenic grinding, or cryogenic milling, is a well-established method, which produces cleaner pulverized rubber without surface oxidation. During this process, the rubber from ELTs is frozen using liquid nitrogen, and then ground into fine rubber powder, to be used in, e.g., rubber-modified asphalt, new rubber products, and coatings.

Genan uses state-of-the-art technology to perform cryogenic milling at their facility in Viborg, where material from the granulation process is used as feedstock and produces homogeneous output of micronised rubber powder. Genan's cryogenic mill line has a total capacity of 22,500 tonnes per year[54].

3.2.5 Recycling – Devulcanization

Devulcanization is a process that breaks the sulphur bonds in vulcanized rubber, returning the material to a flexible, reusable state. This allows the rubber to potentially be re-vulcanized, enabling its incorporation into new rubber products, including the possibility of new tyres.

The devulcanization process is more feasible for certain types of tyres, such as truck tyres, which generally have simpler compound compositions[55]. In contrast, passenger car tyres are more challenging to devulcanize due to their complex mix of up to 200 different trace compounds and additives[55]. While devulcanization can cut the sulphur bonds and make the rubber more pliable, it cannot fully revert the material to its original ingredients, meaning the rubber's full composition remains changed.

Despite these challenges, devulcanized rubber holds significant promise for recycling in new rubber products. Once devulcanized, the rubber can be reprocessed, re-vulcanized, and used in a range of applications, thereby extending the life cycle of the material. This process supports sustainability goals within the rubber and tyre industry by offering a means to reincorporate used rubber into production, reducing dependency on virgin materials.

However, devulcanization is currently neither financially nor practically viable. The rubber powder from tyres is not devulcanized, and alternative processes like pyrolysis, which involves

[54] https://www.genan.eu/about/technology/

[55] Interview with SDAB on 07.10.2024

combustion in the absence of oxygen, have yet to prove economically viable, especially since they need to yield high-quality products to have market value.

3.2.6 Recycling – Reverse Polymerization

Currently, the majority of ELTs are downcycled into rubber granulates, yet recent efforts aim to improve tyre circularity by enhancing the quality of recycled carbon black. This goal includes increasing the recycled carbon black content in new tyres from the current 10% to a target of 40%[56]. Carbon black, which makes up about 25% of a car tyre's material, is essential for wear resistance and durability and has applications beyond tyres, being used in batteries, cables, textiles, and coatings.

Reverse Polymerization (RP) is an innovative process that breaks down the chemical bonds in ELTs using heat and microwave energy. This method produces similar outputs to pyrolysis – oil, metal, and carbon black – but with a critical advantage: tests indicate that RP yields a higher quality recycled carbon black compared to traditional pyrolysis[56]. Nonetheless, this quality is not yet fully sufficient to meet all manufacturers' requirements.

In Denmark, WindSpace Group ApS is taking steps to advance RP technology[56] by establishing a dedicated facility to process ELTs and produce high-quality recycled carbon black, which could be pivotal for the tyre industry's shift toward circularity. The primary application of this higher-grade recycled carbon black is in new tyre production, potentially reducing dependency on virgin materials and supporting sustainability goals within the rubber industry.

3.2.7 Recycling/Energy recovery – Pyrolysis

One emerging and innovative technology is the thermochemical processing of ELTs through pyrolysis. During pyrolysis, ELTs are heated in an oxygen-free environment, causing them to decompose into three primary materials: pyrolysis oil, pyrolysis gas, and pyrolysis char[57].

Carbon black stands out as one of the most valuable outputs from pyrolysis. If pyrolysis technology can consistently produce carbon black that meets the quality standards required for new tyre manufacturing, it would create a closed-loop recycling opportunity for the tyre industry[117]. Some recyclers are also exploring the production of ultra-fine rubber granules, which can be used by certain manufacturers in lower-grade tyres, though these granules are non-devulcanized and can only be used in small percentages.

The pyrolysis market in Europe is currently growing, with initiatives emerging in several countries. Although there have been attempts to recycle tyres by pyrolysis in Denmark, they have not been successful[62].

Major players include Pyrum, which processes around 5,000 tonnes annually[52], and Poland's ReOil, which, though smaller, is expanding its processing capacity. As demand for sustainable tyre disposal methods increases, the number of pyrolysis initiatives across Europe has grown to 68[55], most of which focus on tyres specifically. Although many of these projects are still at the laboratory scale and funded by the EU's Horizon Programme, they hold promise for future commercial operations.

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[56] https://www.dti.dk/services/new-partnership-to-improve-recycling-of-end-of-life-car-tyres/44992

[57] https://www.sciencedirect.com/science/article/pii/S0921344923003890?ref=pdf_download&fr=RR-2&rr=8dd3ee2d2b4992fe

Countries like Sweden[55] lead Europe in pyrolysis initiatives, with the capacity to secure feedstock supplies for up to ten years. However, new tyre compositions present challenges for pyrolysis facilities. Modern tyres contain higher silica content in both tread and body, resulting in ash and sludge by-products that complicate processing. Additionally, the shift toward bio-based materials, such as rubber sourced from birch trees or dandelions, limits compatibility with current pyrolysis technology, as these materials may not break down effectively in pyrolysis conditions.

Despite its promise, the pyrolysis industry faces significant hurdles. The inconsistency in the quality of carbon black output poses a challenge, as it limits the material's suitability for high-value applications like tyre manufacturing. Furthermore, a lack of consistent regulation across Europe restricts both the growth of the industry and the development of stable markets for pyrolysis products[68]. Financial challenges are also common, with many pyrolysis companies in both Europe and the Unites States struggling to maintain funding, resulting in numerous closures before reaching full commercial scale.

The demand for pyrolysis as a solution for ELTs is expected to rise, especially as more tyres reach end-of-life stages and sustainable disposal methods become essential. However, achieving full-scale commercialization will depend on overcoming technical, regulatory, and financial barriers. The successful adaptation of pyrolysis technology to evolving tyre materials and securing stable funding will be crucial to supporting the industry's growth and ensuring a sustainable future for ELT recycling in Europe and beyond.

3.2.8 Energy recovery – Incineration

Energy recovery through incineration is the process that involves burning waste materials to generate energy, which can be used to produce electricity, heat buildings or power industrial processes. This waste management process provides an alternative to landfilling waste, while also supplying usable energy. Energy recovery generally includes energy recovered in cement plants and in dedicated incineration plants.

According to The European Tyre and Rubber Manufacturer's Association (ETRMA), 40% of the ELTs collected and processed in 2019 went to incineration with energy recovery. This indicates that a substantial share of ELTs continues to go to this waste processing method.

The amount of energy recovered during the incineration of ELTs is only a fraction of the energy required to produce a new tyre[58]. According to a study, the amount of energy recovered during incineration of ELTs is only a fraction of the energy required to produce a new tyre: the incineration of one tonne of ELTs produces 32 GJ of energy and has CO2 emissions of 2,270 kg CO2-eq, whereas the energy required to produce one tonne of new tyres is 209 GJ[58].

In Denmark, the current system heavily incentivises recycling, as collectors can only receive the subsidy when ELTs are delivered to the approved recyclers. As a result, virtually no ELTs are sent to incineration with energy recovery and are therefore sent to recycling.

However, with the introducing of new tyre technologies like NCTs and SSTs in the Danish market in recent years, it may become necessary to divert some of these tyres to energy recovery. Currently, recycling technologies are not available for these specialized tyres, and they cannot be sent to landfill due to the European regulations. As a result, until new

[58] https://www.sciencedirect.com/science/article/pii/S0921344923003890?ref=pdf_download&fr=RR-2&rr=8ddb26dffd8a9986

processing technologies are developed, energy recovery may remain the most viable solution for managing these tyres at their end-of-life stage.

4. Market forecast

In 2023, the tyre market size reached 437 million new tyres sold in Europe[59,60] and 2.47 billion globally[61]. By 2032, these figures are expected to grow to 552 million tyres[59,60] in Europe and 3,012 million tyres globally[61]. Both markets are expected to exhibit a growth rate (CAGR) of 2.6% from 2023 to 2032[59].

Leading tyre manufacturers are investing heavily in R&D for electric vehicles specific tyre technology, which is expected to become a larger share of the overall market. For example, the markets for SSTs and NCTs have been growing and according to stakeholders, in 5 or 6 years, these tyres will be a substantial part of the market[62,55]. On the other hand, airless tyres are coming into the market within a few years, which will demand new ways for material recycling[55].

4.1 Data and forecast for Danish tyre market

The current regulation covers only replacement tyres, and thus the available data from DBMF and other sources are all focused on replacement tyres. In the following, data is therefore first presented for replacement tyres, and after data for vehicles sales, and thus new tyre sales, is presented.

4.1.1 Replacement tyres

The replacement tyre market for Denmark is tracked by DBMF[63], with the help of Skattestyrelsen (Tax authorities), based on paid fees. This is assumed to encompass 100% of all new replacement tyres sold, and the share not paying the fee (i.e. sold through on-line shops from outside Denmark directly to private consumers), is assumed to be negligible.

Since 2019 the Danish tyre replacement market saw an overall decrease in sales of group 1 and 3 tyres (new tyres for PVs and LVs), and a slight increase in sales of group 5 and 7 tyres (trucks and heavy-duty tyres), as seen in FIGURE 15. Overall, the market fell from 3.53 million tyres sold in 2016 to 3.31 million in 2022 and took a further decline in 2023 to 2.99 million tyres sold in total (based on numbers of tyres).

This decline, however, seems to right itself in 2024, where data is available for Q1-Q3, and Q4 sales were forecasted based on previous years' sales share in Q4. In 2024 the total sales were 4.1 million tyres, averaging the two years to around 3.5 million tyres sold per year, being closer to the 5-year average for the 5 previous years. Since 2023 and 2024 both seem to be outliers, and DBMF indicated that there might be an error in how the data was reported from the Tax Authorities, the sales in 2025 were estimated based on the average sales between

[59] https://www.researchandmarkets.com/report/europe-automotive-tyres-market?srsltid=AfmBOopnQYVFfx5EdHCfaapIVgE7cGIxFuTxSZQVYvipjdeqIeChPOFI

[60] https://www.imarcgroup.com/europe-tyre-market

[61] https://www.smithers.com/resources/2023/november/infographic-overview-of-the-global-tires-market#:~:text=The%20global%20tire%20market%20will,over%20the%20next%20five%20years

[62] Interview with DækBranchens MiljøFond on 16.09.2024

[63] https://www.daekbranchens-miljoefond.dk/statistik

2020-2024. Furthermore, the numbers from 2023 and 2024 were averaged between the two years to account for this error.

4.1.2 Re-treaded tyres

In Denmark, re-treaded truck and bus tyres (Group 4 and 6) accounted for 21% of the C3 tyre market in 2023. Historical data from the Association for Danish Re-tread Manufacturers (FFRD)[64], presented in FIGURE 14, indicates significant growth of the number of re-treaded tyres for trucks between 2007 and 2012, reaching nearly half the market by the end of this period. According to the FFRD, most re-treaded tyres sold in Denmark are produced domestically.

While the DBMF data shows a percentage of re-treaded tyres in Group 2 as well, all tyre market experts contacted in this study (including DBMF) agree that the reported number is grossly overestimated and most likely a fault in the registration with the Tax Authorities, as light vehicle tyres are generally not re-treaded, anywhere in Europe. This was also confirmed by the neighbour check.

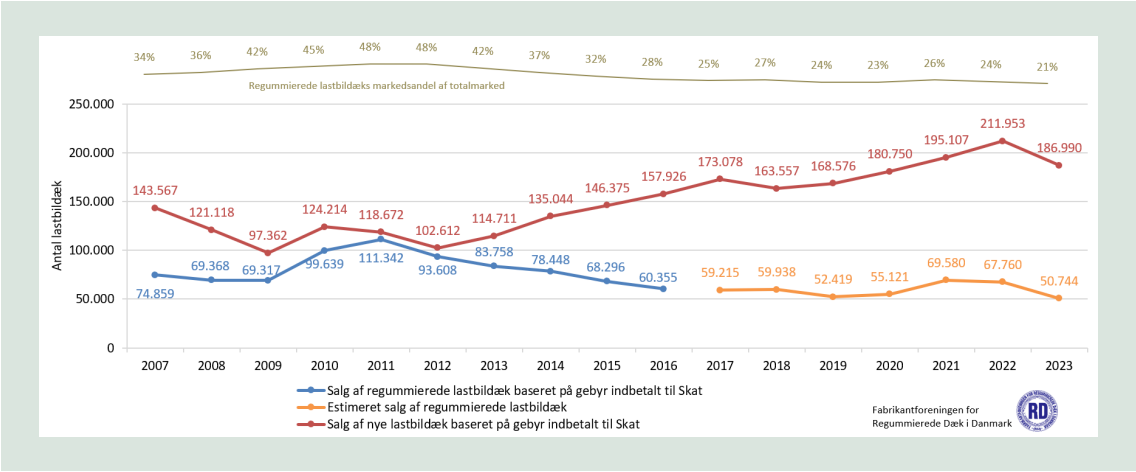

FIGURE 14. Number of re-treaded tyres for trucks sold in Denmark between 2007 and 2023, source: from the Association for Danish Re-tread Manufacturers – Note Danish decimal separator used, figure from FRDD.

Forecast

The forecast of replacement tyres was done group by group, as the market for the different tyre types develop differently. All forecasts were based on linear extrapolation of historic data, however, the period included in the linear regression varied, due to regulatory changes, which affected the data:

- For group 1 and 3 the forecast was made based on data from year 2017 and forward, because a change in the regulation in 2017, in the load index defining the two groups, meaning that around 100,000-200,000 tyres changed classification from group 3 to group 1. If data back to year 2,000 was used, the forecasted market increase would be unrealistically high.
- Re-treaded tyre groups, i.e. Group 4, 6, and 8, were based on data from 2000-2016, because the regulation change of 2017 left re-treads out of the scope[65], and thus data collection before and after 2017 cannot be compared.

[64] Interview with FFRD on 30.10.2024

[65] Retreads made from Casings collected in Denmark.

- Group 5 and 7 were forecasted based on all data from 2000 and forward, as not regulatory changes were made to these groups.
- Group 2 was excluded completely from the forecast, due to faulty data. Overall, the registered number of re-treaded tyres far exceeded what any market expert or the FFRD know to be realistic, and further it showed a steep increase in sales of passenger car re-treaded tyres. This is against both Danish and international market knowledge, as seen in the neighbour check, there is a general agreement that re-treading C1 tyres is a dying market and it is simply not profitable[66].

The forecast for all tyre groups is shown in FIGURE 15.

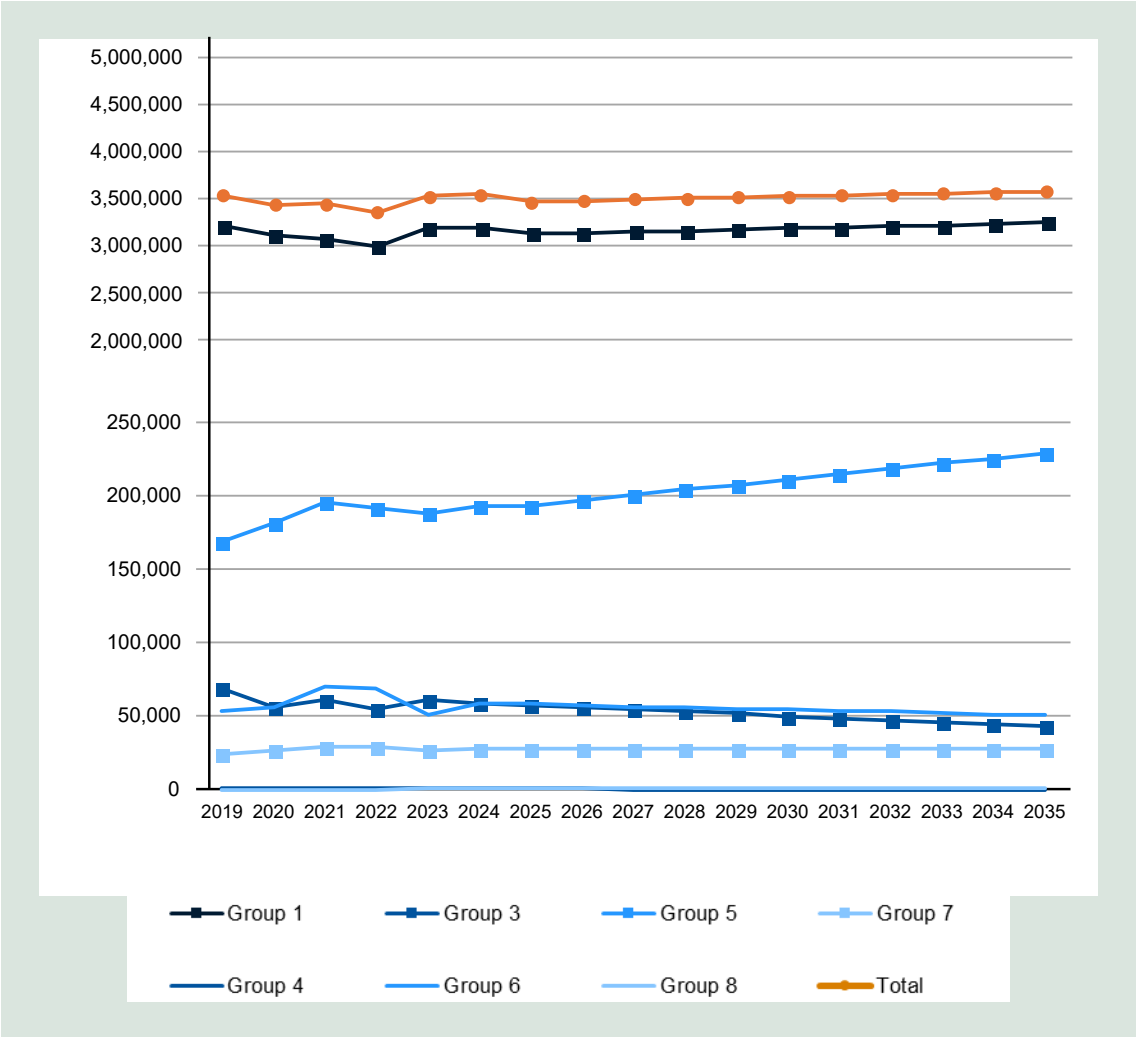

FIGURE 15. Tyres sales for replacement tyres, based on DBMF (Dæk Branchens Miljø Fond / The Tyre Industry Environmental Fund) data until 2024, and forecasted until 2035. The graph for re-treaded truck tyres (group 6) is based on estimated numbers from the Association for Danish Re-tread Manufacturers. See TABLE 21 in Appendix 4 for tyre group specifications.

As can be seen from the figure, a slight increase in overall tyre sales is expected towards 2035, mainly driven by group 1 tyres and with some contribution from group 5 (truck and bus tyres). Other groups (3, 4, 6, 7, 8), show a slightly decreasing tendency, both for new and re-treaded tyres. Since this is based on historic data, it should be viewed as a "business as usual" forecast, meaning that this is how tyre sales is expected to evolve, of no regulatory

[66] Only re-treading of very specific tyre types such as rally tyres is known to be performed systematically for this tyre size.

changes are introduced. If, for example the re-treaded C3 tyres are winning market shares again, it is likely to see an increase in group 6, and less of an increase in group 5. However, the total tyres sales is expected to remain close to stable, with maybe a slight increase.

4.1.3 New tyre technologies

Based on the interviews with stakeholders from the different systems in Europe, there is a clear increase in the sales of tyres with new technologies, such as SST, NCT, airless, and smart tyres. These technologies and their presence in the market are further described below. Both market segments are expected to increase going forward, as seen in FIGURE 16 - SST with a CAGR of 8.7% per year, and NCTs market is expected to grow with the sales of Electric Passenger Vehicles. This is based on the assumption that there is no overlap between the categories, i.e. that a tyre cannot be both SST and NCT but is either/ or.

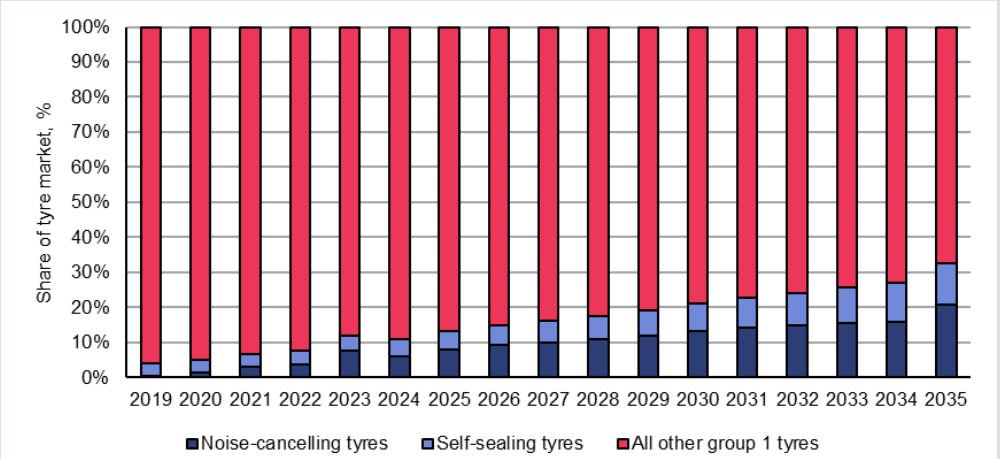

FIGURE 16. Estimate of the share of NCT and SST tyres on the Danish market from 2019 to 2035.

4.1.3.1 Self-sealing tyres

There are currently no figures for how many SSTs have been sold on the Danish market in the past. However, in 2022, the global SST market size was 16.17 billion USD and by 2032 it is expected to grow to 37.2 billion USD[67]. This results in a CAGR of 8.7% per year, which is also used for the forecast of SST sales in FIGURE 16.

The market for SSTs in Europe is growing and is expected to continue growing within the next decade. According to Genan, around 2 to 3% of all the tyres currently received at their facilities are SST[36]. Given that there is a 3-5 year delay from the tyre is sold until it reaches end of life, the SST market is estimated to be 3% in 2020 of all tyres, even though all SSTs are assumed to be Group 1 tyres.

4.1.3.2 Noise-cancelling tyres

In Denmark, the NCT market is still emerging, primarily driven by the sale of electric vehicles. According to Genan, NCTs have grown from constituting a share of around 2 to 3% of the

[67] https://www.marketresearchfuture.com/reports/self-sealing-tyre-market-30836

ELTs they received five years ago to over 10% today[68]. Electric vehicle sales are also expected to grow annually by 15.41% until 2029, potentially reaching 172,300 vehicles[69], or the equivalent to 689,200 NCTs. Therefore, there needs to be a greater focus on these tyre technologies and on understanding how they will transform the end-of-life processing and demand for new technology.

A comment from the Germany (Azur network[70]) neighbour check interview states that they do not foresee the share of NCTs to rise as much as this forecast shows, but only to around a 10% market share in the next 5-10 years, partly because of the price, but also due to other technologies competing with NCTs, for example active noise cancellation loudspeakers in electric cars.

4.2 European Legislation and potential market impacts

While this study focuses on ELTs in a Danish context, the Danish market for both tyres and ELTs is highly affected by the wider European tyre market and European regulation, which can affect which tyres are sold on the European and Danish markets, as well as how tyres can be treated at end-of-life. The most important European Legislation affecting the tyre market and the market for recycled tyre materials is listed in this section.

Regulation (EU) 2019/2144, also known as the General Safety Regulation, is an important European regulation for vehicle safety that has implications for the tyre industry. The regulation mandates that all new vehicles (from July 2022 for new models and July 2024 for all new vehicles) must be equipped with advanced safety systems to enhance road safety across Europe. This regulation has led manufacturers to prioritize the development of durable, energy-efficient, and safe tyres above recyclable tyres[71].

Tyre Labelling Regulation 2020/740, which requires tyres manufacturers to label tyres sold within Europe according to rolling resistance, wet grip, and external noise levels. Introduced in 2021, the label provides consumers with information on fuel efficiency, safety, and noise, promoting informed purchasing choices and encouraging environmentally friendly tyre choices. This regulation supports European goals for reducing carbon emissions by promoting energy-efficient products.

Waste Framework Directive (2008/98/EC), which sets guidelines for waste management, particularly enforcing a waste hierarchy based on the principles of prevention, reuse, recycling, recovery and disposal. This hierarchy encourages industries, including tyre manufacturers, to focus on reducing waste at every stage of the product life cycle.

Landfill Directive (1999/31/EC), which aims at reducing the environmental impact of waste disposal in landfills. It prohibits the disposal of whole tyres in landfills since 2003 and shredded tyres since 2006.

End-of-Life Vehicles Directive (2000/53/EC) addresses the management of vehicles once they reach their end-of-life. This directive sets ambitious targets for the recycling and recovery of materials from end-of-life vehicles (ELVs), mandating that at least 85% of the material from ELVs (including tyres) be reused or recovered, promoting tyre recycling.

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[68] Interview with Genan on 10.10.2024

[69] https://www.statista.com/outlook/mmo/electric-vehicles/denmark

[70] https://azur-netzwerk.de/

[71] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1510670993510&uri=CELEX%3A52017DC0658

Registration, Evaluation, Authorisation and Restriction of Chemical substances (REACH) **Regulation (EC No 1907/2006)**, which regulates the use of certain hazardous chemicals in products, including tyres. It has implications for the material composition of tyres and the recycling processes, especially related to substances like polycyclic aromatic hydrocarbons (PAHs) in tyre rubber. In an effort to restrict intentionally added microplastics, the European Commission voted to ban the use of rubber infill on synthetic turf sport surfaces until 2031. This ban was made through the REACH Regulation.

In Europe, there are over 21,000 synthetic turf regulation-sized football pitches subject to homologation and over 72,000 pitches not subject to homologation, all of which have an estimated 90-95% use of rubber infill[72]. Around 90% of synthetic turf football pitches in Europe currently use polymeric infill recycled from ELTs[72]. Because a large portion of the recycled tyre rubber is used for this application, the sector will need to change and adapt to this ban by 2031.

4.2.1 Current developments in European legislation

Europe is continuously developing new legislation, and here a non-exhaustive list is given of the most impactful legislation currently in preparation:

Tyre labelling for C3 re-treads (for trucks and busses), which will provide the framework for requirements on rolling resistance, wet grip and external rolling noise. This legislation is expected to incentivize the re-treading of C3 tyres across Europe, leading to increased market shares of re-treaded C3 tyres.

Energy Efficiency Directive (EED) –The recast of EED will mandate that public procurers purchase only tyres with the highest fuel efficiency class, which applies to all public procurement activities. Without a label for retreaded tyres, this will affect the re-treading market negatively, making it harder to sell re-treaded tyres for public purposes. However, if the tyre labelling for C3 re-treads becomes a reality, the EED recast is expected to have little to no effect.

Ecodesign for Sustainable Products Regulation (ESPR), which is currently under development as part of the European Green Deal. This regulation will set design and sustainability requirements for a range of products, including tyres. Expected to address recyclability, durability, and energy efficiency, this regulation will promote a circular economy approach, ensuring products are designed for minimal environmental impact throughout their lifecycle. In addition, the European Union will implement a new regulation requiring nearly all products sold in Europe to feature a Digital Product Passport (DPP), as part of the Ecodesign for Sustainable Products Regulation (ESPR)[73]. This aims to increase transparency across value chains, including information on the product's origin, materials, environmental impact, and disposal recommendations.

Stakeholders from the Neighbour check believe the ESPR will be beneficial to the tyre market and to the ELT market, because tyre technologies that cannot be recycled but claim environmental superiority (like SSTs), will have to prove the environmental impact or be restricted on the market. Germany (Azur network) also believe the DPP will be beneficial for

[72] https://www.ecopneus.it/en/news-en/the-recent-announcement-of-the-eu-member-states-puts-the-recycling-chain-and-the-circular-economy-of-end-of-life-tyres-at-risk-in-italy/

[73] https://data.europa.eu/en/news-events/news/eus-digital-product-passport-advancing-transparency-and-sustainability

the tyres, because tyres can be located, identified, and data can be easily found on their previous lives, if they are re-treaded.

EURO 7 regulation for passenger vehicles and light- and heavy-duty vehicles[74]. Euro 7 introduces the first regulations targeting tyre wear particles and microplastics. This regulation sets a framework to limit tyre abrasion, becoming the fourth characteristic to be regulated, after rolling resistance, wet grip and external rolling noise[75]. It is still unknown how this will affect tyre lifetimes, but could be expected to increase lifetimes through less wear.

[74] https://www.consilium.europa.eu/en/press/press-releases/2024/04/12/euro-7-council-adopts-new-rules-on-emission-limits-for-cars-vans-and-trucks/

[75] https://www.etrma.org/wp-content/uploads/2023/12/ETRMA_PR_EURO-7.pdf

5. Identified problems and drivers in the current system

Based on the assessment of the current ELT system in Denmark, the five problems shown in below were identified. FIGURE 17 shows the connection between Problems, Drivers and Consequences, a methodology adopted from the EU Better Regulation Toolbox. Each identified problem is explained in more detail below the figure. In Chapter 7 of this report, the identified problems will be linked to objectives and options for intervention.

5.1 Problem 1: New vehicle tyres

The current regulation for the Danish ELT system leaves out tyres sold with new vehicles (§1 subsection 1 and subsection 2), whether they are received from outside of Denmark or fitted on the vehicles in Denmark. This was historically done to avoid a double fee on tyres, as the new vehicles are already subject to a fee, and to not complicate the administrative procedure for the Danish Tax Authorities when charging the fee. However, these tyres still need to be handled in the Danish ELT system when reaching their end of life, and are thus being collected, sorted and treated, also giving rise to subsidies, but without having paid to the system. In other words, leaving these tyres out of scope, results in a freeriding situation, where they benefit from the actions and efforts of the Danish ELT system without paying to it.

5.2 Problem 2: Re-treading

While re-treaded tyres (based on casings that can be documented to have been collected in Denmark) have been exempted from paying a fee to the ELT system since 2016 from paying the fee when placed on the market, there is no incentives for collectors for sorting out tyres fit for re-treading and sending to re-treaders.

The market for re-treaded tyres is very price sensitive as these tyres compete with cheap, imported, new tyres. As indicated in the interview with the Danish Manufacturers' Association for Re-treaded Tyres the re-treaders cannot pay enough for the casings for it to be attractive for collectors to sort these and send them to re-treading, rather than sending them to recycling and getting the subsidy.

Most tyres that are re-treaded today, do not enter the ELT system, but are sent directly from waste producers to re-treaders. However, given the relatively low share of re-treaded tyres in the market (20% of truck tyres in 2023, as opposed to almost 50% in 2011), indicates that a certain share of tyres eligible for re-treading enters the recycling stream. While both collectors and recyclers send a small number of casings to re-treading each year, this share is almost negligible, and it is highly likely that a number of casings are recycled, which could have been re-treaded[76].

[76] RD (The Manufacturers' Association for Retreaded Tyres in Denmark)

5.3 Problem 3: New tyre technologies

Self-sealing tyres (SSTs) cannot be recycled, due to the tar-like rubber blend used on the inside of the tyres. This substance ensures that any puncturing of the tyre seals itself when removing the foreign object, however it is also the cause of the problems of recycling these tyres with the most used shredding technology for treating ELTs. The rubber substance sticks to the shredder's blades and insides, dulling the blades and ultimately in worst-case instances inducing a fire in the equipment. This has resulted in recyclers charging high fees from collectors, if they deliver SSTs. The alternative route for self-sealing ELTs is incineration.

Noise Cancelling Tyres (NCTs) cannot be recycled due to the foam and the glue it is attached with on the inside of the tyres contaminating the recycled material fractions. The foam and glue often end up in the textile and rubber fractions, and it difficult to separate, this reducing the quality and the application options of the rubber granulate.

Today technologies already exist to remove the foam from the inside of NCTs used in Germany and Netherlands[77], where a machine that physically removes / pulls out the foam can be added as an additional step in the recycling process to avoid the majority of this contamination. On the other hand, investing in such machinery requires a consistently high daily volume of processed tyres to justify the cost—a threshold that is difficult to achieve given the relatively small market share and limited supply of NCTs. Additionally, while current technologies can significantly reduce foam and glue contamination from NCTs, it cannot be guaranteed that residue will be completely eliminated. Based on the current number of NCTs, the remaining contamination is unlikely to significantly impact the quality of the rubber granulate. However, as the share of NCTs in the tyre stream increases in the future, the risk of contamination and reduced product homogeneity may grow, potentially affecting the quality, market value, and application options of the recycled granulate. This creates uncertainty about maintaining consistent quality with existing technologies.

Another issue with the NCTs is that these tyres have a poor incineration value, as gas emissions during combustion with household waste are difficult to control, resulting in lower energy output.

An uncertainty that was raised for both NCTs and SSTs, is whether they are easily identified and defined, e.g. a specific code or mark on the tyre wall, or other means by which collectors and recyclers can easily identify them. According to both collectors and recyclers, they have no trouble identifying them by visual inspection.

5.4 Problem 4: Economic inflexibility

As mentioned above, the Danish ELT regulation was changed in October 2023[78], opening for collectors to charge remuneration when picking up tyres from waste producers. This change was necessary, because the gate fees increased the subsequent years, and the subsidy amount was no longer covering these fees, while collectors were obliged to pick up the tyres free of charge. This situation showed the imbalance of the system, where the charged fees could no longer cover the full collection costs through subsidies.

The increase in gate fees was reported by recyclers to result from several external conditions including increasing energy prices[79], increasing transportation costs, increasing inflation, and

[77] Interview Dick De Vries

[78] https://www.retsinformation.dk/eli/lta/2023/1264

[79] Especially in the years 2020-2022

increasing labour costs[80]. According to a calculation made by the Danish Chamber of Commerce in October 2022[81], there was (at that time) a need to increase the economy of the Danish ELT system by 89-110% depending on whether the scope was to be extended to include tyres on new vehicles or not. According to the Danish Chamber of Commerce, the by far largest part of this suggested increase was due to increasing energy prices, while only 7% was due to indexation from 2017 to 2022. Even though the European energy prices were back to reasonable values in 2023, the gate fees have not decreased similarly, and in 2023 the system was therefore changed to allow collectors to charge a handling fee from waste producers to adjust more readily to cost changes in the market.

The addition of this collection fee is not in line with the original purpose of the tyre regulation, which was to ensure collection of all tyres and avoid dumping or other environmentally harmful handling of ELTs, by providing remuneration free collection. Other disadvantages include increased administrative burdens for waste producers, as they must manage separate invoicing, contract arrangements, and logistical planning. For waste producers and end-users, the dual-fee structure —one fee for purchasing new tyres and another for disposal of used tyres— has led to frustration and questions about the system's fairness, as this double charge was not originally intended under the free pick-up model.

On the other hand, some tyre collectors argue that the waste producers can gain a small profit margin from this, as the cost for the additional fee is not regulated, and they can invoice the end-user more than they pay the collectors. This is also seen to a large extend in Germany (where they have a free market for ELTs).

At the same time collectors repot rising costs for transportation, labour, and gate fees, as the subsidy provided under the system is insufficient to ensure a fair price for collection, making it challenging for collectors to cover their operational costs and pay the gate fees charged by recyclers. This means that the subsidy does not adequately support the costs of running the collection operations, and thus they charge an extra fee from waste collectors to obtain a viable business. Since many of the collectors are not collecting only tyres, and are thus not economically dependent on collecting tyres, it is assumed that it must provide a viable business, when they choose to continue to collect tyres.

In summary the study shows that the additional handling fees are necessary for collectors to maintain their profitability. While data collected is not precise, and some variation occurs in the market, the economic balance for collectors shown in FIGURE 12, (Section 2.4.5), show that the handling fees are needed for the collectors and thus that the current ELT system does not fully pay the collection and transportation of the ELTs.

Adding to the risk of imbalance, is also the situation on the Danish market today with only two companies being approved recyclers, means there is only these two recyclers the collectors can send the tyres to, to get the subsidy pay-out. This creates a lock-in in the system, where the collectors have no other option than to send the tyres to these recyclers, no matter the gate fee they charge. Therefore, as cost of recycling has increased, especially due to energy prices increasing, the gate fees have risen accordingly and opened up for collectors being able to charge waste producers for collection. Energy is used directly in the processing as well

[80] https://www.danskerhverv.dk/presse-og-nyheder/nyheder/2022/oktober/weekendarbejde-dakker-hoje-udgifter-genan-sparer-en-million-om-maneden/

[81] Dansk Erhverv, "Dækordning i Danmark – behov for at øge økonomien i ordning", October 2022, can be found as part of the Consultation response for the 2023 changes to the Danish ELT regulation here: https://prodstoragehoeringspo.blob.core.windows.net/9dc3eb0f-7b3d-4531-a83a-e0119c0ffb49/H%C3%B8ringssvar.pdf

as for transportation, to and from the recycling facilities: of ELTs to the facility from all over Denmark, and the recycled fractions from the facilities to purchasers, which are often far away as there is no or very low demand in Denmark and immediate neighbour countries.

While some cost increase could be handled through increasing the economy of the system, there is also a risk that the recyclers continue to increase gate fees beyond what is incurred strictly by increasing energy costs, to improve their own profitability. While this is not expected to be the case yet, even if gate fees did not decline again with more reasonable energy prices since 2023, it is important to avoid this in the future, to avoid continuously increasing gate fees, which would ultimately result in additional fees to end-users, who end up paying the price.

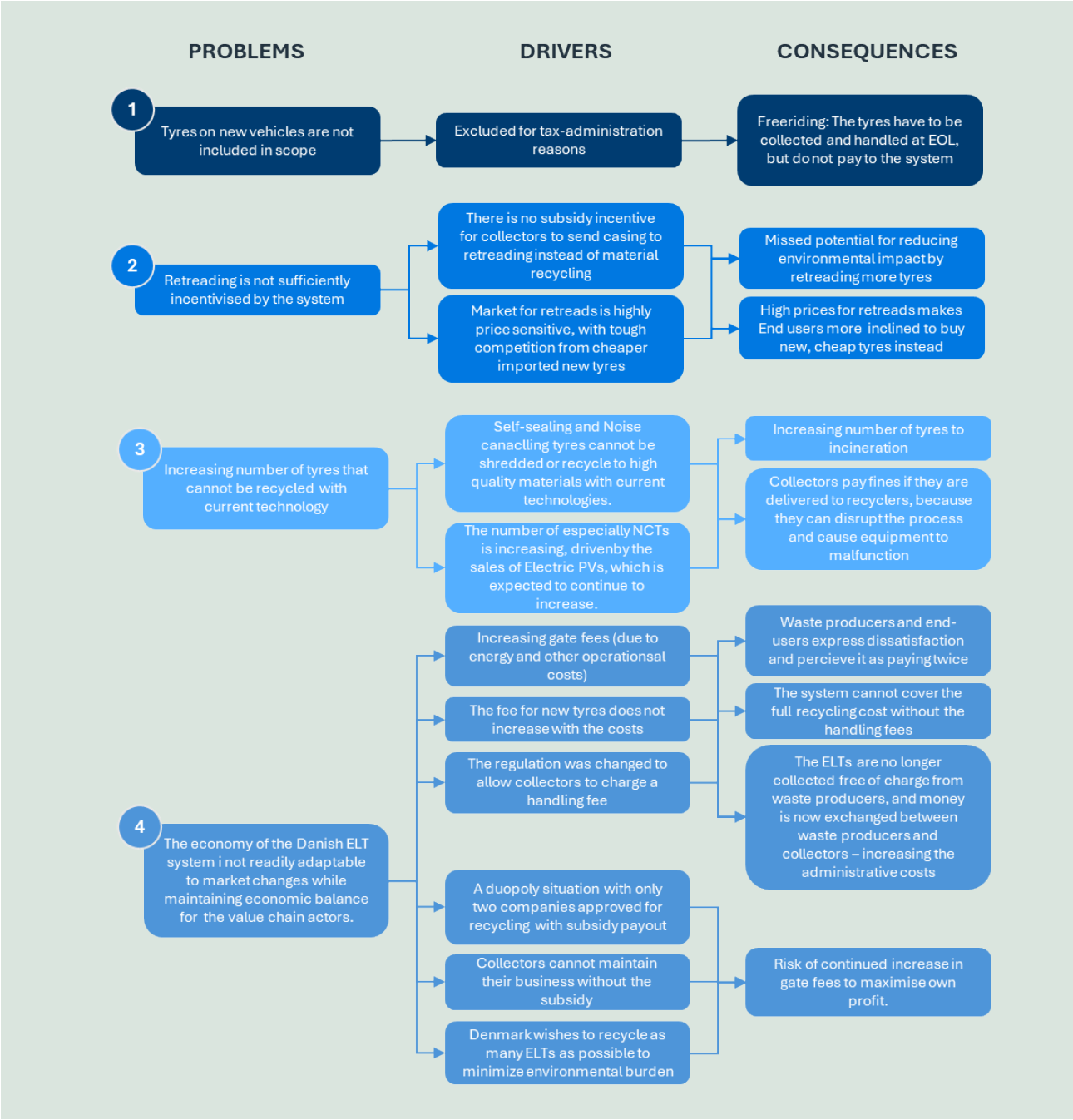

FIGURE 17. Problem tree showing the defined problems, drivers and consequences for the current end-of-life tyre system in Denmark. (based on EU Better Regulation Toolbox Tool#11[82]).

[82] Better Regulation Toolbox, European Commission, 2023, https://commission.europa.eu/law/law-making-process/planning-and-proposing-law/better-regulation/better-regulation-guidelines-and-toolbox/better-regulation-toolbox_en

6. Review of schemes in neighbouring European countries

In order to learn from ELT systems in other European countries, a Neighbour check was performed, by investigating the solutions used on five selected countries, and use their experiences of advantages and disadvantages in their respective systems, to improve the Danish system.

6.1 Selection of neighbouring European countries

To perform the Neighbour check, five countries were selected, based on the type of ELT system applied, proximity and similarity to Denmark, and their overall performance. According to the European Tyre and Rubber Manufacturer's Association (ERTMA), there are currently three[83] main different models for managing ELTs:

1. Extended Producer Responsibility (EPR)
2. Liberal system (Free market)
3. Tax/subsidy system (Governmental)

In an **EPR scheme**, producers take full or partial financial and operational responsibility for the disposal of their product once it reaches its end-of-life. EPR schemes (in Europe) must live up to the European Waste Framework Directive[84,] which sets minimum requirements for such schemes. This system holds manufacturers accountable for ensuring that waste from their products is managed in an environmentally responsible way. In EPR schemes, the tyre industry organises themselves in one or more non-profit organizations "Producer Responsibility Organisations" (PROs) to handle the collection and recycling of ELTs using cost-effective methods. The far majority of EPR schemes in Europe are purely financial and consist of the producers paying an Eco-fee to the PRO, who then coordinate collection of ELTs and recycling.

The PROs can be set up in different structures, according to who owns the ELT materials (the collectors, the processors, or the PRO itself), and how collectors are organised (in open coemption, contracted for 3-5 years), and who owns the recycling plant (private or owned by the PRO).

Under the **free market system**, legislation outlines the objectives but does not specify who is responsible for managing them. All operators involved in the recovery process work under free market conditions while complying with the law. Voluntary collaboration between companies may also encourage best practices. In this system, consumers pay workshops to dispose of

[83] According to the Swedish PRO (Svensk Däckåtervinning) a fourth exists: Stewardship, which is applied in other parts of the world, e.g. Australia, Canada, New Zealand. Stewardship system is not applied in Europe.

[84] Directive 2008/98/EC of the European Parliament and of the Council, (OJ L 312 22.11.2008, p. 3) https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02008L0098-20180705

their old tyres. The workshops then compensate collectors for picking up the tyres, and the collectors pay a gate-fee to the recyclers for processing the tyres.

Finally, the **tax/subsidy system** is the current model used in Denmark. Under this system, producers pay a fixed fee on all tyres introduced into the market. These fees are gathered into a fund managed by the tax authorities, which is then used to fund the waste management activities, including collection, transport and processing. The tax imposed on tyre producers or importers is ultimately passed on to consumers.

There is, however, a fourth hybrid model for managing ELTs: **stewardship**. This is a joint system between state (or territory, province, etc.) and industry organisations in various forms[85]. Under this system, the EPR principles apply, and tyre manufacturers and importers must take responsibility for the end-of-life of their products. These producers generally contribute to a stewardship fund, which is then used to finance the management of ELTs. However, in this system, the government establishes standards, monitors compliance and ensures transparency. As a result, this system creates partnerships between producers, recyclers, government agencies and local businesses. It therefore encourages shared responsibility and community involvement, potentially leading to innovative waste management solutions. TABLE 10 below outlines which counties applies which type of systems in Europe.

TABLE 10. ELT management systems in Europe.

System	Countries
EPR scheme	Belgium, Bulgaria, Czech Republic, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Turkey
Liberal system	Austria, Albania, Bosnia and Herzegovina, Germany, Montenegro, North Macedonia, Serbia, Switzerland, UK
Tax/subsidy system	Croatia, Denmark

The selection of European countries for revising EPR schemes was guided by the Nabotjek methodology[86], which compares regulations among neighbouring or similar countries to get inputs and gather experiences to be used for improving the Danish system. Countries were chosen based on their geographical proximity to Denmark and the quality, innovation, and effectiveness of their EPR schemes, while ensuring representation from each of the three main management systems. The goal is to ensure the review identifies best practices across Europe. Five European countries were selected to provide a comprehensive review of these systems, with a particular focus on EPR schemes.

Sweden, the Netherlands, Germany and the United Kingdom have previously been examined in the 2016 study on the environmental, market and economic analysis for the Danish tyre scheme[87]. As previously noted, the latter two countries do not have an EPR scheme established but instead operated under a free market system, where no single entity or organization is responsible for ensuring compliance with legislation. The United Kingdom was not further investigated, as it is not part of Europe. However, despite not being an EPR scheme, **Germany**'s free market model has proved to be successful in terms of recycling rates: in 2020, around 68% of tyres were recycled or re-treaded, whereas the remaining 32%

[85] Interview with SDAB on 07.10.2024

[86] https://erhvervsstyrelsen.dk/nabotjek-som-metode

[87] https://www.teknologisk.dk/_/media/66181_D%E6kanalyse.pdf

were used in the cement industry[88]. Due to this success, and its geographical proximity to Denmark, Germany's ELT management system was selected for the review. This also provides an opportunity to compare its strengths and weaknesses against other systems.

Sweden was selected based on the close geographical location to Denmark and due to the establishment of the EPR scheme as early as 1994, which indicates a well-tested and implemented EPR system. Sweden recently made a similar study to improve their own ERP system, and decided on a novel model, where the PRO contracts the regional collectors and processors, but own the material and recycling facility themselves. In addition, Sweden handles the recycling of tyres coming from Norway, further cementing its successful performance.

The **Netherlands** was selected for this review due to its well-organized and efficient EPR scheme, established in 2004, which works closely with certified recycling companies that repurpose the materials across various applications. The Dutch system focuses a lot on sorting at the collectors, and thus have a high re-use rate of tyres, which are often exported and for their second life. Additionally, the similarities between the Netherlands and Denmark provide a valuable opportunity for direct comparison and insight-sharing.

Out of the remaining 14 EPR schemes in Europe, Turkey was excluded due to its non-European status. Although Norway is Denmark's neighbouring country, it was also excluded because it is not part of the European Union, and it sends its collected tyres to Sweden for processing and recycling. Poland, Czech Republic, Romania, and Slovakia were also excluded due to insufficient data. The remaining eight countries (Belgium, Finland, France, Greece, Ireland, Italy, Portugal and Spain) underwent an initial screening. This screening was based on metrics from annual reports, such as collection, recycling, re-treading, and energy recovery rates, as well as recognition from the 2023 Recircle Awards[89].

The quality of **Portugal**'s EPR scheme is highlighted by Valorpneu's recognition at the 2023 Recircle Awards, where it was honoured for its success in operating within a small market while achieving high tyre recovery and recycling rates. Additionally, our project team includes native Portuguese speakers, which will facilitate a more thorough review of this EPR scheme. These factors contributed to our decision to include Portugal in the study.

Although the remaining EPR schemes have good performances in terms of collection and recycling rates, particularly **Belgium** and Spain, the **Italian** EPR scheme was selected for several reasons: it handles large quantities of tyres and has a high collection rate. Italy is different from other EPR schemes, since there are several PROs and some individual companies approved to collect and handles ELTs, each with their own collection targets. Another unique feature of the Italian system is that subsidies are paid not only to collectors, but also to shredders and recycling plants. As a result, it was selected for this review.

Each of the EPR schemes selected (Sweden, the Netherlands, Italy and Portugal) operate through Producer Responsibility Organizations (PROs) that manage the collection and recycling of tyres. The national regulations vary in terms of the specific types of tyres that must be collected and recycled, as well as the taxes, fees, and fines imposed. In Germany, on the other hand, there is no PRO, and the collection and recycling of ELTs are based on free market forces. These differences contribute to varying success rates in collection and recycling and will be explained in more detail in this chapter. TABLE 11 presents an overview

[88] https://wdk.de/pressemitteilungen/altreifenzahlen-2019/

[89] https://recircleawards.com/

of the main characteristics of the chosen ELT systems.

TABLE 11. Overview of the main characteristics of the chosen ELT systems.

Selected countries						
Country	**Relevant Organisation**	**Founding year**	**Collection amount (tonnes) (2023)**	**Collection rate (2023)**	**Recycling rate (2023)**	**Energy recovery (2023)**
Germany	WDK and Azur Network	None	504,000	115%	46% recycled 14% retreaded	23%
Sweden	Swedish Tyre Recycling[90]	1994	84,808	Not specified	27%	68%
Nether-lands	RecyBem[91]	2004	Not specified 9.8 million tyres	108%	73% recycled 22% reused 3% retreaded	2%
Italy	Ecopneus[92]	2011	187,818	112%	50%	50%
Portugal	Valorpneu[93]	2002	92,041	110%	70% recycled 12% retreaded	18%

6.2 Free market system in Germany

The German Circular Economy Act established in 2012 mandates that carcasses and worn tyres must be disposed of in an environmentally responsible manner[94]. This means that the transport, sorting, storage, and recycling of used tyres must be reported to the appropriate authorities, and disposal companies handling them must have official approval. Illegal treatment, storage or disposal of ELTs can result in fines of up to 50,000 euros for the offender[95].

Germany operates under a free market system, where the collection and processing of ELTs are driven by demand rather than mandates. This system does not specify who is responsible for legal compliance (e.g. to not landfill tyres, or dump tyres), meaning that every part of the recycling chain must adhere to the regulations while functioning within free market conditions. As a result, private companies dominate the collection, recycling, and recovery processes, with the tyre industry businesses often collaborating with recycling companies to ensure proper disposal. Competition within the sector helps keep costs manageable. This system covers all types of tyres.

Under this system, end users can hand in their ELTs to the tyre dealer for a small fee (<5 €/tyre). Alternatively, they can bring their ELTs to local recycling centres or municipal waste facilities, though these services typically involve a small fee. Once collected, the tyres are sorted in containers for pick-up by collectors, who charges a handling fee from waste

[90] https://www.sdab.se/wp-content/uploads/2024/06/Arsrapport-2023-30-ar-med-det-svarta-guldet.pdf

[91] https://www.recybem.nl/sites/recybem.nl/files/user/240731_avv_monitor_autobanden_2023-gecomprimeerd.pdf

[92] https://www.ecopneus.it/wp-content/uploads/2024/06/report-2023.pdf

[93] https://www.valorpneu.pt/wp-content/uploads/2024/09/DA_2023_vf2-Assinado.pdf

[94] https://zertifizierte-altreifenentsorger.de/die-initiative-zare/folgen-der-falschen-altreifenentsorgung-rechtliche-konsequenzen/

[95] https://www.bussgeldkatalog.org/umwelt-altreifen-autorecycling/

producers. Sorting can occur at this stage, either by the dealer or the collector. Dealers who sort their tyres properly can benefit from reduced fees charged by collectors, creating a financial incentive for better pre-sorting practices[87]. Tyres are sorted based on their condition and potential for recycling, re-treading, export, or incineration or further processing. The system is thus financed by the end users, when handing in their tyres, the waste producers paying some of this fee to the collectors, for picking up tyres, and the collectors can also get paid for re-selling the tyres for either re-use, re-treading or energy recovery. To send the tyres to material recycling often costs them money, however.

Once collected, ELTs are transported by specialized logistics companies to processing and recycling facilities. There are multiple independent companies involved in the collection and transport of used tyres across the country. Germany is currently working on further regulating the collectors and having specific approvals for collectors who can pick up tyres to avoid the cherry-picking and dumping, and ensure all ELTs go into the right system. To be a certified collector, you would have to sign a declaration that you will sort the tyres according to their best second use. It is an important factor that the collectors will have to sort to be certified, to ensure that they are a value adding step in the ELT supply chain. They also sign that they will report data on how many tyres they collect, where they transport them, and that they are not exported for other than a second use. This is to get better data of how many tyres and what happens to them. That could potentially, in time, turn into quotas.

Every year, this system handles approximately 500-600,000 tonnes of used tyres[96], which are typically disposed through material recycling, energy recovery, re-treading and export. It is the role of the collectors to sort the tyres, and the incentive for doing so is purely market based, as they can get an income for selling tyres to reuse (often outside Europe), and to re-treading, while they pay a minor gate fee for recycling, and an even larger gate fee for incineration.

However, challenges exist due to the lack of specific approvals for tyre collectors. Many waste collection companies who pick up tyres also pick up many other waste fractions, and the only way they can get rid of the tyres is by sending them to incineration. Additionally, some collectors engage in "cherry-picking," where they take 10-15% of the best tyres from dealers for reuse without charging a collection fee, leaving low-value scrap tyres for responsible collectors. This practice can lead to the dumping of old tyres in nature and it is assumed that the far majority of these (usually batches of 50-200 tyres in one place), are dumped by these “cherry pickers” who cannot resell all the tyres.

Despite these issues, Germany has no intentions of getting rid of the free market system, as they want the collectors to be able to charge what they want, regulated by supply and demand. Decisions about where tyres should be sent will remain the decision of collectors, based on where they can get a higher price, e.g. when energy prices are high, more tyres go to energy recovery, which also happens in some countries with EPR systems. There are no targets set by the government as to how the tyres should be handled at end-of-life.

Pros:

- One of the main advantages of the current system in Germany is the fact that it handles all types of tyres, depending on the supply and demand of each type of ELT.
- The system is economically efficient, as it is based on supply and demand, meaning it is able adapt to market changes through competition among private collectors and recyclers, keeping costs manageable and encouraging innovation.

[96] https://zertifizierte-altreifenentsorger.de/verwertungsmethoden/zahlen-daten-und-fakten/

- High re-treading rates, due to demand, but also because of financial incentive for collectors to send to re-treading, because they get an income as opposed to material recycling or incineration, which is a cost (gate fee).
- The fact that collectors charge different prices, based on the how well the tyres are sorted, incentivises proper sorting by tyre dealers, which leads to purer fractions of ELTs, increasing processing efficiency.

Cons:

- Some waste collection companies pick different waste fractions together, sending all of them to incineration. As a result, many tyres are sent for energy recovery, instead of being delivered for recycling, which is a preferred treatment method.
- The lack of control in this system results in cherry pickers leaving low-value scrap tyres behind and sometimes dump ELTs that cannot be resold.

What DK can adopt:

- Although Denmark currently favours recycling of ELTs, providing flexibility for collectors to choose the waste treatment method based on market conditions can both increase competition and adaptability to the changing market. However, to avoid high rates of incineration (especially when energy prices are high), and boost re-treading, some subsidy would be needed to regulate the tyre flows.
- Setting sorting targets for collectors or incentivise sorting through subsidies (e.g. by subsidising re-treading) to increase re-treading rates.
- Germany is working on a regulation that sets specific requirements to be approved as tyre waste collector, to improve control with ELTs and ensure better sorting, anti-dumping etc.

6.3 EPR scheme in Sweden

In 1994, Sweden became one of the first countries in the world to establish an ordinance of producer responsibility for tyres (1994:1236)[97]. This ordinance introduced the legal framework for ELTs, in which producers must take responsibility for the collection and recycling of the tyres placed on the market.

In anticipation of the new legislation, representatives from the DFTF (Tyre, Rim, and Accessory Suppliers Association) and DRF (Tyre Specialists National Association) established a collective system, represented by Svensk Däckåtervinning AB (hereafter referred to as SDAB). SDAB is the approved PRO in Sweden, responsible for organising the collection, processing, marketing, and reporting necessary to comply with the legislation.

According to the ordinance on producer responsibility for tyres from January 2024 (2023:133)**Error! Bookmark not defined.**, tyre producers must be registered with the Swedish EPA and be affiliated with an approved PRO[98]. From 2027, the PRO must ensure that at least 95% of all ELTs are collected[99], but it is up to them to decide how to achieve this. Today the collection rate is 105-110% and stabile. The changes the SDAB are making to the

[97] https://sdab.se/wp-content/uploads/2024/06/Annual-report-2023-SDAB-30-year.pdf

[98] https://www.naturvardsverket.se/en/guidance/extended-producer-responsibility-epr/producer-responsibility-for-tyres/

[99] https://www.riksdagen.se/sv/dokument-och-lagar/dokument/svensk-forfattningssamling/forordning-2023133-om-producentansvar-for-dack_sfs-2023-133/

ELT value chain do not at all influence the collection structure other than it is easier to order collection through a newly developed app.

This EPR scheme covers tyres for passenger cars, trucks, buses, motorcycles, tractors, all-terrain vehicles, motor equipment, trailers, and trailing vehicles[100]. Currently, the only tyres not included under the EPR scheme are those mounted on new vehicles weighing under 3.5 tons, such as cars and small vans, which are instead managed under the producer responsibility for vehicles, as stipulated by the ELV directive**Error! Bookmark not defined.**. This used cause the main free riders in the system, because car recyclers did not take responsibility for the "last" four tyres on a car as agreed as a trade-off for SDAB to handle the first four tyres on a new car (under ELV). Today the remaining free-riders are addressed together with the EPA (Naturvårdsverket), who since 2024 have the right to give penalty to producers that are not part of a PRO. Previous legislation did not have this possibility. Remaining free-riders are web-trade from abroad and original mounted tyres on agricultural equipment, trailers etc. from smaller actors.

Tyres that do not comply with Registration, Evaluation, Authorisation and Restriction of Chemical substances (REACH) – the European's regulations regarding tyre content and related standards – may be rejected for collection[101] to recycling, and need to be incinerated instead.

Consumers are able to return ELTs at no cost in the 4,702 collection points (in 2023), which include affiliated tyre workshops, car workshops, recycling centres and other actors handling tyres without engaging in their sale**Error! Bookmark not defined.**.

When tyres are replaced, retailers or repair shops are required to collect the old tyres and ensure they are sent to authorized recycling facilities. The collection of ELTs is now managed through an app, and tyre collectors, including workshops and recycling centres, order the collection of tyres through mobile phone or computer. The tyres are afterwards transported to a nearby recycling facility where they are sorted and processed[105] by SDAB.

Producers are required to submit retrospective reports to SDAB detailing the number of tyres they introduce into the Swedish market for each category. Following this reporting, Swedish Tyre Recycling issues invoices for the applicable recycling fees, along with VAT[102].

All fees entering the system must be used for collecting, processing, and marketing recycled tyre material and related activities**Error! Bookmark not defined.**. SDAB may periodically revise recycling fees to account for fluctuations in the costs of collection, transportation, and recycling, ensuring the financial sustainability of the system[102]. SDAB owns the material from collection at tyre workshops until sold. To prepare for the future, SDAB need to keep some "free volumes" for larger contracts in material recycling and pyrolysis and those customers have not yet scaled up from new facility investments. In the meantime, some volumes are thus still sold on the international "spot market", i.e. mostly to cement industry. In 2024 SDAB managed to increase material recycling to over 50% and that trend will continue over time although depending on short term on those new customers. The intention is that the reselling

[100] https://www.riksdagen.se/sv/dokument-och-lagar/dokument/svensk-forfattningssamling/forordning-19941236-om-producentansvar-for-dack_sfs-1994-1236/

[101] https://bileko.zendesk.com/hc/sv/articles/6470415859868-Svensk-d%C3%A4ck%C3%A5tervinning-SDAB-samarbetar-med-Ragn-Sells-D%C3%A4ck%C3%A5tervinning-AB

[102] https://sdab.se/producent/

of tyre materials together with the fees paid by tyre producers, can cover the ELT treatment costs.

If producers or importers fail to comply with the legislation, an environmental sanction fee may need to be paid[103]. This fee will depend on what requirement the producer has failed to meet but could result in a fine of up to SEK 50,000.

Besides the recycling fee for the management of ELTs, producers must pay an annual fee of SEK 1,000 to the Swedish EPA, which is used to keep a digital registration of all producers and to ensure that producers comply with the regulations[104].

In 2019, SDAB ended its contract with the previously selected main contractor and pursued a new direction as a PRO under its own management. As a result, the transport, sorting and processing of ELTs is the responsibility of SDAB in collaboration with regional subcontractors across the country. New recycling facilities have been established throughout Sweden[105], processing varying amounts of ELTs.

The Swedish system was implemented in 2023 and was based on a global scan of ELT schemes. SDAB chose this “insourcing” approach where they own the material and facilities for recycling to avoid a lock-in where only few recyclers can alone determine the market price of handling ELTs, and because they saw a decrease in the opportunities to use the recycled materials. At the same time, they have seen a lack of mechanical recycling in Europe, for up to 100 million tonnes of tyres, and a cement industry that is increasingly looking towards electrification and biobased fuels.

Hence, the focus is now on R&D on material recycling, which they can now pursue because they own the material. This includes:

1. Sorting the tyres before shredding and granulation based on type, to get more uniform rubber blends.
2. Looking into devulcanization of especially truck tyres / large tyres, because they usually consist of more simple mixtures, whereas passenger car tyres can have up to 200 different trace compounds and additives.

Furthermore, SDAB have full subsidiary daughter company, BonOrbit, acting as the seller of the recycled rubber, and have a plan to make all the knowledge on material purposes open source, because even though rubber is a very well-researched material today, most of the information is confidential and kept within private companies. By owning the material and researching new uses, the plan is to this profitable enough to eventually bring down the Eco-fee in the ERP.

SDAB has seen an increasing interest in rubber from pyrolysis companies. As a result, SDAB has entered into delivery agreements for tyre raw material with several pyrolysis actors.

Pros:

[103] https://www.naturvardsverket.se/en/guidance/extended-producer-responsibility-epr/producer-responsibility-for-tires/

[104] https://www.naturvardsverket.se/en/guidance/extended-producer-responsibility-epr/producer-responsibility-for-tyres/

[105] https://sdab.se/dackatervinningen/anlaggningar/

- One main advantage is that there is mandatory collection and forwarding to authorized recycling facilities of ELTs at retailers or repair shops when tyres are replaced. This ensures that the ELTs are properly managed and included in the system.
- There are many advantages to the current EPR scheme in Sweden. SDAB adjusts fees as needed to reflect the actual costs of the waste management activities and, by insourcing recycling, SDAB also avoids dependency on external recyclers and market price fluctuations. This approach also gives SDAB more control over material quality, processing efficiency and the sale of recycled material. At the same time, SDAB's ownership of the recycled material facilitates research into advanced recycling methods, such as devulcanization and pyrolysis.
- SDAB's focus on profitability and material innovation will also lead to reduced recycling fees in the future, creating a more cost-efficient system.
- Finally, economic sanctions to producers and importers when they do not comply with the legislation minimizes the risk of non-compliance.

Cons:

- However, there are also some disadvantages of this system. Firstly, it does not include tyres fitted on new vehicles, which can lead to these tyres not being properly managed once they reach their end-of-life.
- In addition, SDAB's ownership of processing facilities and materials may in the future create a monopoly-like situation, which limits competition and innovation in the recycling industry. In addition, it also requires significant investments in R&D, new processing facilities, leading to higher initial costs, which could temporarily increase the fee producers must pay.
- Finally, despite being low, the annual fee that producers must pay to the Swedish EPA is an additional cost that they must consider when selling tyres in the Swedish market.

What DK can adopt:

- Similarly to SDAB, the Danish system could periodically revise the subsidies and fees of the system to reflect actual costs, ensuring the system is financially sustainable (see section 2.2 on economic structure of the current Danish scheme).
- High focus on research and innovation to find uses for the ELT materials.

6.4 EPR scheme in Netherlands

In 1995, the Dutch government introduced the first legislation on ELTs: the Decree on removal of car tyres, which places the responsibility on producers to establish and manage the entire process for handling ELTs[106]. However, in 2004 the Dutch Ministry of Environment replaced this legislation with the Car Tyre Management Decree. This legislation places responsibility on tyre producers to ensure that ELTs are properly collected, recycled or disposed of in an environmentally responsible manner.

The legislation applies to tyres from passenger cars, light commercial vehicles, trailers and caravans (category C1). However, there is no formal system in place for collecting other types of tyres, such as those from motorcycles or trucks. As a result, only used car tyres from the replacement market, along with tyres from caravans and trailers, are collected.

[106] https://www.recybem.nl/en/new-tyres/dutch-legislation-end-of-life-tyres

To comply with this legislation, the Dutch Tyre Association founded RecyBEM, a collaborative initiative involving tyre suppliers, manufacturers, importers, and their customers, which serves as the PRO since 2004.

Consumers can drop off old tyres free of charge in approximately 12,000 retailers[107] or at their municipalities. RecyBEM-certified collectors operate across the country, gathering ELTs from various sources, including garages, tyre specialists, suppliers of car accessories, car dealers and similar companies in the tyre industry. There are 14 certified collectors[108] that must live up to the requirements set by RecyBEM to be certified. These collectors are the only ones that can get subsidy, and they are all professionalised and specialised in car tyres, and have a contractual agreement with the EPR operator that they have to sort the tyres.

The collected tyres are sorted into two categories: 20-30% are deemed reusable[107], while the remainder are classified as scrap. This is incentivised by the economic benefit of reselling reusable tyres. Both the professionalisation of the collectors to be able to sort, and the economic incentive of the subsidy from the PRO (RecyBem) are drivers for the high reuse rate: collectors get 1.35 EUR per tyres for collecting them, but if they sort and export them for reuse (documentation necessary), they get between 2-4 EUR per tyre.

Reusable tyres are given a second life, either through direct reuse or by being re-treaded. Scrap tyres, on the other hand, can be repurposed for alternative uses, sent for material recycling, or used as fuel in cement kilns and power generation plants. RecyBEM currently collaborates with seven certified recycling companies to ensure the proper processing and sustainable disposal of scrap tyres. Tyres can only be sent to certified treatment facilities, and RecyBEM maintains ongoing dialogue with these facilities to monitor and manage the associated costs[108].

All tyre manufacturers and importers are required to register with RecyBEM and pay fees based on the number of tyres placed on the market. These fees fund the collection, recycling, and environmentally safe disposal of ELTs. Free-riding is not a huge problem, but online sales do pose a risk for free-riding in the system.

RecyBEM is responsible for determining the waste management contribution and the collection subsidy annually, according with the pay-as-you-go system. Once the year ends, the rate is definitively determined based on the available financial information[109.] However, once every two or three years, a market and cost price study is carried out by an independent party, considering all the costs of the system, such as collection, processing and administration, as well as inflation and investments. According to RecyBEM, these cost assessments cost between 50 and 80 thousand EUR[108]. Because some of the tyre collectors also collect other fractions of waste, it is difficult to assess the collection costs. As a result, this full cost research only focuses on pure tyre collectors[108].

A portion of the collected ELTs qualifies for second-life use as tyres, which are typically exported. While the primary market used to be within Europe and United Kingdom, the largest share is now in Latin America and Africa, accounting for 50% of exports[108]. Collectors are required to report to RecyBEM the destination of all exported tyres. To be eligible for reuse, tyres must be inspected and certified, with a minimum tread depth of 1.6-2.0 mm, though most

[107] https://www.recybem.nl/en/about-recybem/collection-and-processing-system

[108] Interview with RecyBEM representatives on 03.10.2024

[109] RecyBEM annual report 2023: https://www.recybem.nl/sites/recybem.nl/files/user/240731_avv_monitor_autobanden_2023-gecomprimeerd.pdf

have 3-5mm. Many of the tyres exported for reuse come from leased vehicles, where tyres are often replaced when the vehicle is returned. Additionally, when individuals experience a puncture in one tyre, they frequently replace all four, even if the remaining tyres are still in good condition.

The high rate of tyre reuse is a result of the collectors' expertise in sorting, ensuring that tyres in good condition are identified for reuse. In recent years, larger collectors have increasingly automated their sorting processes, further enhancing efficiency and quality.

Pros:

- One of the main advantages of the EPR scheme in the Netherlands is that its PRO requires all collectors and recyclers to be certified, ensuring quality control across the supply chain. In addition, the PRO determines the fees and subsidies annually based on the previous year and commissions third party cost analysis studies every two to three years, ensuring that fees remain fair and aligned with the costs of the system, resulting in financial sustainability.
- In addition, the high-quality sorting leads to high reuse rate of ELTs, reducing waste and extending the life cycle of the tyres. Although most ELTs for reuse are exported, the PRO requires collectors to report on the destination of the tyres, which ensures traceability.

Cons:

- There are several challenges in this system. The major one being the fact that it applies only to C1 ELTs, leaving all other types of ELTs outside this system. Those tyres are not formally managed, which can result in unsuitable end-of-life processing.
- Because the reused tyres are exported to countries in Africa and Latin America, the system heavily relies on these markets. Therefore, if there are any changes to market demands, the system is left with ELTs that need to be managed differently. In addition, the prolonging of the tyres life in these countries is dependent on how many kilometres are left in the tread. If few km is left, the export is merely passing the burden of ELT management to these countries, where the end-of-life treatment will likely be worse compared to the Netherlands, leading to higher environmental impacts.

What DK can do:

- Denmark can adopt a pay-as-you-go model for fees and subsidies. It can be based on annual financial information on the real costs of the waste management. In addition, conducting cost analysis studies regularly will also help determine accurate and suitable fees and subsidies.

6.5 EPR scheme in Italy

In 2006, Italy adopted its comprehensive environmental law (Legislative Decree 152/2006), which sets waste management principles and the responsibility of producers to handle various types of waste, including tyres. Under Article 228 of this decree, tyre manufacturers and importers are obliged to manage a quantity of ELTs equal in weight to that placed on the replacement market in the previous calendar year[110]. However, there is no further guidance on how this obligation should be fulfilled, such as which technologies to use or specific methods of treatment.

However, there was no national system that managed the complete collection and recovery of tyres. In 2011, the Italian government introduced the Decree 82/2011, which introduced

[110] https://www.ecopneus.it/en/who-we-are/corporate/mission-and-objectives/

specific regulations to manage ELTs. This decree defined the responsibilities of tyre producers and importers under the EPR framework, requiring them to ensure the collection, recovery and recycling of used tyres at national level. Since the introduction of the EPR, illegally disposed tyres, which constituted 25% of tyres put on the market in 2010, have steadily decreased[111].

To meet these obligations, leading tyre manufacturers in Italy (Bridgestone, Continental, Goodyear-Dunlop, Marangoni, Michelin, and Pirelli) formed a non-profit PRO in 2011: Ecopneus. This PRO manages the collection, transportation, processing and disposal of ELTs on behalf of producers. Ecopneus is one of 25 PROs in Italy, where there are nine consortiums and 16 individual organisations, all responsible for the management of ELTs. However, it is the largest and most prominent one, handling around 350,000 tonnes of ELTs annually[112].

Under the Italian EPR scheme, tyre producers and importers must join a consortium to meet their legal obligations. Each consortium manages the logistics, financing and operations related to the collection and processing of ELTs.

The Italian EPR scheme covers small, medium and large ELTs, ranging in weights. Replacement tyres coming into the national market must pay the fee. However, according to Ecopneus, online sales are not included. As a result, these tyres do not contribute to the system but must still be collected and processed. As a result, each year this scheme has a collection rate over 100%. In addition, the scheme does not cover tyres fitted onto new vehicles and are instead covered under the End-of-Life Vehicles Directive.

Consumers can return used tyres to various collection points, including tyre dealers, garages, and recycling facilities. Many dealers offer free tyre disposal when new tyres are purchased. Once ELTs are removed from vehicles, they are transported to specialized facilities where they are weighed, examined, and stored before being sent to processing plants[113].

The fee is used to finance the collection, transport, and processing of ELTs, as well as R&D and administrative activities. Ecopneus prepares tenders, for which collectors, shredders and processing facilities prepare a proposal stating the volumes of tyres they can handle and for what price. These tenders are typically for three years, and the fee is calculated for this period, based on the collection target and the tenders. However, the fee can be reviewed each year if there are changes to the collection target or to the market.

Under Italian law, ELTs are classified as waste. As a result, ELTs cannot be reused or re-treaded and PROs can only deliver them to material or energy recovery. However, the ELTs in best condition can be sold and exported to other countries to be reused or re-treaded, which is currently uncontrolled.

Pros:

- This scheme handles several types of tyres, ranging from 0 to over 705 kg.
- The PRO receives proposals from collectors and processors of ELTs, detailing the quantity of tyres they can collect and/or process, along with their pricing. This approach incentivises competition among collectors and processors.

[111] Interview with Ecopneus on 04.10.2024

[112] https://www.ecopneus.it/en/who-we-are/system-and-management/the-italian-scenario/

[113] https://www.ecopneus.it/en/elt-recycling/end-of-life-tyres/recycling-and-recovery-of-elts/

Cons:

- Once used tyres are classified as ELTs. These can no longer be sent to reuse or re-treading, complicating re-treading efforts. Therefore, there is a high focus on material and energy recovery.
- Some of the tyres are put on the market illegally, such as tyres bought online, and therefore are not contributing to the system but still require collection and processing. This is additional challenge, as the fees coming into the system must be able to cover all the tyres collected and processed.
- With more than one PRO there is a risk that the organisations only handle the amount of tyres that are covered by the fees and refuse to handle any other tyres, leading to some tyres being disposed improperly.
- There are several PROs working on managing ELTs, which has led to management challenges: the geographical decision of where and how each PRO must collect is difficult.

6.6 EPR scheme in Portugal

The Portuguese government introduced the Decree-Law No. 111 in 2001, which established the applicable rules for the management of used tyres. This decree mandates that tyre producers, importers, and retailers are responsible for the collection, treatment, and recycling of ELTs. Additionally, it sets guidelines for creating a system to ensure that all used tyres are properly managed. According to the legislation set by Portuguese government, the PRO is responsible for ensuring 96% of the ELTs are collected and 65% of these prepared for reuse or recycling. This goal will increase in the future[117].

To meet these obligations, tyre producers together with the tyre re-treading and rubber industry sectors created Valorpneu. Valorpneu is a private non-profit organisation established by leading tyre manufacturers in collaboration with Portuguese associations in 2002 with the primary goal of creating and developing a system for the proper management and processing of ELTs[114].

The EPR scheme covers the entire national territory, including the autonomous regions of Madeira and Azores, situated in the Atlantic Ocean. Due to their distance to the mainland, operation costs are higher[117].

The Portuguese EPR scheme covers all types of tyres (14 different categories), from bicycles to passenger cars, industrial vehicles and aircrafts.

Distributors, workshops, dismantlers, local authorities, and individuals who hold used tyres can drop them off free of charge at one of the many collection centres spread across the country (51 in 2023**Error! Bookmark not defined.**). These centres serve as temporary storage sites for used tyres. The autonomous regions also have collection centres, where the tyres are delivered and then sent to waste treatment, either in one of the islands or the mainland[117].

In the collection hubs, the tyres are weighed, classified, sorted and prepared to be sent to the relevant treatment facilities. It is the collection hub's duty to ensure that the tyres are decontaminated (from algae, dirt, or other contaminants) by promoting the delivery of clean tyres. When there is a contaminated tyre, the collection centre may refuse to accept the tyre

[114] https://www.valorpneu.pt/sobre-a-valorpneu/quem-somos/

or may clean the tyre afterwards. The collection centre may incur on fees, fines or performance penalties if the tyres are delivered to the treatment facilities contaminated.

There are 21 transport providers, 20 re-treading companies, two recycling companies and five energy recovery operators that are part of Valorpneu's network**Error! Bookmark not defined.**. Despite only having two recyclers, the Portuguese PRO has not registered issues regarding increases in the gate fee of these recyclers. According to Valorpneu, this is because they consistently try to supply ELTs according to the amount the recyclers require, ensuring that one does not have a larger share of the market and are therefore distributed according to demand[115]. As a result, this guarantees that recyclers are on equal footing and the recyclers are operating at a balanced and fair price.

Some tyres are reused; however, this is only possible when the tyre maintains legal tread depth and is in good condition for further use[117]. These tyres are only reused domestically and are not exported to other countries where regulations regarding tyre specifications are more lenient[117].

Under this system, any individual or organisation responsible for placing tyres on the national market is required to enter into an agreement with Valorpneu[116] and pay the applicable eco-fee for the tyres being introduced, which is included in the cost of the tyre introduced into the national market (new or used)[117]. The producer pays Valorpneu the eco-fee corresponding to the quantities they produced or imported and placed on the market**Error! Bookmark not defined.**. The eco-fee supports the collection, transportation and processing (preparation for reuse, recycling and energy recovery) of ELTs. The system also includes marketing and communication activities, as well as funding of R&D activities[117].

The fee varies according to the type of tyre placed on the market but is charged only once per tyre: re-treaded and reused tyres reintroduced domestically are exempt from an additional fee. However, re-treaded and reused tyres imported into Portugal must still pay the eco-fee[117]. Furthermore, scrap dealers importing end-of-life cars must also pay the eco-fee. In addition, vehicles sold with tyres already attached are also required to pay the eco-fee[117].

The eco-fee is calculated based on an estimate of the costs of the entire system, ranging from costs for collection, transport, recycling and energy recovery, to marketing, R&D and administrative costs[117]. This fee is reviewed whenever necessary, typically when a new licence is issued, but can also be modified during the current licence period[117].

The eco-fee is itemized on the invoice and paid by the consumer, ensuring full transparency[117]. However, certain challenges may arise: if consumers purchasing new tyres do not request an invoice, there is a risk that the fee may be excluded from the final price, perhaps to offer a more competitive price. As a result, the tyre is not registered with Valorpneu and does not contribute to the system, meaning it will still need to be collected and processed but there is no fee to cover for this[117].

Pros:

- The main advantage of this system is that it applies to all types of ELTs, including those from bicycles, industrial vehicles and aircrafts, ensuring that none are disposed

[115] Email correspondence with Valorpneu on 21.11.2024

[116] https://www.valorpneu.pt/sistema-sgpu/modelo-operacional-e-financeiro/

[117] Interview with Valorpneu on 18.10.2024

of improperly. In addition, the system also applies to tyres fitted in vehicles and tyres in imported ELVs.

- In addition, any tyre entering the national market, regardless of if it is new, re-treaded or reused, must pay the eco-fee. Despite potentially discouraging cross-border trade, it ensures that all tyres entering the market contribute to the system. On the other hand, the system also includes
- In addition, tyres in good condition with adequate tread depth are only reused domestically, not relying on foreign demand. By not charging an eco-fee to reused tyres reintroduced domestically, the system can encourage reuse.
- In addition, the system is capable of handling the mainland and the autonomous regions, which are islands and require further costs.
- The fact that no other PRO emerged throughout the 20+ years that the EPR scheme has been in place suggests that the system with Valorpneu works well and has positive results.

Cons:

- The scheme has higher costs due to the operations in the islands, which come with transportation and logistical challenges. On the other hand, tyres sold without proper invoicing may evade the eco-fee, creating in the future ELTs that have not contributed to the system.
- The model is not door-to-door and the tyres must be delivered to the nearest collection hubs at the cost of the entity responsible for its delivery, such as retailers or workshops.
- Some tyres enter the market illegally and are not contributing to the system but are still collected and processed. This adds an additional cost for the system.

What can DK do:

- Include all types of tyres in its system

6.7 Comparison of strengths and weaknesses of the different ELT systems

The EPR schemes analysed function similarly, in the sense that they require tyre producers and importers to pay an eco-fee when tyres are introduced into the national markets, which is then used to cover the costs of the end-of-life management, including the collection, transport and processing of the tyres, which is managed through a PRO. All EPR schemes have only one PRO, apart from Italy, which has several PROs operating independently. Overall the **Danish ELT system is very similar to an EPR** scheme, in the sense that a fee is charged for placing tyres on the market, an organisation is set up to handle the system and subsidies (DBMF in collaboration with the Danish EPA who is assisted by the Danish Tax Authorities), and that subsidy is paid based on the collection and even environmentally differentiated, since the subsidy depends on the recycling rate of the recycler it is delivered to.

The most different system is the German free market system, which is driven by supply and demand of ELTs, where private companies oversee the collection and processing activities and there are no entities responsible for legal compliance, but every part of the value chain must adhere to the legislation and function within the free market conditions. Because the German system allows for competition among private collectors and recyclers, the costs for collection and recycling are kept manageable. In addition, this system also adapts more readily to market changes, such as the rise of energy prices, which leads to more tyres used for energy recovery.

Although the **fees across EPR schemes** vary according to the type of tyre sold, it is possible to draw a comparison of the fees per kilogram of tyre. As shown in TABLE 12, Italy, on average, has the highest fee per kg of tyre, with an average of €0.281, followed by Sweden, Denmark and the Netherlands. Although Portugal has the lowest fee per kg of tyre, with an average of €0.120, the fees will be adjusted in 2025, with some increasing and others decreasing. Germany does not have a fee that producers must pay when selling their tyres in the national market. However, it should be noted that this comparison is conducted in absolute terms, and it does not account for general price level differences or purchasing power disparities between the countries.

The selected EPR schemes **adjust the fees differently**: both the Swedish and the Portuguese PRO adjust the fees of the system on a need basis, to reflect the actual costs of the system. These adjustments are based on an estimate of the costs of the system, which is carried out internally by the PRO. The Italian PRO sets the fees based on the costs of the system for the next three years but can review them on a need basis, if there are changes to the market. On the other hand, the Dutch PRO provisionally determines the fees and subsidies annually and every second or third year commissions a third-party cost analysis of the ELT system and adjusts the fee based on this. These adjustments ensure that fees remain fair and aligned with the costs of the system. Although the fees in the Danish system are adjusted annually according to the general price and wage index, there must also be a balance between fees and subsidies over a four-year period. To maintain this balance, fees, subsidies or both may be adjusted based on the findings of a market study.

Besides the eco-fee paid, in Sweden tyre producers must also pay an annual fee of SEK 1,000 to the Swedish EPA. This fee supports the maintenance of a digital registry of all producers and ensures compliance with the regulations. Although this contributes to the well-functioning of the scheme, it adds an additional financial burden to the producers. On the other hand, and in contrast to the eco-fees that PROs charge to producers, it is more difficult to transfer directly these fees to consumers.

In terms of **tyres covered** by the different systems, the EPR schemes apart from the Netherlands, which covers only passenger car tyres, include most of the different types of ELTs for cars, vans, trucks, buses, and agricultural and construction vehicles, with Portugal also covering aircraft and bicycle tyres. Similarly, Denmark also covers most of these tyre categories, whereas Germany covers the ELTs for which there is a demand.

On the other hand, except for the Portuguese EPR scheme, the remaining ELT systems analysed include only **replacement tyres** and not tyres fitted onto new vehicles. Although some of these tyres are covered by separate legislation, such as in Sweden and Italy, in the remaining countries analysed these tyres are not covered. This means that these tyres are not contributing to the ELT system but still require proper disposal that does not include landfill, according to European legislation.

In terms of **collection**, EPR schemes allow consumers to deliver their used tyres free of charge in collection points. However, in Germany the collection of ELTs can either be for free or for a small fee. Despite this, Germany has the highest collection rate (115%) among the countries examined, collecting 504,000 tonnes in 2023, followed by Italy (112%), Portugal (110%) and the Netherlands (108%). In comparison, in Denmark collectors have, since 2024, charged waste producers for the collection of ELTs, as a result of the increased gate fees from recyclers.

While in Sweden, the Netherlands and Italy, the consumers can hand in their ELTs in collection points for free, such as retailers, workshops, recycling centres and other actors handling tyres, in Portugal the tyres must be delivered to specific collection centres spread out

across the country, which means that the cost for this fall onto the companies or individuals that need to dispose of tyres.

The **sorting** occurs differently in the analysed countries. In both Italy and Sweden, the tyres are weighted, classified and sorted at centres and recycling facilities, respectively. Similarly, the Dutch and Portuguese PROs require collectors to be responsible for the sorting, promoting the delivery of pure fractions to each processing method. On the other hand, in Germany, the tyres are first sorted in containers by tyre dealers, which are then picked up by collectors. Dealers are encouraged to sort ELTs, by providing financial incentives. There are, however, some challenges with the current German system, as some waste collection companies get rid of tyres by sending them to incineration instead of recycling. In addition, some collectors “cherry-pick” high-value ELTs, which are sent for reuse, while low-value ELTs that cannot be resold are dumped in nature.

In contrast to other systems, where the collectors are paid by the PRO to deliver the tyres to waste processing, according to national legislation objectives, in Denmark the collectors can only receive the subsidy when delivering ELTs to one of the approved recyclers. This means that there is a high incentive in Denmark to recycle ELTs, which has led to a recycling rate of 96% in 2023, the highest among the countries analysed, as seen in TABLE 12. This **high recycling rate** may also be a consequence of the relatively short transport distances (compared to other countries) and the proximity to recycling facilities.

The Dutch and Portuguese EPR schemes also registered a high recycling rate in 2023, of 73% and 70%, respectively. In the Netherlands, the high recycling rate can be caused by the unique collaboration of parties across the value chain, whereas Portuguese legislation mandates certain material recovery rates, which the EPR system must fulfil. Similarly to Denmark, in Portugal there are also two recyclers. However, there have not been issues regarding gate fees. This is because the PRO consistently supplies ELTs according to the recyclers’ demand, ensuring that none of them have a much larger share of the market and artificially inflates the gate fee.

In Europe overall, many ELTs are sent to the **cement industry**, or energy recovery in general, which represents the lowest tier of tyre recovery[108]. Some of the key challenges, in addition to transport distances, are the economic incentives to send to recycling over energy recovery is not large enough or is missing in some systems. Also, most systems do not ban this way of handling, even though some PROs set recycling targets. This results in between 1,3 and 1,5 million ELT being **exported** outside of Europe for processing (out of the total 3,5 million ELTs generated in Europe), a significant part of these to cement industries, for example in Morocco. Furthermore, there can be restriction with transporting waste across borders, and in some countries like Italy, once tyres are classified as waste, they can no longer be reused as tyres (or for re-treading).

In Sweden, in 2023, around 68% of ELTs were sent for **energy recovery**, either to incineration plants or the cement industry. On the other hand, only 27% were recycled in the same year. To increase the low recycling rate that Sweden has registered in the past years, the Swedish PRO has recently decided to insource recycling, by investing in several recycling plants across the country and being responsible for the whole management system of ELTs, in collaboration with subcontractors across the country. This not only ensures that ELTs are recycled but also that the PRO is in control of the product development of the granulate. In addition, it reduces the scheme’s dependency on external recyclers. Although there is potential for this to improve recycling methods, there is a risk that it creates a monopoly-like situation, which will limit competition and innovation in the industry. In addition, the initial costs of these investments could also temporarily increase the fees of this system. In 2024, Sweden managed to increase recycling rates to above 50% with this new system.

The Swedish system was implemented in 2023 and was based on a global scan of ELT schemes. SDAB chose this “insourcing” approach where they own the material and facilities for recycling to avoid a lock-in where only few recyclers can alone determine the market price of handling ELTs, and because they saw a decrease in the opportunities to use the recycled materials. At the same time, they have seen a lack of mechanical recycling in Europe, for up to 100 million tonnes of tyres, and a cement industry that is increasingly looking towards electrification and biobased fuels.

The Dutch EPR scheme has high direct **reuse rates**, which is due to its high-quality sorting, one of the requirements that approved collectors must fulfil. However, these tyres are not reused domestically but are instead typically exported to countries in Africa and Latin America, which makes the country rely heavily on this external market. In addition, there are only environmental benefits to reusing tyres if these tyres have many kilometres left in the tread. Otherwise, it can be argued that the burden of waste handling is simply shifted to poorer countries where the waste management systems for ELTs are worse when compared to the Netherlands.

Re-treading has declined significantly over the past few decades in Europe, leading to a generally low re-treading rate among the selected countries, with countries like Sweden not sending any ELTs for re-treading. The reason for this decline is the diminished demand for re-treaded tyres, both C3 and C1 tyres, where the latter almost completely disappeared, largely due to public perception that re-treaded tyres are of lower quality. The increasing availability of cheap tyre imports in the European market also plays a big role, with many end-users opting to purchase new tyres over re-treaded ones.

Despite this trend, both the Netherlands and Portugal achieved considerable re-treading rates of 3% and 11%, respectively, in 2023. However, Germany registered the highest re-treading rate in the same year, reaching 14%. This relatively high rate can be attributed to the demand for re-treading tyres used in construction and agricultural vehicles, for which casings are typically expensive. As a result, collectors are incentivised to sell ELTs to re-treaders, as they can earn more money. In contrast, countries like Italy face additional challenges in reusing and re-treading of tyres due to regulatory barriers. Under Italian law, ELTs are classified as waste, meaning that once used tyres are categorized as ELTs, they cannot be reused or re-treading within the country, discouraging these treatment methods. Instead, the focus shifts to recycling and energy recovery, which in 2023 were evenly split, with each accounting for 50% of the treatment methods. Such regulatory framework surrounding waste management acts therefore as a barrier in this regard[108].

TABLE 12. Comparison table of selected End-of-life Tyre management systems and Danish End-of-Life Tyre system.

Country	Type of scheme	Relevant Organisation	Types of tyres collected	Amount of tyres collected	Collection Rate[118]	Recycling rate (% of collected sent to recycling)	Re-treading rate (% of collected sent to retreading)	Energy recovery rate (% of collected)	Tyre fee per kg[119]
Denmark	Tax/subsidy system	Danish EPA + Dækbranchens Miljøfond	Passenger cars, motorcycles, vans, truck, buses, agriculture vehicles and construction vehicles	45,444 tonnes	125%	96% (of this approx. 89% is recycled[120])			€0.182
Sweden[121]	EPR	SDAB	Passenger cars, trucks, buses, motorcycles, tractors, all-terrain vehicles, motor equipment, trailers and after vehicle.	84,808 tonnes	Not specified	Material recycling: 23% Recycling for energy recovery: 4%	-	68%	€0.191
Netherlands[122]	EPR	RecyBEM	Passenger cars	9.8 million tyres	108%	Reuse: 22% Material recycling: 73%	3%	2%	€0.170

[118] The collection rate in this table is calculated as Tyres collected, since this is the numbers available from other countries. However, in Denmark the collection rate is usually calculated using the "potential", which is the average tyre sales for the previous 3 years vs. collection in the current year. This number was 95% in 2023.

[119] The tyre fee per kg for each country was calculated based on the fee per tyre and the average weight of each type of tyre. When unavailable, assumptions were made

[120] https://www.daekbranchens-miljoefond.dk/

[121] Data collected from SDAB's Annual Report 2023: https://sdab.se/wp-content/uploads/2024/06/Annual-report-2023-SDAB-30-year.pdf

[122] Data collected from RecyBem's report 2023: https://www.recybem.nl/sites/recybem.nl/files/user/240731_avv_monitor_autobanden_2023-gecomprimeerd.pdf

Country	Type of scheme	Relevant Organisation	Types of tyres collected	Amount of tyres collected	Collection Rate[118]	Recycling rate (% of collected sent to recycling)	Re-treading rate (% of collected sent to retreading)	Energy recovery rate (% of collected)	Tyre fee per kg[119]
Italy[123]	EPR	Ecopneus	Covers different types of tyres, from 0 to more than 705 kg	187,818 tonnes	112%	Material recycling: 50%	-	50%	€0.281
Portugal[124]	EPR	Valorpneu	All types of tyres, including bicycle	92,041 tonnes	110%	Reuse: 1% Recycling: 70%	11%	28%	€0.120
Germany[125]	Free market	Wdk + Azur Network	All that have value	504,000 tonnes	115%	Recycling: 46%	14%	23%	None

[123] Data collected from Ecopneus' Sustainability Report 2023: https://www.ecopneus.it/wp-content/uploads/2024/11/2711_Ecopneus_Report-2023-ITA_SINGOLA_per-approvazione.pdf

[124] Data collected from Valorpneu's Sustainability Report 2023: https://www.valorpneu.pt/wp-content/uploads/2024/09/DA_2023_vf2-Assinado.pdf

[125] Data collected from ZARE's website: https://zertifizierte-altreifenentsorger.de/en/sustainable-waste-tire-disposal/used-tire-recycling-in-germany/

7. Potential solutions to the identified problems

In accordance with the Better Regulation Toolbox, the five identified problems in the problem tree in section 2.3 are repeated here, but this time with the solution-side of the problem tree, namely the policy objectives and potential solutions (labelled A to L). Each solution is described in this section.

The specific objectives related the problems are all based on two overarching general objectives:

1) Creating a level playing field for the actors in the ELT value chain
2) Ensure ELTs are handled with the least possible environmental impacts, baes on ensuring treatment according to the highest possible level in the waste hierarchy

The fee and subsidy system is fundamentally based on the waste hierarchy for tyres, aiming to ensure the collection and recycling of ELTs, and avoid dumping and landfilling. This approach is intended to achieve the most optimal solution for handling discarded tyres in an environmentally responsible manner, with a focus on recycling. While the Waste Hierarchy (shown in section 3.2) gives a prioritisation of end-of-life handling methods, it does not differentiate between different technologies for recycling, or the trade-offs there can be with reuse. A more thorough environmental quantification like and LCA would be needed for that, to also include the derivative effects of how tyres are handled.

1. **Reuse:** Tyres discarded by users may still be usable in certain cases, primarily abroad, where safety requirements may differ. For instance, tyres with a tread depth of 3 mm, which are discarded in Denmark, may still be used in regions like Africa and the Middle East on dry roads, where there is no requirement for tread depth to provide water drainage. On the other side these practices could be controversial, by example exporting to Africa are anyway very close to the end of life means that the receiving countries will need to take care of the end of life and often these countries are not ready for a proper end-of-life treatment.

2. **Re-treading**: Tyres that cannot be used for continued driving may, in some cases, be re-treaded, giving the tyre a "new life" with a new tread. This form of reuse is the second priority in the waste hierarchy but is not eligible for subsidy in the Danish tyre system. However, Danish tyres that are collected and re-treaded in Denmark are exempt from fees when the re-treaded tyre is placed back on the market.

3. **Recycling**: When tyres cannot be used for continued driving or re-treaded, recycling becomes relevant under the Danish Tyre Executive Order, and it is covered by the fee and subsidy system in Denmark. Here, the tyre is processed through granulation or pyrolysis, and the resulting fractions are used in the production of new products.

4. **Incineration:** Incinerating tyres can be a form of recovery by utilizing the tyre's calorific value. However, incineration of tyres at waste incineration plants presents challenges due to the tyres' size and high calorific value, which require special handling. Increasingly, tyres must be pre-shredded to reduce volume, optimize incineration conditions, and prevent the release of harmful substances, as tyres contain a mix of chemicals, including heavy metals and organic compounds that are released during combustion[126].

5. **Disposal:** The final step in the waste hierarchy is landfilling. However, this is beyond the scope of the Tyre Executive Order, and it is illegal to send old tyres to landfills within Europe and other regions. Landfilling tyres is problematic due to the large space they occupy, potential soil and groundwater contamination, fire hazards, and the waste of valuable resources that could otherwise be recycled.[127]

Some solutions may relate to more than one problem, and some problems may require more than one solution. The solutions are not finalised policy options but should be seen more as necessary actions to achieve the objectives, that need to be further refined.

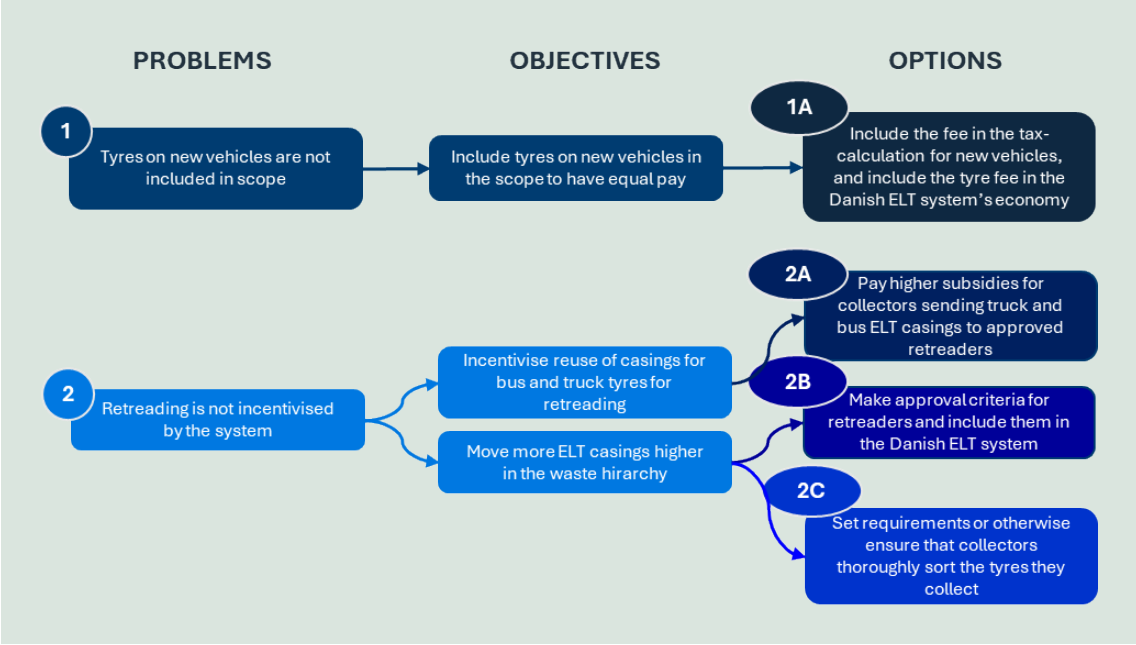

FIGURE 18. Solution-side of the problem tree for problems 1-2 (continued next page), based on the Better Regulation Toolbox Tool#11[128].

[126] Dæk, Miljøstyrelsen

[127] European Tyre & Rubber Manufacturers Association (ETRMA)

[128] Better Regulation Toolbox, European Commission, 2023, https://commission.europa.eu/law/law-making-process/planning-and-proposing-law/better-regulation/better-regulation-guidelines-and-toolbox/better-regulation-toolbox_en

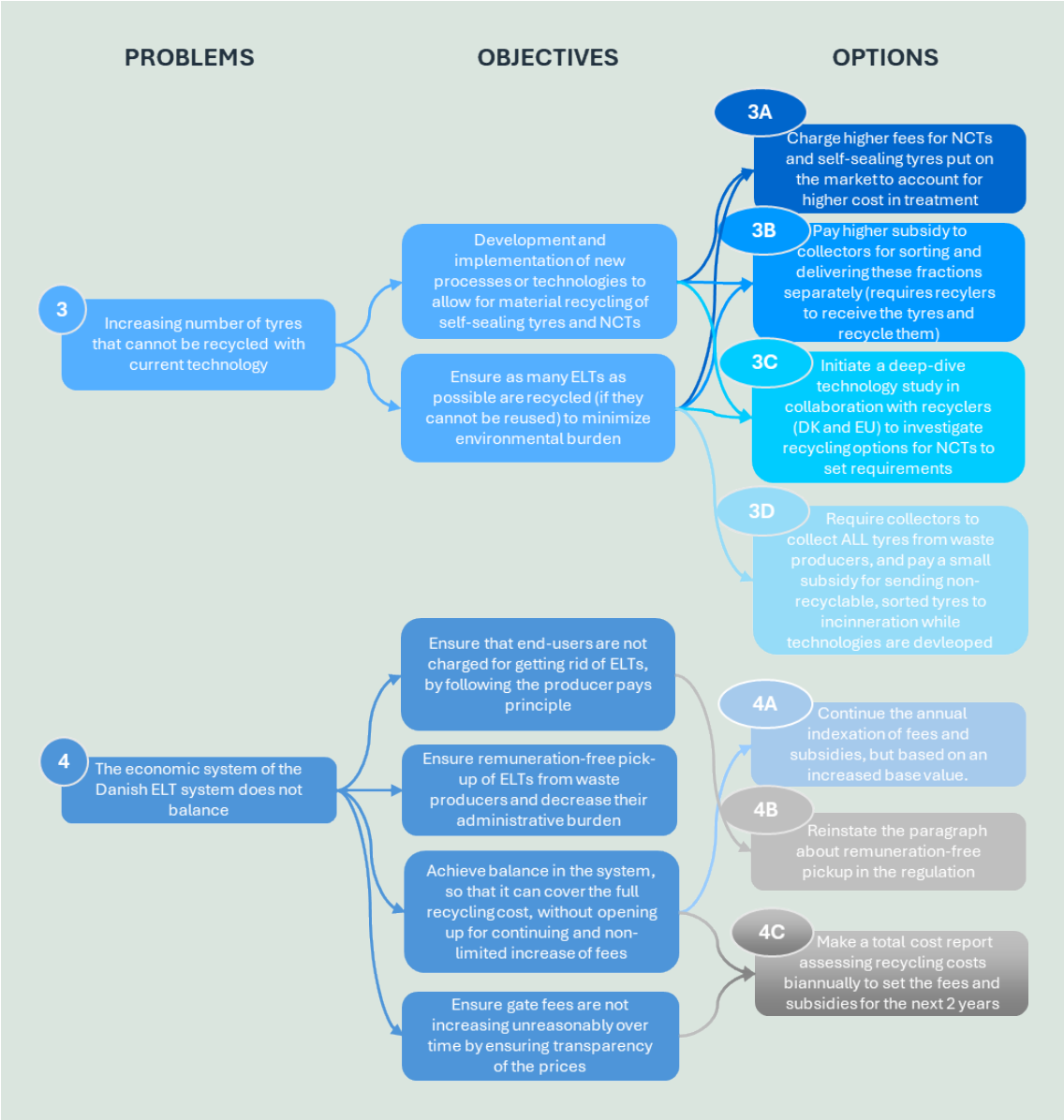

FIGURE 19. Solution-side of the problem tree for problems 3-4 (continued from previous page), based on the Better Regulation Toolbox Tool#11[129].

7.1 Problem 1: New vehicle tyres

7.1.1 Solution 1A: Include new vehicle tyres in scope

To prevent the issue of freeriding with tyres fitted on new vehicles entering the Danish market – tyres which are processed through the ELT system but currently do not contribute to it financially –, these must be subject to the same fee as replacement tyres. By incorporating this fee into the tax calculation for new vehicles, we ensure that all tyres entering the market contribute fairly to the ELT system's funding.

In other European countries, such as Portugal, fees are also applied to tyres fitted on vehicles entering the national market. This approach ensures that ELT management

[129] Better Regulation Toolbox, European Commission, 2023, https://commission.europa.eu/law/law-making-process/planning-and-proposing-law/better-regulation/better-regulation-guidelines-and-toolbox/better-regulation-toolbox_en

systems can handle all tyres within the system without needing to charge duplicate fees, like Denmark, or significantly raising existing fees. It also allows these systems to manage a small number of ELTs that, for several reasons, have not previously contributed financially to the system.

A 2022 assessment by Dansk Erhverv[130] emphasizes the need to increase tyre fee rates overall to ensure that the ELT system can cover the current costs, warning that the system may end if no action is taken. Dansk Erhverv argues that if tyres fitted onto new vehicles also pay fees, these will only need to increase by 89%, as opposed to the 110% increase that is required if these tyres are excluded.

By including a tyre fee on these tyres, not only become the distribution of costs fair across all tyre users but also strengths the financial sustainability of the Danish ELT system, ensuring that it can continue to handle the growing amounts of ELT.

Risks

- Administrative burdens: implementing and managing an additional fee requires coordination between multiple stakeholders and the Tax Authorities.
- Increased vehicles costs: charging fees to tyres fitted on new vehicles may increase the cost of new vehicles, as producers will likely pass this cost onto consumers.

FIGURE 20 shows the effect of expanding the scope to include tyres on new cars. The bars show the current scope (replacement tyres) in the dark blue, and new-car tyres on top. The red lines show the change in total fees incurred by the scope expansion. In total 1.3 million more tyres would be liable to fees in 2035 (varying depending on tyre type), resulting in an increase of almost 23 million DKK in fees in 2035, compared to the baseline.

[130] https://prodstoragehoeringspo.blob.core.windows.net/9dc3eb0f-7b3d-4531-a83a-e0119c0ffb49/H%C3%B8ringssvar.pdf

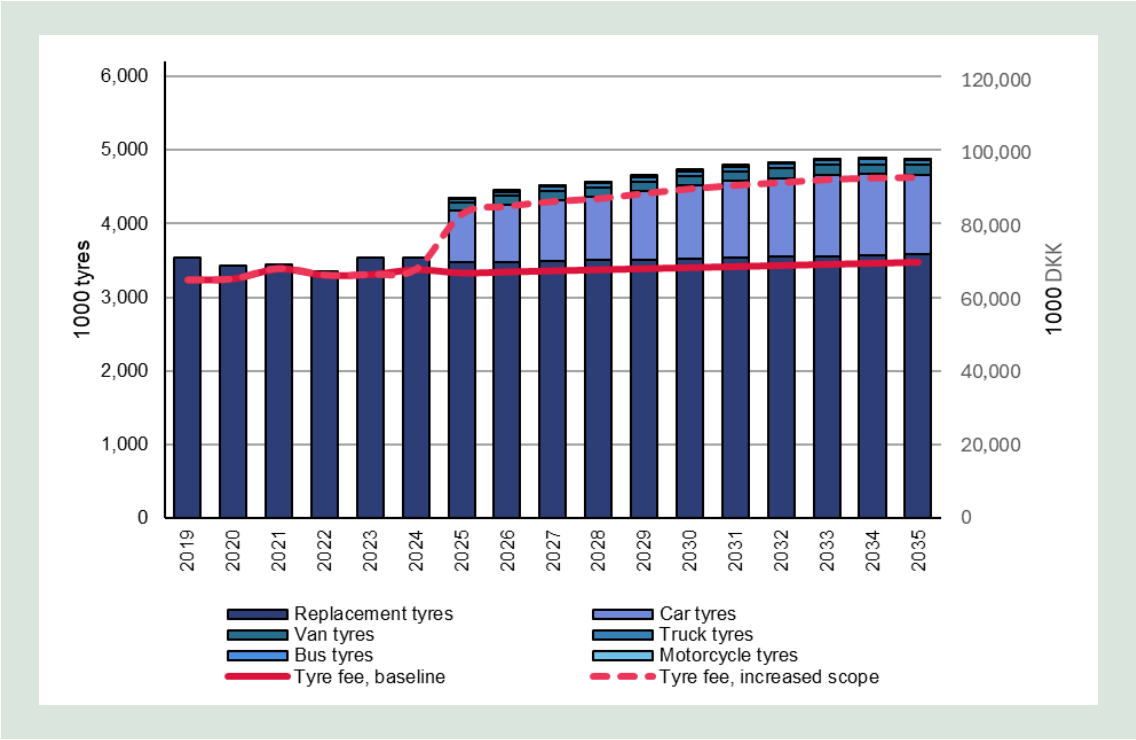

FIGURE 20. Replacement tyres are the total number of tyres included in scope of the end-of-life tyre system today. The additional bars on top is the additional number of tyres that would be included, if tyres on new cars are to be included in the scope. The red line (full) is the baseline of total tyre fee, the red line (dashed) is the total tyre fee included the tyres on new cars.

7.2 Problem 2: Re-treading

If the economic incentive existed to spend more resources sorting casings for re-treading, a larger share could be sent to re-treading. This could also have the derived secondary effect of keeping the prices for re-treaded tyres low enough to increase their competitiveness with cheap, imported tyres.

With the waste hierarchy in mind, waste producers and collectors were asked about the impact it would have on them if the size of the subsidy varied depending on whether the tyre was reused, re-treaded, or recycled into different types of products. The responses of the collectors indicate mixed views regarding the idea of differentiated subsidies based on the use of tyres. Several respondents expressed concerns about the complexity and administrative challenges this could create, especially for smaller collectors or waste producers, and advocated for a simpler system, or were satisfied with the current system. Others acknowledged that aligning subsidies with specific recycling or reuse outcomes could incentivize more environmentally friendly practices.

Introducing differentiated subsidies for both recycling and re-treading would incentivise collectors to prioritise re-treading, as higher subsidies for this process could improve profitability. This could lead to an increase in the number of tyres being re-treaded, and thus a larger market share of re-treaded truck tyres. The effect is expected only to be seen for re-treaded truck tyres (group 6), since re-treading of passenger car tyres is not a viable business, according to all stakeholders questioned about this in this study.

7.2.1 Solution 2A: Higher subsidy for re-treading

Paying higher subsidies for collectors who send truck and bus ELT casings to approved re-treaders has several benefits. This approach incentivizes collectors to prioritize re-treading over disposal, which extends the life of tyres and aligns with the waste hierarchy's emphasis on reuse over disposal. By supporting re-treading, the solution reduces the environmental impact, as re-treaded tyres avoid the need for entirely new production, saving both energy and raw materials. Additionally, this approach fosters a more sustainable framework for managing ELTs within the system by promoting circular economy practices.

Moreover, diverting casings suitable for re-treading reduces the volume of tyres processed by recycling facilities, potentially lowering costs and streamlining operations. The solution also provides economic benefits by supporting local re-treading businesses and stimulating economic activity in sustainable industries.

To avoid that tyres not fit for re-treading are sent to re-treaders (to then be discarded in their sorting) with the only objective of accessing to higher incentives, this solution is highly co-dependent on Solution 2B, and one should not be implemented without the other. This could result in a high rate of discarded tyres at the re-treading plant, with questions on how these discarded tyres would be treaded and who is going to pay for this further step. The subsidy pay out should be scaled according to the actual number of tyres re-treaded and sold as re-treads.

Risks:

- Increased sorting and differentiation complexity: Collectors or waste producers would need to sort casings suitable for re-treading from other types, which could increase labour, logistical demands, and the risk of errors.
- Complications in collection practices: Differentiating between tyre types for separate handling might require adjustments to collection processes, potentially leading to increased operational complexity and higher transportation and storage costs.
- Potential neglect of non-subsidized tyre types: Collectors may prioritize only those casings eligible for the higher subsidy, potentially neglecting or improperly managing other types of tyres

7.2.2 Solution 2B: Approve re-treaders

By formally recognizing and approving re-treaders within the system, re-treading becomes a validated option in the tyre lifecycle, making it eligible for subsidies or other financial incentives. This inclusion would encourage collectors and waste producers to prioritize sending casings suitable for re-treading to approved facilities rather than recycling or disposal.

By integrating re-treading into the ELT system, the financial structure would better support re-treading, reducing waste, and extending the tyre life, aligning more closely with circular economy principles. This could ultimately lower the costs within the system and reduce environmental impact by minimizing the number of tyres needing full recycling or disposal.

To avoid that tyres not fit for re-treading are sent to re-treaders for the higher incentives, just to be discarded at the re-treading plant, the approval of re-treaders should impose some of the same requirements as there are fore recyclers in the current system. This includes annual reporting and calculation of utilisation rate and

documentation for the re-treaded entering the market. The utilisation rates (i.e. tyres sent to re-treading that is actually re-treaded and sold again), should be used to scale the subsidy collectors receive, to incentivise them to accurately sort the tyre before sending to re-treading/recycling.

Risk:

- Higher administrative burden: Collectors and re-treaders would need to comply with more rigorous registration and documentation requirements, creating additional administrative work and potentially slowing down the overall process.

7.2.3 Solution 2C: Sorting requirements

Setting requirements for collectors to thoroughly sort the tyres they collect could improve the efficiency and sustainability of the ELT system. By ensuring that collectors sort tyres accurately, it becomes easier to direct each type of tyre to the appropriate end-of-life solution, whether that is recycling, re-treading, or incineration. Thorough sorting allows for a more precise allocation of resources and prevents recyclable or re-treadable tyres from being mistakenly sent for incineration, which would waste valuable materials. In the Dutch PRO, RecyBem, they have requirements for the collectors to sort the tyres thoroughly, which results in high recycling rates, and investment of the collectors in automatised sorting facilities.

Sorting is also required if for example NCTs are to be recycled. One of the problems today is the contamination of the foam of the waste fractions, and while this could be removed first, this would require these tyres to be sorted and handled separately to go through this additional “foam removal” process. The suggestion here is to put the sorting responsibility on the collectors, as in the Dutch ERP scheme, and deliver sorted fractions to recyclers for processing.

Additionally, sorting could enhance data accuracy in the ELT system by providing a clearer picture of the types and volumes of tyres within each disposal category. This could help authorities and policymakers make better-informed decisions, optimize subsidy distribution, and refine regulatory requirements based on the specific needs of each tyre category.

Risks:

- Dissatisfaction and resistance among stakeholders: The introduction of new requirements may face resistance from collectors, who might perceive them as unnecessary bureaucracy and a financial burden. This could strain collaboration between waste producers, collectors, and regulatory authorities.
- Logistical complications: Thorough sorting could also introduce logistical challenges, as different tyre types would need to be handled and stored separately, requiring additional space and coordination. This could be particularly difficult for smaller actors with limited resources.

Effects of the solutions:

FIGURE 21 shows the estimated effect on the truck tyre market (Group 5 and 6), and the development in market share of group 6 (re-treaded tuck tyres), when implementing Solution 2A, 2B, and 2C. This results in a market share of 30% re-treaded truck tyres (of the total truck tyre market), compared to a baseline of 18% re-treaded (corresponding to 23,000 more re-treaded tyres). While there may be a potential for increasing the share of re-treaded tyres even more, other external factors, such as import of cheap tyres, also affects the re-tread market, which are independent on the ELT system.

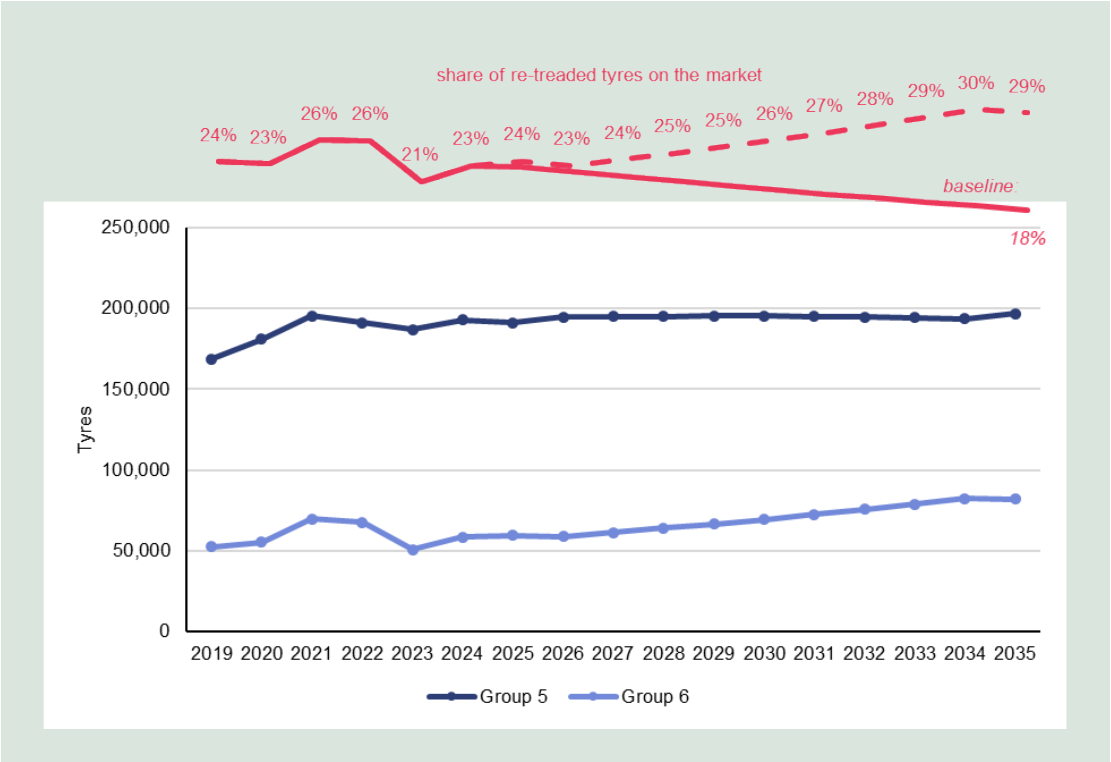

FIGURE 21. Projection of sales for truck tyres in group 5 and 6 when solution 2A (Higher subsidy for re-treading) and 2B (Approve re-treaders) are applied. See TABLE 21 in Appendix 4 for tyre group specifications.

The economic consequence of introducing a subsidy for sending tyres to re-treading, is an increased cost for the system as a whole. Both in the baseline and in the scenario calculation for this solution, the Net Sum depicted in FIGURE 22 is negative, i.e. the subsidies paid for re-treading + recycling exceeds the income from fees. This is based on an assumption of all ELTs being collected and recycled, with a recycling rate of 95% on average, and is not based on actual subsidy paid.

What should be noted is the difference in the Net Sum, between the baseline (green dots) and the scenario calculation (red dots), showing a cost difference of 12.2 million DKK in 2035. Already in the baseline there is a negative Net Sum of the fee / subsidy balance when looking at group 5 and 6 isolated, of -7.3 million DKK. The added subsidy for re-treading results in a payout of approximately 9,5 million DKK extra in 2035, and the lower income through fees (due to new truck tyres being replaced with retreaded) is around 2.7 million. This results in a Net Sum of -19.5 million in 2035.

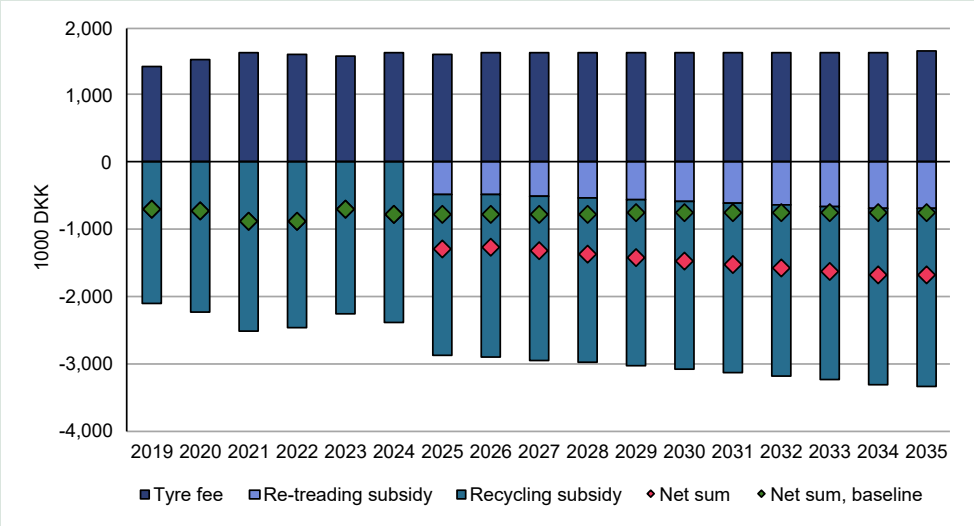

FIGURE 22. Projection of the economic effect of introducing a re-treading subsidy per casing. Note: the subsidy for tyres is applied in the year it is sold.

7.3 Problem 3: New tyre technologies

7.3.1 Solution 3A: Higher NCT and SST fees

To promote the recycling of NCTs and SSTs at their end-of-life, higher fees when these tyres enter the market must be charged. By charging higher fees, it is possible to incentivise the development and implementation of new processes and technologies to allow for material recycling of these tyres, which has been the biggest constraint to the end-of-life processing of these tyres.

The higher fees are not going to solve the issue, unless the extra fees are channelled toward specific investments/solutions to solve this issue as you are proposing in solution 3B and 3C. Moreover, higher fees can discourage consumers from buying these categories of tyres (or manufacturers from placing them on the market). Some stakeholders in the survey made for this study, suggested that technologies such as SSTs should be banned completely.

7.3.2 Solution 3B: NCT and SST subsidy

A higher subsidy for NCTs and SSTs incentivizes collectors to invest in the extra effort required for sorting and delivering specific types of tyres, ensuring better recycling outcomes. This approach relies on recyclers' capability and willingness to process these specialized fractions, creating a more efficient and environmentally friendly recycling chain.

In the survey made for this study, collectors emphasized that tyres were only sent for incineration when recyclers refuse to accept them, which is the case for SSTs and NCTs, or severely deteriorated tyres. This aligns with the fact that 25% of collectors reported that they often or always paid fines to processors like Genan A/S or Imdex A/S if they delivered tyres that could not be processed. Costs for delivering tyres to other places than recyclers range from 0 DKK to 2000 DKK per ton, with a weighted average of 925 DKK per ton. They highlight the need for financial incentives, like

subsidies, to support proper handling and recycling. They also argue that incineration is sometimes the only feasible option for unusable tyres.

7.3.3 Solution 3C: Fund research in NCT and SST recycling

To address the current processing challenges of NCTs and SSTs at the end-of-life, a comprehensive research study should be conducted in collaboration with recyclers in Denmark and across Europe. This deep-dive study should first investigate existing processing technologies for these types of tyres, as well as any technologies expected to come into the market in the next 5 to 10 years. Based on these, a cost-benefit analysis of the different recycling approaches should be included, as well as an assessment of the environmental impacts of each approach.

As stated under solution D, one of the issues is also to sort these tyres, but another is the constantly evolving technology. While the problem of the SSTs is the tar-rubber compound, for NCTs there is both the foam (which contaminates recycled material fractions), and the fact that this foam is attached in different ways. It can either be the same tar-like substance as the SSTs, but it can also be different types of glue. While these may not give same problems, but there could be other unforeseen issues such as chemical content of the glue. Several collectors responding to the survey made for this study, suggested that technical advancements are needed to make these tyre types recyclable.

If no processing technologies are in place in the near future, the study should include recommendations on short-term solutions, such as incineration with energy recovery and storage of these tyres until technologies come into the market, especially since the numbers are still quite small. In addition, it should also draw a comparison between these two solutions.

Finally, based on the insights gained from this research, the Danish EPA could establish guidelines related to the recycling of these tyres. It can also be used in the upcoming ESPR process for tyres, for the Danish EPA to argue for some Ecodesign requirements of tyres that removes some of these very hard to recycle tyre technologies from the market in the future.

It should be noted, that both solution 3B and 3C would require the current fee to be a tax instead, as the fee can only be used directly to cover costs for recycling – not for subsidising incineration.

Risks:

- Costs of the study: conducting a comprehensive research study can be expensive and budget constraints could limit the scope of the study.
- Uncertainty regarding processing technologies: if technologies identified are still in development, there is a risk that these may not be scalable in the future and are therefore not viable. In addition, technologies developed in other European countries may not be applicable in Denmark.

7.3.4 Solution 3D: Collect all principle

Requiring collectors to pick up all types of tyres from waste producers and providing a small subsidy for sending non-recyclable, sorted tyres to incineration could address the issue of selective collection. This solution would ensure that waste producers can

dispose of all tyre types, including those with challenging materials like self-sealing compounds. By offering a subsidy for non-recyclable tyres sent to incineration, this approach encourages proper disposal and helps avoid illegal dumping or improper handling. Additionally, this would allow time for the development of new recycling technologies that can eventually handle these currently problematic tyre types, supporting a more sustainable approach in the long term.

Waste producers emphasized in the survey that collectors should be obligated to take all types of tyres, regardless of their recycling potential, to ensure proper and environmentally friendly handling. However, this requirement may add administrative and logistical costs for collectors, especially if different handling or processing steps are needed for non-recyclable tyres. Overall, this approach aims to ensure environmentally responsible tyre management while supporting the transition to more comprehensive recycling capabilities in the future.

Risks:

- Increased costs for collectors: Collectors may face significant additional expenses in collecting and sorting tyres that cannot be recycled. The extra handling and transportation to incineration facilities could strain collectors' finances, especially if the subsidy for non-recyclable tyres is minimal.
- Potential reliance on incineration: The solution could create a temporary reliance on incineration, which may be difficult to shift in the long term. This reliance could also impact the tyre system's goal of promoting recycling as the top priority according to the waste hierarchy.
- Administrative and logistical challenges: Both waste producers and collectors could experience increased operational complexity. Waste producers may need to coordinate and document various tyre categories, while collectors would face administrative and logistical challenges in managing the different tyre types. Both parties would need to ensure proper sorting and documentation to receive the subsidy, which could increase time and administrative costs.

Effects of the solutions:

If Solution 3A-D is implemented, the intended consequence is a higher recycling rate of the NCTs and SSTs. As seen in FIGURE 23, NCTs and SSTs are forecasted to constitute 39% and 12% of the Group 1 tyre market, respectively. This corresponds to almost 1.7 million NCTs and 0.5 million SSTs sold in 2035, hence a significant number of tyres on the Danish market. If no recycling technologies are developed, and status quo is kept, these tyres will be sent to incineration (with energy recovery. By implementing the proposed options, it is assumed that the far majority of these tyres will instead be recycled.

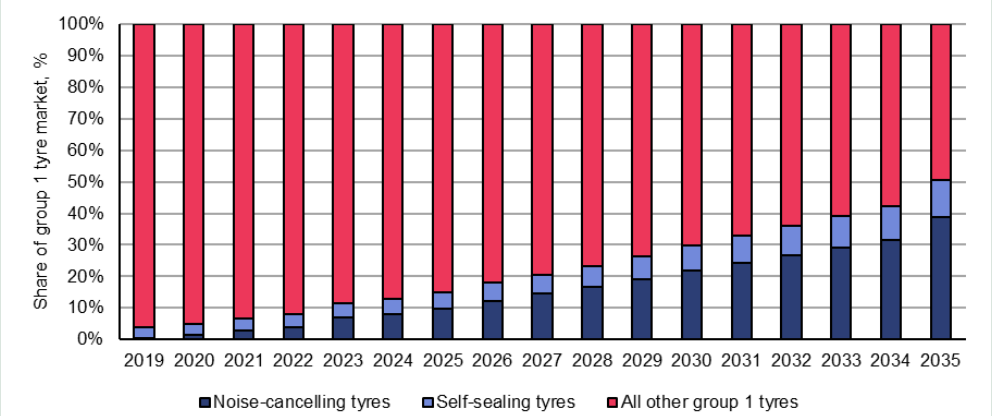

FIGURE 23. Market share of NCTs and SSTs on the Group 1 tyre market, forecasted until 2035. See TABLE 21 in Appendix 4 for tyre group specifications.

7.4 Problem 4: Economic balance

7.4.1 Solution 4A: Increase the base fees

The review of the cost of the currents system shows that the current subsidy level does not cover rising costs in the collection and recycling chain. These costs include transportation, sorting, registration, handling fee, labour, and gate fees, all of which have increased significantly over the years, where the tax and subsidies have been lacking behind. Due to higher operational expenses, recyclers have raised gate fees, which collectors must pay to deliver tyres for recycling. This increase is largely a response to external conditions, such as energy prices and inflation. Indexing subsidies based on an increased base value could better align with these growing costs, relieving some financial pressure from collectors. However, in the current situation the fees are too low to be adjusted solely through indexation, if free collection is to be obtained again. An increased base value combined with the indexation would immediately adjust for these escalating expenses and help ensure financial sustainability.

There are multiple approaches to recalibrating the fee structure and determining the level of increase. One is to mimic the approach by RecyBem and make a total cost report. Another is to base the fee increase on the current handling fees paid by waste producers to collectors, as this handling fee must be assumed to be set in a way to cover the additional costs they have. The handling fee was reported in this study to be on average 285 dkk/ton. (section 2.4.1).

Approximately 45,500 tonnes collected per year, amounting to around 13 million DKK being paid in handling fees in total. This corresponds to roughly 25% of the current system subsidy payout, which is about 50.6 million, and would need to increase to 63 million. Not accounting for taxes, a similar amount would thus need to be paid more in fees.

In 2024, 3.55 million tyres were sold in Denmark, counting only the replacement tyres. Dividing the 13 million on these tyres, would result in 3.7 DKK/tyre in extra fees.

If the new car tyres were included in the fee system, (solution 1A), the 13 million would instead need to be distributed on 4.38 million tyres in 2024, corresponding to an additional 3.0 DKK/tyre

It is important to notice this calculation is a rough estimate based on the information collected in this study, and additional data may need to be gathered to get more robust data on what the handling fees are.

TABLE 13. Calculations on increasing the base fees based estimated financial deficit.

Tyre group	Fee 2024, in DKK/tyre	New fee, only replacements included	% fee increase	New fee, with implementation of 1A	% fee increase
1 & 2	12	15.7	30.6%	15	24.9%
3 & 4	24	27.7	15.3%	27	12.4%
5 & 6	85	88.7	4.3%	88	3.5%
7 & 8	250	253.7	1.5%	253	1.2%

If, in addition to 1A solution 2A was to be implemented, the cost needed to be covered would be 12.2 million DKK, corresponding to 2.7 DKK/tyre. However, if these costs are chosen to be added only to group 5 and 7 (266.000 tyres in total), which is the tyre types eligible for re-treading, it would increase the cost for these tyres by almost 46 DKK/tyre.

Risks:

- Increased costs for end-users: Raising the base value would make tyre fees more expensive, which could negatively impact consumers as the cost of new tyres rises. This could create resistance among end-users and industry stakeholders, as a fee increase might not be fully justified by the actual waste management costs involved.
- Potential inefficiency in subsidies: If the increased base value is not targeted to specific problem areas (e.g., types of tyres that are difficult to recycle or regions with high transportation costs), the funds might be too broadly distributed, failing to address the actual economic challenges in different parts of the value chain. This could make the system more expensive without necessarily improving its effectiveness.
- Too high fee could make less competitive tyres in DK up to a point where consumers could start thinking convenient buying tyres in Sweden or Germany

7.4.2 Solution 4B: remuneration-free collection

The increase of fees and subsidies should be implemented alongside a requirement for collectors to retrieve tyres free of charge, as the adjustment of fees and subsidies should cover the necessary costs as indicated in solution 4A. This would eliminate the need for collectors to charge waste producers for tyre collection, streamlining the process and aligning with the system's original intent of ensuring cost-free tyre collection.

Based on waste producers responses, it can generally be concluded that they prefer a solution where the collection of ELTs is free, and they regard this as a key factor in preventing tyres from being sent for incineration. Collectors, however, have indicated that they are happy with the possibility to charge a handling fee, to be more in control of their own economy.

Risks:

- Insufficient Subsidy Adjustment: If the increased base value for fees and subsidies does not fully cover the actual costs of collection, transport, and processing, collectors may face financial difficulties. This could lead to a potential risk where collectors find it financially unsustainable to operate without charging waste producers, potentially leading to fewer collectors or reduced service levels.
- Market Fluctuations and Cost Variability: Factors such as fluctuating fuel prices, labour costs, and maintenance expenses could impact collectors' operational costs. If subsidies are adjusted annually but fail to keep pace with rapid changes in operating costs, collectors may struggle to cover expenses, paying an increase in the gate-fee etc.
- Potential Impact on Service Quality: If collectors feel financially squeezed by the "free collection" mandate, they may limit the frequency of collection, reduce service coverage, or cut corners in operations, which could negatively impact the quality and efficiency of tyre collection services.
- Not collecting all tyres: This could indicate that collectors will only pick up tyres that they are certain will qualify for the subsidy and can be accepted for processing. This could lead to a situation where certain types of tyres, such as those with self-sealing technology or other problematic materials, are left uncollected. If collectors selectively choose only the tyres that guarantee subsidy payments, some waste producers might struggle to dispose of other types of tyres, potentially leading to issues with improper disposal or increased handling costs for specific tyre types that are less desirable for collectors.

7.4.3 Solution 4C: Cost assessment report

To ensure the system can sustainably cover its costs without requiring continual fee increases, a comprehensive cost assessment report on recycling costs should be conducted every second years. The primary goal of this report is to set appropriate fees and subsidies for the subsequent second-year period, based on the estimated recycling costs. The study can either be conducted internally by the Danish EPA or commissioned to an independent third party.

In the Netherlands, for example, the PRO RecyBEM is responsible for annually determining fees to be paid by producers, as well as subsidies for collectors. This is initially done by setting provisional fees and subsidies based on the previous year’s data. Once the year ends, these rates are finalized based on updated financial information. In addition, every second to third years, RecyBEM commissions an independent party to perform a detailed market and cost analysis of the ELT system, in order to determine what the fees should be to maintain a functional system. The costs of conducting a market and cost analysis of the ELT system are estimated at approximately 50–80 thousand euros per study (370,000-590,000 DKK). Implementing such analyses in Denmark would require additional resources to ensure they are carried out in a detailed and comprehensive manner. This would exceed the current allocation of 2.2 million DKK designated for current administrative tasks under the existing tyre management system, highlighting the need for supplementary funding to support these activities.

On the other hand, the Portuguese PRO Valorpneu typically reviews the fees of the system whenever their license is renewed or when adjustments are deemed necessary. These adjustments are based on a comprehensive estimate of the system's total costs.

Both approaches help maintain sufficient funding for the ELT systems, while minimizing the need for frequent fee adjustments and avoiding the need for new fees.

Risks:

- High costs: conducting the study every 2 years can become expensive to the Danish EPA, either if it's conducted internally or via a third party. This will therefore require funds, that will need to be accounted for when setting the fees and subsidies.
- Administrative burdens: Conducting these assessments will place an additional burden on the Danish EPA, who needs to commission
- Inaccurate cost assessment: the study may not accurately capture the costs of the recycling tyres, especially if data is incomplete or there are inconsistencies in financial data collected from recyclers.
- Inflation and economic changes: inflation rates, energy costs or changes in the market for recycled materials. As a result, the fees and subsidies could become outdated, requiring an increase.
- Stakeholder resistance: there is a risk that recyclers will be against this study and will refuse to provide data on the costs of the processing. In addition, recyclers may reject the conclusions of the studies.
- Influence by stakeholders: recyclers might attempt to influence cost assessments for financial advantage. As a result, this could lead to an overestimation of the costs and therefore lead to fees higher than they should.
- Limited scope: the studies may fail to address factors, such as environmental and social impacts, as well as changes in policy and regulations both in Denmark and in Europe.

8. Conclusion and recommendations

The study showed that the Danish ELT system has high collection rates[131], the highest recycling rate of the systems included in the Neighbour check and is generally perceived as a well-functioning system by both Danish actors in the system (collectors, recyclers) and interviewees from the Neighbour check countries. The system is very alike an EPR, with DBMF in place of a PRO, but there are legal limitations related to the current authorisation through the Environmental Protection Regulation, which limits the scope to waste. Even if specific data was not possible to find for all he Neighbour check countries' systems, all information points to the Danish system being efficient and with no excessive administrative cost.

The main conclusions from the assessment of the current Danish system and market- and technological development showed that:

- Economically there is a deficit in the system, which arises from increasing gate fees due to increased processing costs driven mainly by energy prices, since both the transport of ELTs and the recycling process are energy intensive. There are only to companies in Denmark that collectors can send the ELTs to, to get the subsidy payout, which poses the risk of inflated gate fees.
- This imbalance is increased by the fact that tyres on new vehicles do not contribute to the system, as they are exempted from fees.
- The re-treading market is declining (from 48% of the truck tyre market in 2000 to 20% in 2023) due to especially price-sensitivity due to cheap tyres imported from outside Europe, and the current system does not incentivise re-treading other than exempting re-treaded tyres (from Danish casings) from the fee.
- New tyre technologies are emerging in the market which cannot be recycled with the current dominant technologies, and new recycling technologies are not ready to be operated on commercial scale yet.

Proposed solutions
Based on the findings of the study, experiences from the Neighbour check and interviews with Danish actors in the ELT value chain, it is recommended to implement the following options (option numbers are based on the Solution tree in FIGURE 18).

1A	Include tyres sold with new cars, so they pay their share of the ELT system, and the overall economy of the system is increased.
Effect	By including new-car tyres in scope of the system, approximately 1.3 million more tyres would be liable to fees in 2035 compared to continuing with the current system. The fee for these tyres varies depending on tyre type / group, resulting in an increase of almost 23 million DKK in fees in 2035, compared to the baseline.
2A	Include re-treading as an option for subsidy. This incentivises an end-of-life scenario higher in the waste hierarchy and increases competition for recyclers. There is an economic challenge since a truck tyre re-treaded two

[131] When calculated in the same way as in countries included in the neighbour check: Tyres sold / tyres collected in the same year

times, would then pay only one fee, and get subsidy two times for re-treading, and once for recycling. It is necessary to ensure that this can be covered by the system. Only re-treads from tyres collected in Denmark should be eligible for the subsidy.

2B To be able to subsidise sending casings to re-treading, an approval process for re-treaders needs to be put in place, similar to that of recyclers in the current system. Solution 2A and 2B need to be implemented simultaneously, as they are codependent in order to work.

Effect The economic consequence of introducing a subsidy for sending tyres to re-treading, is an increased cost for the system as a whole. There is already today a negative balance between fees and subsidies in the truck tyre groups (Group 5 and 6), corresponding to -7.3 million DKK in 2035[132]. Both the additional subsidy for tyres sent to re-treading and decrease in fees due to lower market share of group 5 (new) vs group 6 (re-treaded) tyres, result in further deficit in the system. The added subsidy for re-treading results in a payout of approximately 9.5 million DKK extra in 2035, and the lower income through fees (due to new truck tyres be-ing replaced with retreaded) is around 2.7 million. This results in a deficit of -19.5 million in 2035 (i.e. 12.2 million DKK lower than the baseline). To cover these 12.2 million DKK, the fee for new group 5 and 7 tyres would need to increase by almost 46 DKK/tyre.

Based on information about administrative costs for recyclers, it is assumed that including re-treaders in the system would result in comparable expenses.

3A It is recommended to incur a higher fee for NCTs and SSTs placed on the market than for normal tyres of the respective group they belong to, because they pose a problem in the cur-rent recycling system, and incurs higher costs for the actors who handle them due to the way they are designed. A barrier to this can be that there is no official classification of tyres as NCTs or SSTs, but it depends solely on the appraisals used by the manufacturer. Hence a technical based definition may need to be developed.

3B Even though NCTs and SSTs cannot be recycled using the current material recycling pro-cesses, it is suggested to pay a small subsidy for collectors, for collecting and correctly sorting these tyres, even though they currently go to incineration. This is to prepare the system for future recycling technologies for these tyres and incentivise their correct handling.

3C The increased fees for the NCTs and SSTs should be used to cover research into recycling technologies that can handle these tyre types. Optimally, this could be done in collaboration with other actors in Europe, for example the Azur network, or SDAB, who are already funding research in tyre recycling.

Effect If Solution 3A-D is implemented, the intended consequence is a higher recycling rate of the NCTs and SSTs. NCTs and SSTs are forecasted to constitute 39% and 12% of the Group 1 tyre market, respectively in 2035. This corresponds to almost 1.7 million NCTs and 0.6 million SSTs sold in 2035, hence a significant number of tyres on the Danish market. If no recycling technologies are developed, and status quo is kept, these tyres will be sent to incineration (with energy recovery). By implementing the

[132] This is based on a simplified calculation of all ELTs being collected and recycled, with a recycling rate of 95% on average, and is (not based on actual) subsidy paid.

proposed options, it is assumed that the far majority of these tyres will instead be recycled.

The specific fee for these tyre types for Solution 3A has not been estimated, but it should reflect the additional handling and difficulties posed by these tyres, and be enough to support research in the recycling of these tyre types.

The timing of option 3C should be considered, as a lot of research is currently happening al-ready, e.g. in pyrolysis, hence it should be considered how additional research funds form the scheme could benefit the Danish system best.

4A In general, the fees in the system should be increased enough to cover handling fees charged by collectors to obtain a sustainable business (approx. 285 DKK/ton). This corresponds to a 3.7 DKK/tyre increase in all the fees if solution 1A is not implemented, and 3.00 DKK/Tyre overall increase if it is. Even with this increase the general annual indexation should still be maintained.

4B It is recommended to reinstate the principle of remuneration-free collection of tyres form waste producers, as the opening of charging a handling fee has given rise to a lot of complaints from especially waste producers and end users. To ensure remuneration-free collection, however, the fees need to be increased according to option 4A.

Effect The effect of implementing these options economy of the system would again balance, and the system would be to get back to the original intension, which is to let the producer bear the cost for waste handling of their products and let the waste producers (and by extension end users) get rid of their used tyres for free. This would help keeping a high collection and recycling rate and ensure continued satisfaction with the system, since the waste producers.

4C A cost assessment report could be used as a one-off option to determine the adequate in-crease in fees for option I. It is not necessarily the same type of cost assessment as used in the Dutch PRO, but at least a more in-depth economic analysis than what has been possible to conduct in this study.

Effect This solution is suggested only as a one-off. The Danish ELT system worked for a long time without it, so there is no immediate need to make this assessment at a regular interval. The assessment should also include specific assessment of a suitable fee for NCTs and SSTs if solution 3A is implemented.

It is not recommended to implement option 2C and 3D.

2C It is not recommended to set specific sorting requirements to collectors, due to the assumed administrative burden for both the collectors, and the Danish EPA to enforce the requirement. Instead, it is suggested to follow the other options (2A, 2B, 3A, 3B) for incentivising better sorting of ELTs.

3D As with option 2C, it is not suggested to set a hard requirement to collectors to pick up all tyres, but instead rely on the incentives (Option 3B) to ensure all tyres are collected. Furthermore, the study has shown no apparent problem with dumping of tyres, because they are not collected.

In general, it should be noted that the incentives in the form of subsidies and fees cannot be overstretched, especially in the European single market and for a small country as Denmark. Too high fees could make it less competitive to sell tyres in DK up to a point where consumers could start thinking it convenient buying tyres in Sweden or Germany, especially since Germany has not fee.

The reverse risk of high subsidies making it profitable for collectors to look for tyres outside Danish boarders to get the subsidy, is not as imminent, as this is safeguarded by the requirements for documentation that the tyres are collected in Denmark. This ensure that the Danish system does not end up managing and paying for the end of life of tyres used outside the Danish border.

Appropriateness of EPR for Tyres in Denmark and Legal clarifications

In this study, the mechanisms of the Danish ELT system were analysed, and improvement options suggested purely based on the objective of improving environmental performance at appropriate costs. However, the proposed options are more principles than final regulatory proposals, and some of them requires the Danish ELT regulation to be based on another authorisation than the Environmental Protection Regulation. This also leaves the final choice between a modified version of the current regulation and an actual EPR system. While this is a political decision, this study shows no need to implement an EPR system:

- The Danish system is already very similar to an EPR system and can be tailored to include all the same principles and mechanisms.
- The EPRs are controlled by PROs, and all the control is laid out to them, meaning that the environmental ministries are only scarcely involved (usually only to receive annual reports from the PROs), and thus have less control over the EPR systems compared to the current involvement of the Danish EPA in the current Danish system. The PROs often consist of actors form the tyre production- or ELT value chains.
- While it was not possible to gather completely comparable data on administration costs for all the countries, the Danish system seems to be quite lean and low-cost, (total cost around 2.2 million DKK, see TABLE 1) compared to the EPR schemes, also based on the impressions of the interviewed stakeholders and PROs.
- The biggest risk of not implementing an EPR system for tyres in Denmark, is if the European Commission decides to make it mandatory at some point. There is, however, no indication of this happening in the near future, especially with Germany, being a very large player in Europe, wanting to stick with their current free market system.

Appendix 1. Study methodology

Several approaches were used to gather the information needed for the study, including desk research, surveys and interviews with key stakeholders.

Appendix 1.1 Literature review/Desk research

The literature review aimed to identify existing management systems for ELTs, current and emerging technologies for ELT processing, and find relevant legislative trends in Europe. The following steps describe the systematic approach used to gather and analyse data from multiple sources.

1. **Initial background research on end-of-life Tyres**

The review began with the assessment of the previous study from 2016 published by the Danish EPA[133] to identify what was previously done, what countries were investigated and what the conclusions were. In addition, the review included background research on ELT management in Europe. For an initial overview, the European Tyre and Rubber Manufacturers Association (ETRMA) website was consulted to gain insights into the current ELT management systems employed in Europe.

2. **Country-specific analysis of end-of-Life Tyre management systems**

Following the initial overview, the selected ELT management systems were analysed. For each country, information available on the official websites of their respective PROs or relevant stakeholders was reviewed, including annual reports, and data on collection systems, end-of-life processing, and financial models. Annual reports and information provided in the websites served as primary sources, offering detailed insights into operational frameworks, effectiveness, and challenges faced by each management system. This research also provided essential background for the interviews scheduled with stakeholders from each system.

3. **Supplementary research on end-of-Life Tyre management and technology**

To expand the understanding of current management practices and the state of recycling technologies, searches were conducted on Google Scholar using keywords such as “end-of-life tyre processing,” “ELT recycling technologies,” and “market trends for ELTs.” This academic research provided broader context, highlighting both the latest innovations and limitations within current ELT processing methods. Particular attention was paid to technologies like pyrolysis and devulcanization, which are expected to influence ELT management in coming years.

[133] Miljø-, markeds- og økonomianalyse for den danske dækordning

4. **Market trends and industry insights**

Additional research was conducted to capture recent market trends within the tyre recycling and broader tyre industry. Google searches were used to find the latest developments, consumer demand shifts, and economic factors influencing ELT recycling. Sources included market research summaries from reputable industry websites and recent articles on tyre recycling advancements, market forecasts, and financial dynamics impacting ELT programs. In addition to this, the websites of well-known tyre manufacturers, such as Bridgestone, Continental, Michelin and Pirelli, were consulted to understand technology development within the tyre industry.

5. **Legislative review on tyre and end-of-Life Tyre management**

A review of current and proposed legislation concerning tyre and ELT management within the European Union was conducted. Relevant European websites provided policy documents, regulatory updates, and legislative initiatives related to production, labelling, and waste management of tyres.

Appendix 1.2 Survey

Viegand Maagøe conducted a survey that served as the primary basis for mapping the system's economic dynamics. The survey was structured around findings from a previous analysis of the tyre system[134], with separate questionnaires for each actor category: **waste producers and collectors**. Broadly, we collected data on tyre pickup and collection, handling fees, gate fees, administrative costs, and the assessment of impacts from potential system changes. Additionally, these results were cross-referenced with data from the Danish Tyre Manufacturers' Environmental Fund (Dækbranchens Miljøfond) on tyres sold, collected, and processed, as well as on subsidies and fee rates. A total of **75 respondents** answered the survey sent to 411 waste producers and industry organizations resulting in a response rate of approximately **20%.** For the collector survey, **20 responses** were received out of 139 sent surveys yielding a response rate of about **15%.** All surveys were distributed on October 17th, 2024, with a response deadline of one and a half week.

The survey for waste producers contained **23 questions** divided into the following three categories, with all questions listed in Appendix X *[to be included in next version]*:

1. **Tyre Collection and Pickup**: Aimed at understanding contract terms between collectors and waste producers, the proportion of uncollected tyres, and barriers related to handling fee collection.
2. **Fees and Associated Administrative Costs**: Focused on fees and the administrative expenses linked to these processes.
3. **Impacts of Potential System Changes**: Examined aspects such as subsidy levels, inclusion of re-treading, and a potential transition to extended producer responsibility.

Survey respondents for the waste producer questionnaire were selected from the **CVR register** and included business codes for tyre services, tyre centres, car dismantlers, auto dealers, and automotive workshops, **totalling 411 companies**. Additionally, corporate chains **Euromaster** and **Automester**, along with industry associations like

[134] Danish Environmental Protection Agency, 2016, " Environmental, market and economic analysis for the Danish tyre scheme", Link: https://www.teknologisk.dk/_/media/66181_D%E6kanalyse.pdf

the **Tyre Specialists Association** and the **Circular Industry Association**, were asked to distribute the survey to their members.

The collector survey comprised 46 questions across four categories, with all questions detailed in Appendix X *[to be included in next version]*:

1. **Tyre Collection and Pickup**: Aimed at exploring contract terms between collectors and waste producers, the value chain within collection companies, as well as administrative and operational costs.
2. **Delivery for Processing**: Focused on gate fees, contractual terms with processors, export practices, and barriers regarding non-recyclable tyres.
3. **Subsidies**: Aimed at understanding primary reasons for subsidy rejections, the impact of subsidy size on quality, and associated administrative costs.
4. **Impacts of Potential System Changes**: Examined factors such as subsidy amounts, inclusion of re-treading, and a potential shift to extended producer responsibility.

Respondents for the collector survey were drawn from a list provided by the Danish Environmental Protection Agency, comprising all registered collectors, totalling 139 respondents. It is important to note that this method does not include potential free riders—companies that should be subject to producer responsibility but are not in the producer register. However, this is not expected to be an issue, as registration is required to receive subsidies.

Appendix 1.3 Interviews and meetings

To gain insights into both the Danish and the neighbouring ELT management systems in the selected countries, Viegand Maagøe conducted a series of semi-structured interviews with key stakeholders. The full list including dates and names of participants is given in

Table 14. The first Interview was held in the beginning of the project with DækBranchens MiljøFond (DBMF) regarding the current ELT system in Denmark and the goal and scope of this project. After the meeting, DBMF provided the contact information for relevant stakeholders to be contacted.

Each individual was approached via e-mail, where VM outlined the purpose and scope of the research. In this e-mail, the project team introduced the objectives of the study, highlighted the importance of their input for understanding different national ELT management approaches, and described the format of the upcoming interview.

TABLE 14. Interviews with stakeholders from selected end-of-Life Tyre management systems.

Organisation	Date	Participants
Dækbranchens Miljøfond (DBMF)	16 September 2024	Arne Hansen, Erik Neuberg, Volker Nitz
Danish Chamber of Commerce	1 October 2024	Marianne Ladekarl Thygesen
RecyBem (PRO Netherlands)	3 October 2024	Frank Hopstaken, Consultant Ffact, Alex van Gelderen – ETRMA (also invited: Kees van Oostenrijk and Joost Kester)
BRV (Germany)	4 October 2024	Yorick Lowin
Ecopneus (PRO Italy)	4 October 2024	Serena Sgarioto , Giuseppina Carnimeo and Mara Facchi
SDAB (PRO Sweden)	7 October 2024	Fredrik Ardefors (also invited: Martin Lindkvist)
Genan (recycler Denmark)	10 October 2024	Lars Raahauge and Michael Agerkilde
Helstrup Dæk (collector Denmark)	11 October 2024	Malene de Neergård
Azur (Germany)	15 October 2024	Christina Guth and Stephan Rau
Valorpneu (PRO Portugal)	18 October 2024	Paulo Silva
DVIOnline	28 October 2024	Dick De Vries
Fabrikantforeningen for Regummierede Dæk I Danmark (FFRD)	30. October 2024	Erik N. Rasmussen (Chairman), Arne Hansen, Volker Nitz

The interviews were all conducted remotely via Microsoft Teams, with a duration of between 0.5 to 2 hours. The semi-structured format allowed for an informal discussion, where the participants shared an overview of their specific ELT management system and practices. This was followed by targeted questions designed to understand the specific operational aspects of the management system. The following subjects were covered in all interviews:

- Main actors and mechanisms of the ELT system, including the background for its introduction.
- What requirements are set for the different actors in the system?
- What is the economic flow in the system?
- How is it ensured that tyres are collected, sorted and recycled according to the waste hierarchy? Including how re-treading is incentivized. Data was also requested on how tyres are treated.
- How they see the market evolve for ELTs and recycling technologies going forward?
- What advantages and disadvantages they see on their current system and general recommendations for the Danish system?

Throughout the interviews, the project team documented key insights, enabling a comparative analysis of the different systems with Denmark. In addition, the project team worked in close collaboration with the Danish EPA, which has significant insights into the ELT system in Denmark and its current challenges.

Appendix 2. Neighbour check System descriptions

In this section the ELT systems investigated for the Neighbour check are described in more detail.

Appendix 2.1 Free market system in Germany

Similarly to other European countries, Germany is subject to the European Landfill Directive (1999/EC), meaning tyres cannot be landfilled and therefore must be collected for other waste treatments.

The German Circular Economy Act (Kreislaufwirtschaftsgesetz) established in 2012 mandates that carcasses and worn tyres must be disposed of in an environmentally responsible manner[135]. Under this act, old tyres are classified as "waste requiring monitoring". This means that the transport, sorting, storage, and recycling of used tyres must be reported to the appropriate authorities, and disposal companies handling them must have official approval. The goal of this Act is to protect the environment and human health from harmful substances. Illegal treatment, storage or disposal of ELTs can result in fines of up to 50.000 euros for the offender, depending on the federal state where it occurs[136].

There is currently no EPR system mandated in Germany, and it therefore operates under a free market system, where the demand for ELTs drives their collection and processing. This system does not specify who is responsible for legal compliance, meaning that every part of the recycling chain must adhere to the regulations while functioning within free market conditions. As a result, private companies dominate the collection, recycling, and recovery of tyres. Businesses in the tyre industry collaborate with recycling companies to ensure proper tyre disposal, and competition within the recycling sector helps to keep costs manageable.

[135] https://zertifizierte-altreifenentsorger.de/die-initiative-zare/folgen-der-falschen-altreifenentsorgung-rechtliche-konsequenzen/

[136] https://www.bussgeldkatalog.org/umwelt-altreifen-autorecycling/

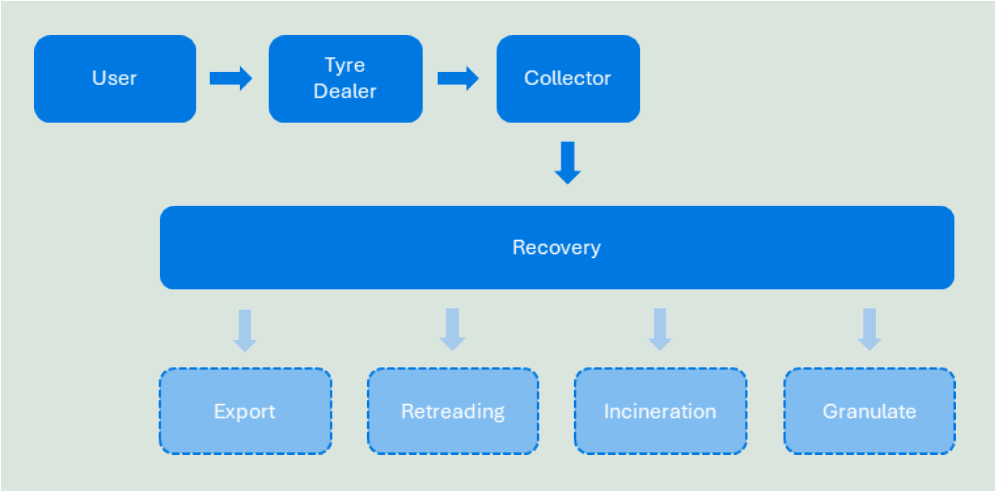

FIGURE 24. German end-of-Life Tyre flow principle, Simplified from WDK diagram[137].

[137] https://wdk.de/kreislaufwirtschaft/

Appendix 2.1.1 Process

End users can hand in their ELTs to the tyre dealer. When replacing old tyres with new ones, tyre dealers often accept the old tyres either for free or for a small fee. Local car repair shops can also assist with tyre disposal, handling the recycling process for a fee and often arranging the collection of the old tyres themselves. Since this is a free market, each tyre dealer (receiver of ELTs) needs to find a collector themselves and make an individual agreement. Used tyres can also be disposed of in the local recycling centre or municipal waste facility. However, a small fee is typically required for this service. In Berlin, the cost to dispose of old tyres at a recycling centre is approximately 2.60 euros per tyre for those up to one meter in diameter, and 7.60 euros for larger tyres[95].

The tyres are then stored in a container, which is picked up by a collector. Either the tyre dealer or the collector sorts the tyres – if done by the tyre dealer, price charged by the collector depends on how well the tyres are sorted, creating a potential financial incentive for the dealer to sort the tyres properly[87]. The tyres are sorted based on their condition – whether they can be recycled, potentially exported or retreaded, or if they are no longer usable and should be sent for incineration or further processing. Sometimes different collectors collect different fractions of the ELTs.

Once collected, ELTs are transported by specialized logistics companies to processing and recycling facilities. There are multiple independent companies involved in the collection and transport of used tyres across the country.

In Germany, companies with ZARE certification meet the requirements for tyre disposal. ZARE (Zertifizierte Altreifen Entsorger) is an initiative of the Federal Association of Tyre Trade and Vulcanization Crafts (BRV) and stands for “certified used tyre disposal companies”. There are currently 17 companies organised in the BRV, 16 of which are certified waste disposal companies[138].

Old tyres in Germany are typically disposed through:

1. Material recycling: in 2023 166,000 tonnes were processed into recycled materials, of which a very small fraction goes to pyrolysis to make Carbon Black to be used in new tyres (usually same quality is not possible to achieve). This is primarily with the German pyrolysis company Pyrum who works with BASF to achieve this.
2. Thermal utilisation: in 2023 Approximately 117,000 tonnes (including exported) of old tyres were thermally processed, meaning they were burned in pulp mills, power plants, and especially cement plants as secondary fuel. Non-combustible materials are used in cement production as part of cement clinker. However, the use of thermal recycling has been gradually declining in recent years, mainly due to declining demand from the Cement industry.
3. Re-treading: Each year, at least 26,000 tons of used tyres are used to produce retreaded tyres, mainly for commercial vehicles.
4. Export: Tyres not completely worn out or with well-preserved treads are suitable for export to other countries, if they pass a quality check. Around 50,000 tonnes of used tyres were exported to other countries in 2019[139].

[138] https://zertifizierte-altreifenentsorger.de/illegale-altreifenentsorgung-in-deutschland/

[139] https://zertifizierte-altreifenentsorger.de/verwertungsmethoden/gebrauchtreifen-export/

Appendix 2.1.2 Environmental performance

Every year, approximately 500-600.000 tonnes of used tyres are generated in Germany[140]. In 2023, 166,000 tonnes of granules and rubber powder were produced, and 109,000 tonnes were used in the cement industry[141]. The percentage of recycled components is: 67% rubber, 18% steel, 14% textile, 1% residues[140].

Since there is no system, there is no approved list or register of tyre collectors. There is a general approval of waste collectors, but not specialised ones, and many waste collection companies who pick up tyres also pick up many other waste fractions, and the only way they can get rid of the tyres is by sending them to incineration (energy recovery). These general waste collectors do not sort the tyres. So, while the waste collection rates are among the highest in Germany, there is almost no sorting, and some issues have been seen with dumping of tyres.

Another issue that arises from there being no control with tyre collectors, is that a few collectors “cherry pick” 10-15% of the best tyres from dealers and take no fee for collecting these tyres. They then send these tyres to reuse. But when the responsible collectors come and pick up all tyres in full containers, they get only the scrap tyres of very low value. Furthermore, Germany has experienced dumping of old tyres in Nature, and it is assumed that the far majority of these (usually batches of 50-200 tyres in one place), are dumped by these “cherry pickers” who cannot resell all of the tyres.

There is no wish in Germany to get rid of the free market system, because they want the collectors to be able to charge what they want, regulated by supply and demand. However, they are currently working on regulating the collectors more and have specific approvals for collectors who can pick up tyres to avoid the cherry-picking and dumping. But where the tyre collectors then send the tyres, should be left up to them, based on where they can get a higher price. E.g. when energy prices are high, more tyres go to energy recovery. This also happens in some countries with ERP systems. Therefore, if a system needs to be regulated through and ERP system, it should include the whole chain form beginning to end and include processers/recyclers – or it should not be regulated at all.

Appendix 2.2 EPR scheme in Sweden

In 1994, Sweden became one of the first countries in the world to establish an ordinance of producer responsibility for tyres (1994:1236)[142]. This ordinance introduced the legal framework for ELTs, in which producers must take responsibility for the collection and recycling of the tyres placed on the market.

In anticipation of the new legislation, representatives from the DFTF (Tyre, Rim, and Accessory Suppliers Association) and DRF (Tyre Specialists National Association) established a collective system, represented by Svensk Däckåtervinning AB (hereafter referred to as SDAB). SDAB was approved by the Swedish Environmental Protection Agency (EPA) as the PRO and conducted its first collection of ELTs in January 1995. SDAB is a non-profit company that organises the collection, processing, marketing, and reporting necessary to comply with the legislation.

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[140] https://zertifizierte-altreifenentsorger.de/verwertungsmethoden/zahlen-daten-und-fakten/

[141] https://zertifizierte-altreifenentsorger.de/en/sustainable-waste-tyre-disposal/used-tyre-recycling-in-germany/

[142] https://sdab.se/wp-content/uploads/2024/06/Annual-report-2023-SDAB-30-year.pdf

The ordinance on producer responsibility for tyres was revised in January 2024 (2023:133)**Error! Bookmark not defined.**. SDAB received approval from the Swedish EPA to continue as the PRO under the updated regulation. The new ordinance imposes stricter requirements: tyre producers must be registered with the Swedish EPA and be affiliated with an approved PRO[143]. In addition, every year by March 31, tyre producers must report information to the Swedish EPA regarding the amount of tyres that the business has supplied to the Swedish market in 2024, whereas the PRO must report information to the Swedish EPA regarding the tyres that have been collected during 2024. According to the new ordinance, from January 1 2027, the PRO must ensure that at least 95% of all ELTs are collected[144].

Appendix 2.2.1 Process

This EPR scheme covers tyres for passenger cars, trucks, buses, motorcycles, tractors, all-terrain vehicles, motor equipment, trailers, and trailing vehicles[145]. Currently, the only tyres not included under the EPR scheme are those mounted on new vehicles weighing under 3.5 tons, such as cars and small vans, which are instead managed under the producer responsibility for vehicles, as stipulated by the ELV directive**Error! Bookmark not defined.**.

Tyres that do not comply with REACH— the European's regulations regarding tyre content and related standards— may be rejected for collection[146].

Under this EPR scheme, tyre producers are required to organise the collection, recycling and proper disposal of ELTs. A tyre producer is defined as any individual or entity that professionally engages in specific activities related to tyres. This includes bringing tyres into Sweden and either using them in a professional capacity or releasing them on the Swedish market. It also includes those who manufacture tyres within Sweden for sale on the Swedish market. Additionally, a tyre producer can be someone from outside Sweden who sells tyres directly to an end user in Sweden, provided that the end user is not covered under the professional activities. Lastly, those who re-tread tyres and release them on the Swedish market also qualify as tyre producers.

Since January 1995, consumers have been able to return ELTs at no cost. Although initially companies and individuals could drop off used tyres at collection stations, today there is free collection at workshops and recycling centres. By the end of 2023, SDAB had 4,702 collection points, which include affiliated tyre workshops, car workshops, recycling centres and other actors handling tyres without engaging in their sale**Error! Bookmark not defined.**.

In 2019, SDAB ended its contract with the previously selected main contractor and pursued a new direction as a PRO under its own management. As a result, the

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[143] https://www.naturvardsverket.se/en/guidance/extended-producer-responsibility-epr/producer-responsibility-for-tyres/

[144] https://www.riksdagen.se/sv/dokument-och-lagar/dokument/svensk-forfattningssamling/forordning-2023133-om-producentansvar-for-dack_sfs-2023-133/

[145] https://www.riksdagen.se/sv/dokument-och-lagar/dokument/svensk-forfattningssamling/forordning-19941236-om-producentansvar-for-dack_sfs-1994-1236/

[146] https://bileko.zendesk.com/hc/sv/articles/6470415859868-Svensk-d%C3%A4ck%C3%A5tervinning-SDAB-samarbetar-med-Ragn-Sells-D%C3%A4ck%C3%A5tervinning-AB

transport, sorting and processing of ELTs is the responsibility of SDAB in collaboration with regional subcontractors across the country. New recycling facilities have been established throughout Sweden[147]:

- In **Linköping**, Årsjö Recycling AB manages the main facility where over 40,000 tonnes of end-of-life tyres (ELTs) are processed. Tyres are weighed, registered by customer, and sorted by type (e.g., passenger car, truck). Two cutting machines prepare the tyres by size, with coarser tyres processed separately from car and truck tyres or summer and winter tyres. The rough cuts are then further processed into smaller pieces using specialized machines based on the desired material. In Central Sweden and Gotland, four subcontractors manage the collection of ELTs, transporting them to the Linköping facility. The facility receives about nine truckloads of tyres daily.
- The **Ekeby** facility, located in southern Sweden, processes approximately 10,000 tonnes of end-of-life tyres annually.
- The **Åshammar** facility processes around 10,000 tonnes of used tyres
- The **Ånäset** facility, located in northern Sweden, handles 10,000 tonnes of ELTs annually.

When tyres are replaced, retailers or repair shops are required to collect the old tyres and ensure they are sent to authorized recycling facilities. The collection of ELTs has also been updated and is now managed through an app, and tyre collectors, including workshops and recycling centres, order the collection of tyres through mobile phone or computer. The tyres are afterwards transported to a nearby recycling facility where they are sorted and processed[105].

The Swedish system was implemented last year (2023) and was based on a global scan of ELT schemes. SDAB chose the “insourcing” approach where they own the material and facilities for recycling to avoid a lock-in where only few recyclers can alone determine the market price of handling ELTs, and because they saw a decrease in the opportunities to use the recycled materials. At the same time, they have seen a lack of mechanical recycling in Europe, for up to 100 million tonnes of tyres, and a cement industry that is increasingly looking towards electrification and biobased fuels.

Hence the focus is now on R&D on material recycling, which they can now pursue because they own the material. This includes:

1. Sorting the tyres before shredding and granulation based on type, to get more uniform rubber blends.
2. Looking into devulcanization of especially truck tyres / large tyres, because they usually consist of more simple mixtures, whereas passenger car tyres can have up to 200 different trace compounds and additives.

Furthermore, SDAB have full subsidiary daughter company, BonOrbit, acting as the seller of the recycled rubber, and have a plan to make all the knowledge on material purposes open source, because even though rubber is a very well-researched material today, most of the information is confidential and kept within private companies. By owning the material and researching new uses, the plan is to this profitable enough to eventually bring down the Eco-fee in the ERP.

[147] https://sdab.se/dackatervinningen/anlaggningar/

Appendix 2.2.2 Fees

The EPR system works due to fees paid by the producers to SDAB: producers and importers are responsible for paying recycling fees (*Återvinningsavgifter)*. Producers are required to submit retrospective reports to SDAB detailing the number of tyres they introduce into the Swedish market for each category. Following this reporting, Swedish Tyre Recycling issues invoices for the applicable recycling fees, along with VAT[148]. Current price list.

All fees entering the system must be used for collecting, processing, and marketing recycled tyre material and related activities**Error! Bookmark not defined.**. SDAB may periodically revise recycling fees to account for fluctuations in the costs of collection, transportation, and recycling, ensuring the financial sustainability of the system[102].

The fees paid by the producer to SDAB are often passed on along the supply chain and ultimately, consumers are often responsible for paying the recycling fee when purchasing new tyres**Error! Bookmark not defined.**.

If producers or importers fail to comply with the legislation, an environmental sanction fee may need to be paid[149]. This fee will depend on what requirement the producer has failed to meet but could result in a fine of up to SEK 50.000.

Besides the recycling fee for the management of ELTs, producers must pay an annual fee of SEK 1.000 to the Swedish EPA, which is used to keep a digital registration of all producers and to ensure that producers comply with the regulations[149].

Appendix 2.2.3 Environmental performance

In 2023, 84,808 tonnes of ELTs were collected by SDAB's subcontractors, of which 349 tonnes were exported as whole tyres, 22,675 tonnes were recycled, 22,029 tonnes were used for energy recovery, and 35,514 tonnes were used for energy recovery in the cement industry**Error! Bookmark not defined.**.

TABLE 15. Flows of end-of-Life Tyres in 2023.

Recycling category	Tonnes (2023)
Export of whole tyres	349
Material recycling for blast mats	3,477
Material recycling for granulate	0
Other material recycling	12,684
Energy recovery	22,029
Energy recovery in cement industry	35,514
Material replacement	6,514
Total	**80,566**

[148] https://sdab.se/producent/

[149] https://www.naturvardsverket.se/en/guidance/extended-producer-responsibility-epr/producer-responsibility-for-tyres/

Appendix 2.2.4 Future

SDAB has seen an increasing interest in rubber from pyrolysis companies. As a result, SDAB has entered into delivery agreements for tyre raw material with several pyrolysis actors. The following table shows the sales by customer type in 2023.

TABLE 16. Sales by customer type (in tonnes) in 2023.

Customer category	Tonnes (2023)
Tyre resellers	349
Blast mat manufacturers	3,477
Steel recyclers	1,486
Pyrolysis operators	1,722
Heating plants	20,308
Cement industry	46,712
Construction and engineering industry	6,514
Total	**80,566**

Appendix 2.3 EPR scheme in Netherlands

Similarly to other European countries, the Netherlands is subject to the European Landfill Directive (1999/EC). In 1995, the Dutch government introduced the first legislation on ELTs: the Decree on removal of car tyres (*Besluit verwijdering personenwagenbanden*), which places the responsibility on producers to establish and manage the entire process for handling ELTs[150].

However, in 2004 the Dutch Ministry of Environment replaced this legislation with the Car Tyre Management Decree, known as *Besluit beheer autobanden*. This legislation places responsibility on tyre producers (manufacturers and importers) to ensure that ELTs are properly collected, recycled or disposed of in an environmentally responsible manner. Under this law, for every new car tyre introduced to the Dutch market by a producer or importer, a used one must be collected free of charge, following the principle of “one old for one new”.

The legislation applies to tyres from passenger cars, light commercial vehicles, trailers and caravans (category C1). However, there is no formal system in place for collecting other types of tyres, such as those from motorcycles or trucks. As a result, only used car tyres from the replacement market, along with tyres from caravans and trailers, are collected. According to the decree, at least 20% of the tyres collected must be reused or designated for material recycling[151].

Following the Decree’s implementation in 2004, the Ministry of Environment concluded that removing the distinction between car tyres and caravan/trailer tyres would enhance its effectiveness. The amendment was issued on June 19, 2007, and took effect on October 1, 2007[152].

[150] https://www.recybem.nl/en/new-tyres/dutch-legislation-end-of-life-tyres

[151] https://wetten.overheid.nl/BWBR0016038/2024-01-01

[152] https://www.recybem.nl/nl/nieuwe-banden/besluit-beheer-autobanden

To comply with this legislation, the Dutch Tyre Association (*Vereniging Band en Milieu*) founded **RecyBEM**, a collaborative initiative involving tyre suppliers, manufacturers, importers, and their customers.

Since April 1, 2004, RecyBEM serves as the Producer Responsibility Organisation, responsible for the collection and high-quality processing of all used tyres from the aftermarket.

All tyre manufacturers and importers are required to register with RecyBEM. They must pay fees based on the number of tyres placed on the market. These fees fund the collection, recycling, and environmentally safe disposal of ELTs. The fee structure ensures that all participants contribute to the sustainability of the system, maintaining its affordability and effectiveness.

RecyBEM conducts a cost analysis every second to third years to determine the fees, factoring in administration costs[108]. This process involves discussions with collectors to establish appropriate compensation and forecasts for future years. The analysis considers inflation, necessary investments, and any existing deficits, as well as gate fees for the treatment processes. It focuses solely on tyre collectors, excluding companies that handle other types of waste. According to RecyBEM, this analysis typically costs between 50.000 and 80.000 euros.

Although the Car Tyre Management Decree mandates that at least 20% of used tyres must be reused or designated for material reuse, RecyBEM has set stricter requirements, requiring certified collection companies to allocate at least 90% of collected tyres for material and/or product reuse. Additionally, a minimum of 60% of all collected tyres must be processed by certified recyclers specifically for material reuse.

Appendix 2.3.1 Process

Consumers can drop off old tyres free of charge in approximately 12,000 retailers[153] or at their municipalities. RecyBEM-certified collectors operate across the country, gathering ELTs from various sources, including garages, tyre specialists, suppliers of car accessories, car dealers and similar companies in the tyre industry at zero cost. There are 14 certified collectors[154] that must live up to the requirements set by RecyBEM. One key requirement is that these collectors must sort the tyres they gather.

The collected tyres are sorted into two categories: 20-30% are deemed reusable[107], while the remainder are classified as scrap. Reusable tyres are given a second life, either through direct reuse or by being retreaded. Scrap tyres, on the other hand, can be repurposed for alternative uses, sent for material recycling, or used as fuel in cement kilns and power generation plants. See also TABLE 17.

Alternative uses for scrap tyres include applications in road and hydraulic engineering, as pit tyres, or as protective barriers for go-kart tracks[155]. Tyres designated for recycling are processed through certified facilities, where they are converted into new products, such as rubber granules, which can be used in various applications, including sports surfaces, playgrounds, and construction materials. Recyclers produce rubber

[153] https://www.recybem.nl/en/about-recybem/collection-and-processing-system

[154] Interview with RecyBEM representatives on 03.10.2024

[155] https://www.recybem.nl/sites/recybem.nl/files/user/240731_avv_monitor_autobanden_2023-gecomprimeerd.pdf

granulate in different classes of grain sizes, from 0.1 mm to 8.0 mm, depending on the demand and application.

RecyBEM currently collaborates with seven certified recycling companies to ensure the proper processing and sustainable disposal of scrap tyres. Tyres can only be sent to certified treatment facilities, and RecyBEM maintains ongoing dialogue with these facilities to monitor and manage the associated costs[108]. This process is illustrated in the diagram below:

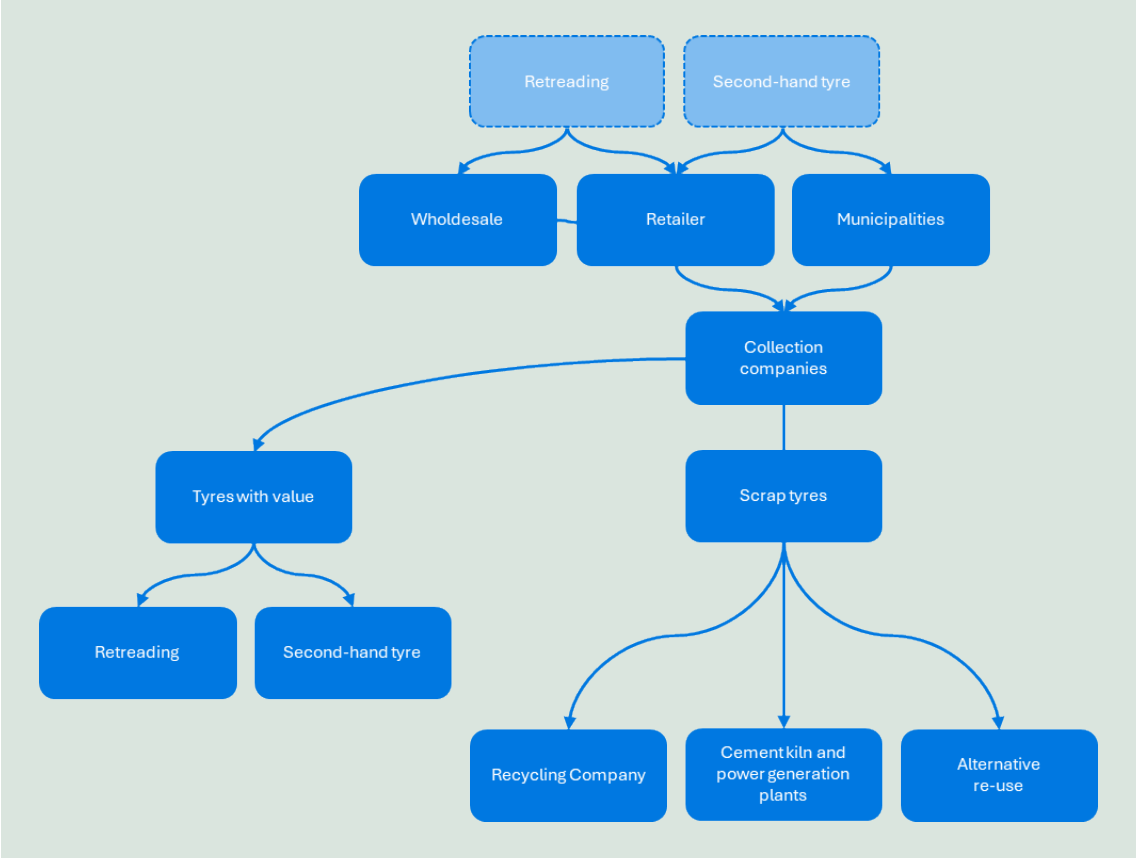

FIGURE 25. RecyBEM's collection and processing system. Source: RecyBEM's website.

With around 10.000 participants in this EPR system[155], it has become one of the most successful ELT management systems in Europe. The unique collaboration between manufacturers, importers, traders, and distribution parties since RecyBEM's inception has fostered a comprehensive and efficient approach to tyre waste management.

Appendix 2.3.2 Fee

Tyres entering the Dutch market for the first time are required to pay a waste management contribution, which must be paid by manufacturers and importers to the Stitching Fonds Band en Milieu. When the EPR scheme was implemented in 2004 this fee started at €2.00 per tyre but a full cost analysis was conducted to determine the reasonable compensation, based on all the costs of the system. In 2023, this contribution was €1.70 per car tyre, which has also been provisionally adopted for 2024**Error! Bookmark not defined.**.

RecyBEM pays a collection fee for each tyre collected. In 2023, the collection fee was increased to €1.35 per car tyre. This fee has increased in recent years as a result of cost increases resulting from (socio-economic and geopolitical developments, which resulted in an increase in costs for energy, wages, transport and storage, shipment and reprocessing[155].

RecyBEM is therefore responsible for determining the compensation based on the previous year. The waste management contribution and the collection subsidy are provisionally determined annually, according with the pay-as-you-go system. Once the year ends, the rate is definitively determined based on the available financial information[155].

However, once every 2 or 3 years, a market and cost price study is carried out by an independent party, considering all the costs of the system, such as collection, processing and administration, as well as inflation and investments. According to RecyBEM, these cost assessments cost between 50 and 80 thousand EUR[108]. Because some of the tyre collectors also collect other fractions of waste, it is difficult to assess the collection costs. As a result, this full cost research only focuses on pure tyre collectors[108].

Appendix 2.3.3 Environmental performance

In 2023, a total of 9,058,646 car tyres were imported or produced in accordance with the Car Tyre Management Decree[155]. In the same period, 9,789,171 discarded tyres were collected under the RecyBEM scheme, achieving a collection rate of 108.1%.

TABLE 17. End of life tyre final treatment in the Netherlands according to RecyBEM.

End of life tyre final treatment	Percentage
Material reuse	73.11%
Product reuse: Second use as tyre	22.38%
Re-treading	3.08%
Alternative reuse	0.01%
Main use as fuel: Energy recovery	1.42%
Total	**100%**

In 2023, the certified recyclers will have recycled more than 57.6 million kilograms of RecyBEM tyres processed. Of this, more than 8.64 million kilograms (15%) are steel and 5.76 million kilograms of textiles (10%). The steel goes to steel manufacturers and is recycled. The textile from car tyres, also called tyre fibres, is cleaned as well as possible after removal. It is then suitable for reuse in, among other things, insulation material for buildings or vehicles, filling material in the construction industry and composite material for, for example, the furniture industry. If reuse is not possible or profitable, the textile is burned with energy recovery.

A portion of the collected ELTs qualifies for second-life use as tyres, which are typically exported. While the primary market used to be within Europe and the UK, the largest share is now in Latin America and Africa, accounting for 50% of exports[108]. Collectors are required to report to RecyBEM the destination of all exported tyres. To be eligible for reuse, tyres must be inspected and certified, with a minimum tread depth of 1.6-2mm, though most have 3-5mm. Many of the tyres exported for reuse come from leased vehicles, where tyres are often replaced when the vehicle is returned.

Additionally, when individuals experience a puncture in one tyre, they frequently replace all four, even if the remaining tyres are still in good condition.

The high rate of tyre reuse is a result of the collectors' expertise in sorting, ensuring that tyres in good condition are identified for reuse. In recent years, larger collectors have increasingly automated their sorting processes, further enhancing efficiency and quality.

The rubber granulates from the recycled tyres have multiple uses, as is the case for all recycling systems in Europe. In the Netherlands the uses are as follows:

TABLE 18. Application flows of the recycled rubber in 2023. Source: RecyBEM's annual report 2023.

Application stream rubber granulate	Percentage	Tonnage	Comments
Safety tiles and roof tiles	26.11%	15,030,024	Sales area doubled
Moulded products	23.96%	13,800,028	Sales area shrank due to refinement of product groups
Infill for artificial grass fields	17.01%	9,799,392	Sales area remains stable
Rubber in asphalt	10.95%	6,308,768	Sales area has increased significantly due to certification of new processer outside Eu-rope
Industrial rubber powders	6.84%	3,942,466	Sales area remains stable
Sub-layer construction for cushioning artificial grass sports fields	3.40%	1,957,086	Sales area shrank
Cow mattresses and stable mats	2.18%	1,257,594	Sales area remains stable
Industrial floors	1.45%	837,344	-
Tyre compounds	0.10%	59,266	Important application for the future
Other applications	8.07%	4,650,894	-

Appendix 2.4 EPR scheme in Italy

In 2006, Italy adopted its comprehensive environmental law (Legislative Decree 152/2006), which sets waste management principles and the responsibility of producers to handle various types of waste, including tyres. Under **Article 228** of this decree, tyre manufacturers and importers and obliged to manage a quantity of ELTs equal in weight to that placed on the replacement market in the previous calendar year, in accordance with the principle of EPR[156].

However, there was no national system that managed the complete collection and recovery of tyres. In 2011, the Italian government introduced the Decree 82/2011, which introduced specific regulations to manage ELTs. This decree defined the responsibilities of tyre producers and importers under the EPR framework, requiring them to ensure the collection, recovery and recycling of used tyres at national level.

[156] https://www.ecopneus.it/en/who-we-are/corporate/mission-and-objectives/

To meet these obligations, leading tyre manufacturers in Italy (Bridgestone, Continental, Goodyear-Dunlop, Marangoni, Michelin, and Pirelli) formed a non-profit consortium in 2011: **Ecopneus**. This consortium manages the collection, transportation, processing and disposal of ELTs on behalf of producers. Although there are other consortia responsible for the management of ELTs (Greentyre, Ecoplatform and PFU Italia), Ecopneus is the largest and most prominent consortium, handling around 350,000 tonnes of ELTs annually[157]. To date, there are 50 Ecopneus members[158], including tyre manufacturers and importers. All consortia are non-profit organisations that work under the EPR scheme in Italy and collaborate with each other.

Under the Italian EPR scheme, tyre producers and importers must join a consortium to meet their legal obligations. Each consortium manages the logistics, financing and operations related to the collection and processing of ELTs.

In 2019, Decree 182/2019 substituted Decree 82/2011, to amend earlier regulations and provide updated rules for how producers and importers of tyres must manage the collection, recovery, and recycling of used tyres[159]. This decree entered into force on 1st January 2021.

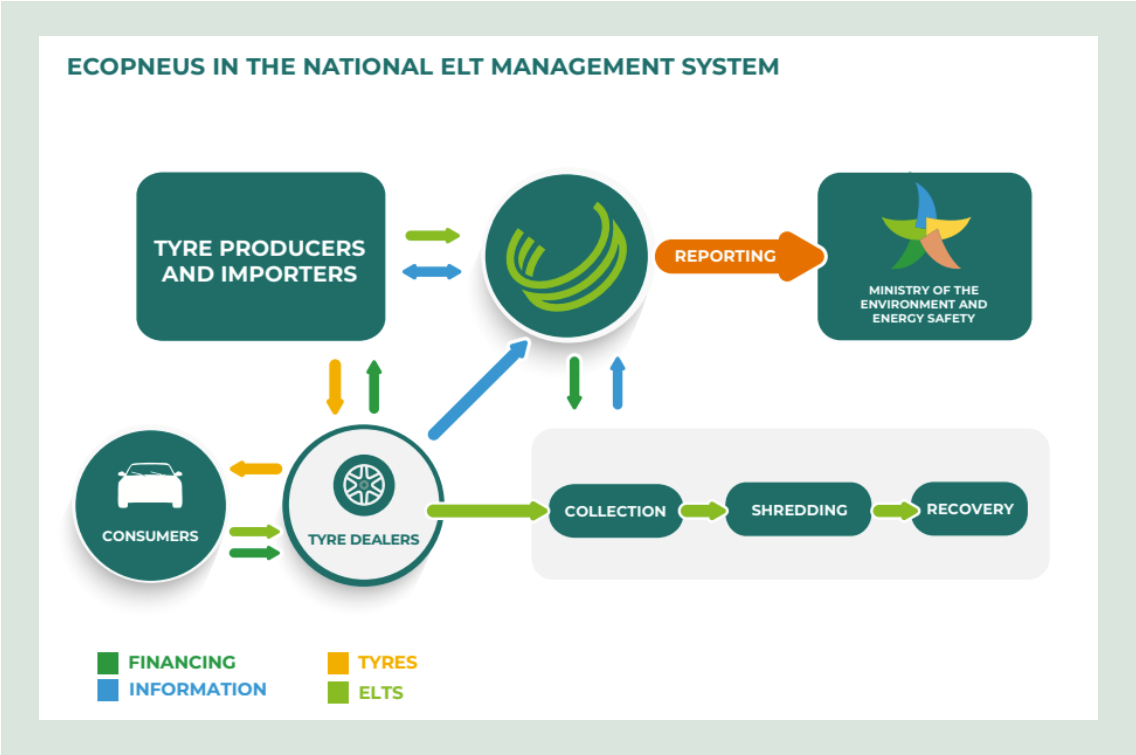

FIGURE 26. Ecopneus' operational system. Source: Ecopneus Sustainability Report 2022.

[157] https://www.ecopneus.it/en/who-we-are/system-and-management/the-italian-scenario/

[158] https://www.ecopneus.it/en/who-we-are/corporate/shareholders/

[159] https://www.ecopneus.it/en/rules-and-regulations/legislation/legislative-reference/

Appendix 2.4.1 Process

Consumers can return used tyres to various collection points, including tyre dealers, garages, and recycling facilities. Many dealers offer free tyre disposal when new tyres are purchased.

Once ELTs are removed from vehicles, they are transported to specialized facilities where they are weighed, examined, and stored before being sent to processing plants[160]. Initially, the ELTs are shredded into smaller fragments ranging from five to 40 cm in size. These pieces can either be utilized for energy recovery or subjected to additional shredding for material separation. During the subsequent shredding stage, the fragments are reduced further in size to enable the extraction of rubber, steel, and textile fibres. The rubber is then processed into granules and powders, which can be used to manufacture new products. The treatment process yields various materials in different sizes and types based on their intended applications, including rubber chips (20-50 mm), rubber granules (0.8-20 mm), rubber powder (< 0.8 mm), textile fibres, and steel.

In addition to overseeing the management of ELTs, Ecopneus is responsible for reporting to the authorities on behalf of its members, which is done through a specialized IT system that certifies the flow of ELT quantities from their source through to collection and processing[110]. The system also manages financial reporting and monitors the quantities introduced to the market each year. If the established targets are not met, manufacturers and importers may face penalties.

Since the introduction of the EPR, illegally disposed tyres, which constituted 25% of tyres put on the market in 2010, have steadily decreased[161].

Appendix 2.4.2 Fee

The EPR scheme is financed by an eco-fee paid for by the consumer – an environmental fee is added to the price of new tyres when they are sold. This fee is then used to finance the collection, transport, and processing of ELTs.

The Italian Ministry of Environment and Energy Security serves as the oversight authority for Ecopneus and all organizations involved in the management of ELTs in Italy. This oversight is conducted through the documented reporting of companies' activities. Additionally, the ministry is responsible for monitoring the flow of ELTs as well as the financial transactions associated with them.

[160] https://www.ecopneus.it/en/elt-recycling/end-of-life-tyres/recycling-and-recovery-of-elts/

[161] file:///C:/Users/MarianaCiprianoJord%C3%A3/Downloads/j.wasman.2019.04.023.pdf

Fee for the shareholders of Ecopneus (VAT to be added)

CATEGORY	TIPOLOGY	WEIGHT RANGE OF TYRES PLACED IN THE MARKET (KG)	ECO FEES
P	1	0 – 4,999	1,00
	2	5 – 7,999	1,80
	3	8 – 12,999	2,60
	4	13 – 15,999	3,70
	5	16 – 24,999	4,70
	6	25 – 34,999	7,70
M	7	35 – 64,999	14,50
	8	65 – 104,999	18,70
	9	105 – 154,999	32,70
G	10	155 – 224,999	56,30
	11	225 – 314,999	79,70
	12	315 – 424,999	112,30
	13	425 – 554,999	148,00
	14	555 – 704,999	184,30
	15	> 705	266,60

FIGURE 27. Eco-fees in Italian EPR scheme. Source: Ecopneus' website.

Appendix 2.4.3 Environmental performance

In 2023, Ecopneus collected 187,456 tonnes of ELTs, achieving a collection rate of 112%**Error! Bookmark not defined.**. In the same period, 95,027 tonnes (50.1%) of used tyres ended up as material recovery and 94,592 tonnes (49.9%) as energy recovery**Error! Bookmark not defined.**.

ELTs are classified as waste, but in Italy you can also bring to the retailer, who can then collect it. But for re-treading you need to collect many tyres of the same tyres. But according to Italian law, you cannot store waste in such quantities, in order to get enough of each type. So, it's a barrier for re-treading that it's classified as waste.

Appendix 2.5 EPR scheme in Portugal

The Portuguese government introduced the **Decree-Law No. 111** in 2001, which established the applicable rules for the management of used tyres. This decree mandates that tyre producers, importers, and retailers are responsible for the collection, treatment, and recycling of ELTs. Additionally, it sets guidelines for creating a system to ensure that all used tyres are properly managed, reducing their environmental impact and supporting a circular economy for tyre materials.

To meet these obligations, tyre producers together with the tyre re-treading and rubber industry sectors created Valorpneu, the primary entity responsible for managing the EPR scheme in Portugal.

Decree-Law No. 152-D/2017 set the basis for EPR in various waste streams, including tyres, and applicable rules to the management of tyres and used tyres. This decree consolidated and updated the existing regulations, including those in Decree-Law No. 111, aligning them with the latest European directives on waste management and sustainability. This decree provides a framework that facilitates tracking, reporting, and compliance for producers and importers across various waste sectors. According to the

legislation, 96% of the ELTs must be collected and 65% of these must be prepared for reuse or recycling. This goal will however increase in the future[117].

Valorpneu is a private non-profit organisation established in 2002 with the primary goal of creating and developing a system for the proper management and processing of ELTs[162]. Valorpneu started operating in 2003[117]. It was established by leading tyre manufacturers in collaboration with Portuguese associations. It is primarily managed by the Automobile Association of Portugal (ACAP), which has a 60% representation, while the National Association of Tyre Re-treaders (ANIRP) and the Portuguese Association of Rubber Industries (APIB) each have a 20% representation.

Valorpneu developed the SGPU (Integrated System for the Management of Used Tyres) – a system created with the aim of coordinating the processes and responsibilities for handling ELTs, eliminating landfill disposal and promoting collection, sorting, recovery and valorisation.

The EPR scheme covers the entire national territory, including the autonomous regions of Madeira and Azores, situated in the Atlantic Ocean. Because these regions are archipelagos and due to their distance to the mainland, operation costs are higher[117].

Valorpneu has 8 employees working on the administration of the system. Other collaborators operate within the system but are not employed by Valorpneu[117].

Appendix 2.5.1 Process

Under this system, both new and second-hand tyres enter the Portuguese market. Any individual or organisation responsible for placing tyres on the national market – whether through manufacturing, importing, or purchasing from within Europe – is required to enter into an agreement with Valorpneu[163]. This ensures that the applicable eco-fee is charged for the tyres being introduced.

Every 3 months, producers must communicate to Valorpneu the number of tyres placed on the market, so the PRO has an estimate of the amount of tyres to be treated[117].

Distributors, workshops, dismantlers, local authorities, and individuals who hold used tyres can drop them off free of charge at one of the many collection centres spread across the country (51 in 2023**Error! Bookmark not defined.**). These centres serve as temporary storage sites for used tyres, accepting all types of tyres at no cost. They aim to control and track the flow of tyres destined for recovery or other processing, ensuring a well-distributed network throughout Portugal. There is at least one collection hub per district[117]. The autonomous regions also have collection centres, where the tyres are delivered and then sent to waste treatment, either in one of the islands or the mainland[117].

Any holder of used tyres can drop off the tyres at these collection centres free of charge.

In the collection hubs, the tyres are weighed, classified, sorted and prepared to be sent to the relevant treatment facilities. The tyres are sorted into categories, such as light, heavy, industrial, agricultural and others.

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[162] https://www.valorpneu.pt/sobre-a-valorpneu/quem-somos/

[163] https://www.valorpneu.pt/sistema-sgpu/modelo-operacional-e-financeiro/

It is the collection hub's duty to ensure that the tyres are decontaminated by promoting the delivery of clean tyres. When there is a contaminated tyre, the collection centre may refuse to accept the tyre or may clean the tyre afterwards. The collection centre may incur on fees, fines or performance penalties if the tyres are delivered to the treatment facilities contaminated[117].

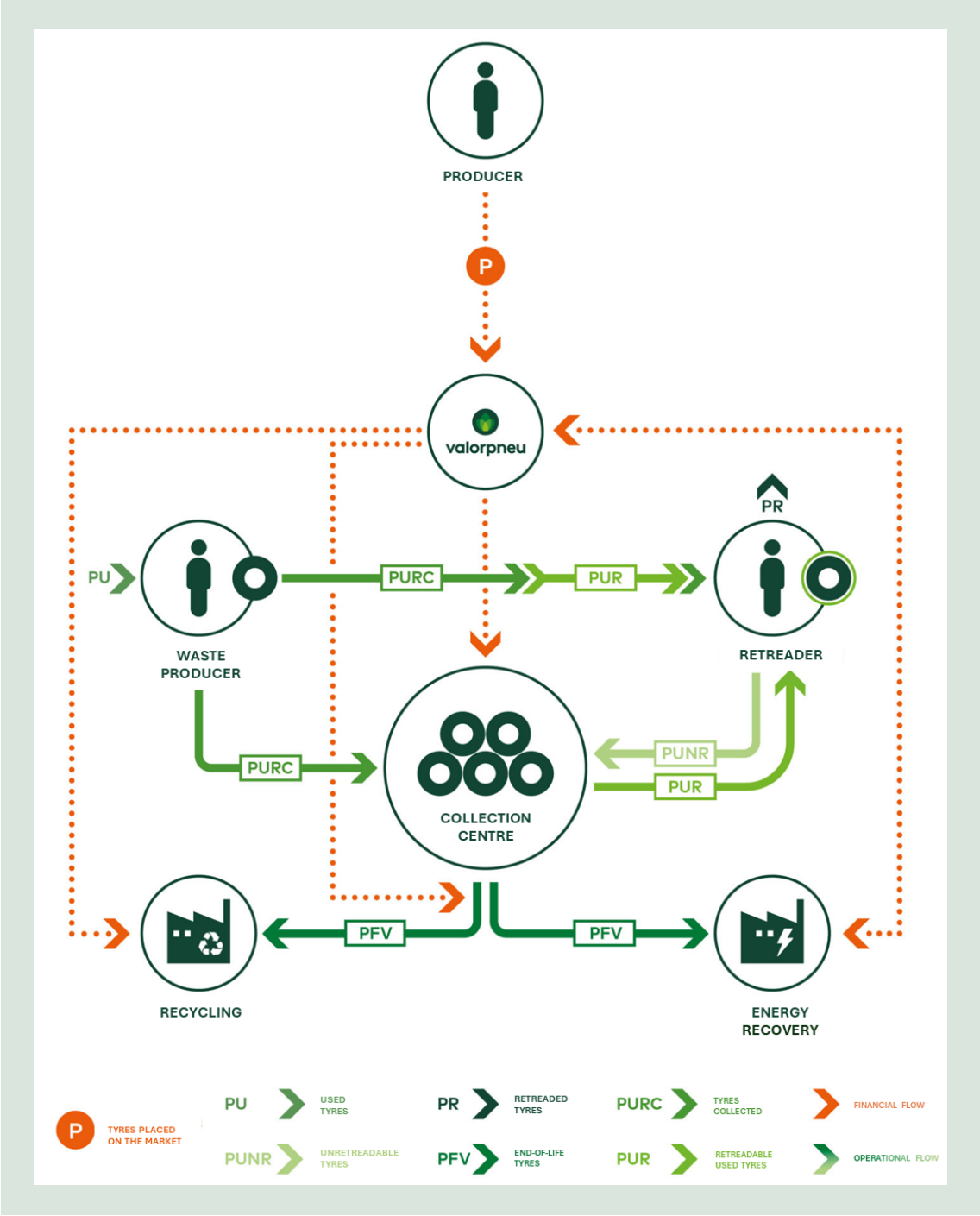

FIGURE 28. Valorpneu's operational and financial system.

Additionally, distributors and other holders can deliver tyres directly to re-treading facilities, which can also deliver used tyres resulting from the sorting of casings at these collection hubs without incurring a fee. Re-treading facilities may also purchase tyre casings from the collection hubs. There are 20 re-treading companies that are part of Valorpneu's network**Error! Bookmark not defined.**.

Once the tyres are gathered, Valorpneu organises their transport from the collection hubs to designated treatment facilities, where they are processed according to established goals, primarily focusing on recycling and energy recovery. The transport of ELTs to reprocessing facilities and energy recovery plants is managed by logistics providers and is overseen and funded by Valorpneu. In 2023, there were 21 transport providers across the country**Error! Bookmark not defined.**.

In exchange for compensation and in compliance with legal targets, reprocessing companies and energy recovery plants receive ELTs from the collection hubs. There is one shredding operator that cuts whole tyres into chips and two recycling companies (Genan and Biogoma) operating in Portugal**Error! Bookmark not defined.**. These companies convert the tyres into rubber granules to be used for rubber-modified bitumen, synthetic pitches, flooring, playgrounds. On the other hand, there are 5 energy recovery operators**Error! Bookmark not defined.** that use the rubber from tyres for energy generation.

The entyre system is supported by an online platform (SGPU Online), which facilitates communication between the various operators and enables Valorpneu to effectively manage and oversee the process. Valorpneu then reports the relevant information on the quantities managed and sent to each final destination to government entities, specifically the Portuguese Environment Agency (APA) and the Directorate-General for Economic Activities (DGAE).

In the first years of the EPR scheme, tyres not paying eco-fee were also collected, transported and treated. To do so, their treatment was spread out throughout several years, to make sure it was financially and practically viable[117].

Some tyres are reused; however, this is only possible when the tyre maintains legal tread depth and is in good condition for further use[117]. These tyres are only reused domestically and are not exported to other countries where regulations regarding tyre specifications are more lenient[117].

There are very few abandoned tyres in the country; when they do occur, municipalities carry out cleaning operations and deliver the tyres to the nearest collection centre[117].

A used tyre has 15% less weight than a new one – when recalculating, one must account for the rubber that disappears with wear[117].

The market is Portugal, Europe and other countries[117].

Operating expenses in 2023[164]:

In 2023, Valorpneu spent 36.8% in recycling and 21.6% in transportation, and 18.2% in collection hubs. In addition, it spent 7.8% in administrative operations, followed by 5.6% in energy recovery and 4.1% in marketing and communication.

[164] https://www.valorpneu.pt/wp-content/uploads/2024/04/2023_Relatorio-Anual-de-Atividades-Valorpneu_resumo_Aguarda-aprovacao-da-APA-e-DGAE_compressed.pdf

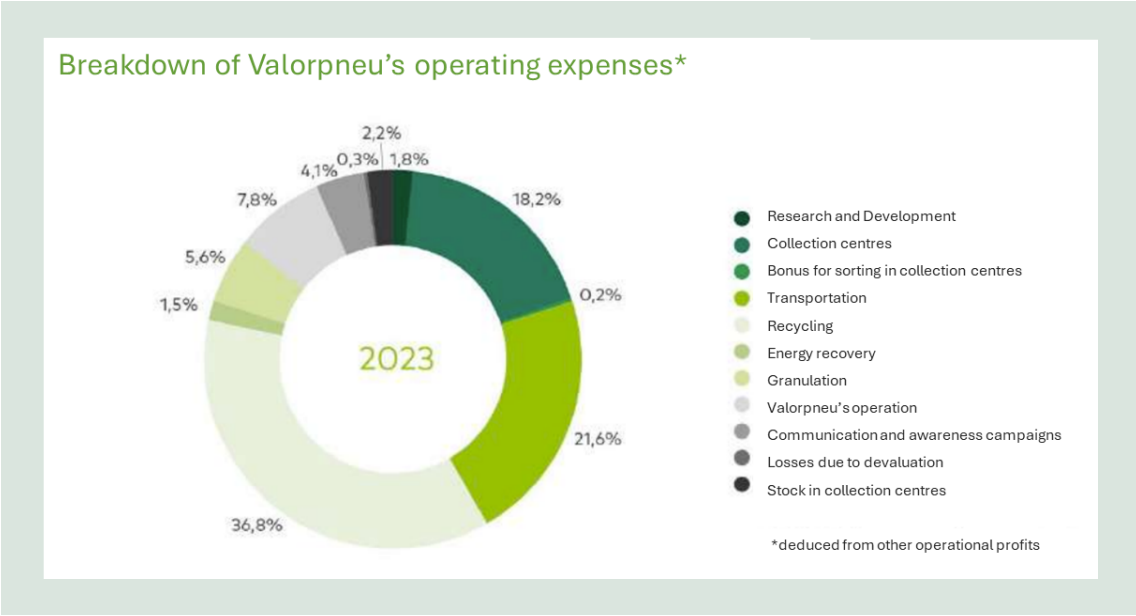

FIGURE 29. Breakdown of Valorpneu's operating expenses in 2023.

Appendix 2.5.2 Fees

This system is financed through an eco-fee ('Ecovalor') that is included in the cost of the tyre introduced into the national market (new or used)[117]. The producer pays Valorpneu the eco-fee corresponding to the quantities they produced or imported and placed on the market**Error! Bookmark not defined.**. The eco-fee supports the collection, transportation and processing (preparation for reuse, recycling and energy recovery) of ELTs. The system also includes marketing and communication activities, as well as funding of R&D activities[165].

The fee varies according to the type of tyre placed on the market but is charged only once per tyre: retreaded and reused tyres reintroduced domestically are exempt from an additional fee. However, retreaded and reused tyres imported into Portugal must still pay the eco-fee[117]. Furthermore, scrap dealers importing end-of-life cars must also pay the eco-fee. In addition, vehicles sold with tyres already attached are also required to pay the eco-fee[117].

The eco-fee also covers tyres that original equipment tyres that are incorporated into the car when it is sold[117].

One difference in the Portuguese EPR scheme compared to the remaining analysed ELT systems is that it covers all types of tyres (14 different categories), from bicycles to passenger cars, industrial vehicles and aircrafts.

[165] Interview with Valorpneu on 18.10.2024

TABLE 19. Eco-fees in Portuguese EPR scheme in 2024. Source: Adapted from Valorpneu's website.

Financial contributions		2023 €/tyre
T	Passenger car	1.05 €
4x4	4x4 on/off road	1.80 €
C	Commercial	1.56 €
P	Heavy	7.44 €
A1	Agricultural (various)	2.75 €
A2	Agriculture (driving wheels)	9.05 €
E1	Industrial (≤ 15'')	1.55 €
E2	Massive (≤ 15'')	3.58 €
G1	Civil engineering (<24'') and massive (16'' and 23'')	7.99 €
G2	Civil engineering (≥24'') and massive (≥24'')	38.02 €
M1	Motorcycles (>50 cc)	0.65 €
M2	Motorcycles (up to 50 cc)	0.20 €
F	Aircraft	1.05 €
B	Bicycles	0.07 €

The eco-fee is calculated based on an estimate of the costs of the entire system, ranging from costs for collection, transport, recycling and energy recovery, to marketing, R&D and administrative costs[117]. This fee is reviewed whenever necessary, typically when a new licence is issues, but can also be modified during the current licence period[117].

The eco-fee is itemized on the invoice and paid by the consumer, ensuring full transparency[117]. However, certain challenges may arise: if consumers purchasing new tyres do not request an invoice, there is a risk that the fee may be excluded from the final price, perhaps to offer a more competitive price. As a result, the tyre is not registered with Valorpneu and does not contribute to the system, leaving its end-of-life management unaddressed and potentially entering a 'parallel market'[117].

Appendix 2.5.3 Environmental performance

In 2023, Valorpneu collected 92,041 tonnes of ELTs, achieving a collection rate of 110.1%.Of this, 11% were re-treaded, 0.9% were reused, 70.2% were recycled and 17.9% were sent for energy recovery**Error! Bookmark not defined.**.

Besides achieving their target of 96% collection rate, Valorpneu voluntarily collected and treated 10,691 tonnes of used tyres.

TABLE 20. End-of-life treatment of ELTs in 2023.

ELT final treatment	Percentage
Re-treading	11.7%
Reuse	0.7%
Recycling	59.7%
Energy recovery	27.9%
Total	**100%**

Appendix 3. Survey questions

Appendix 3.1 Guidance for respondents

Email text:

Waste Producers: Dear key stakeholder in the Danish tyre scheme. The Danish Environmental Protection Agency, in collaboration with the consultancy firm Viegand Maagøe, is mapping the most significant challenges and opportunities in the Danish tyre scheme. As part of this process, we greatly value your expertise and insights as a waste producer and potentially a fee-liable business. We kindly ask you to complete a questionnaire that sheds light on various aspects of the current fee and subsidy scheme for end-of-life tyres, as outlined in Executive Order No. 1660 of 13/11/2020.Your input will contribute to an analysis of the management of end-of-life tyres regarding environmental, market, economic, and system aspects. The survey will also help identify ways to promote more recycling within the industry. The questionnaire consists of 23 questions; all responses will remain anonymous, and data will only be presented in aggregated form. You can access the survey via the following link: Complete the questionnaire here. Please submit your response by 28/10. Thank you for your time and contribution to this important study.

Collectors: Dear key stakeholder in the Danish tyre scheme, The Danish Environmental Protection Agency, in collaboration with the consultancy firm Viegand Maagøe, is mapping the most significant challenges and opportunities in the Danish tyre scheme. As part of this process, we greatly value your expertise and insights as a collector. We kindly ask you to complete a questionnaire that sheds light on various aspects of the current fee and subsidy scheme for end-of-life tyres, as outlined in Executive Order No. 1660 of 13/11/2020. Your input will contribute to an analysis of the management of end-of-life tyres regarding environmental, market, economic, and system aspects. The survey will also help identify ways to promote more recycling within the industry. The questionnaire consists of 43 questions; all responses will remain anonymous, and data will only be presented in aggregated form. You can access the survey via the following link: Complete the questionnaire here. Please submit your response by 28/10. Thank you for your time and contribution to this important study.

Survey Introduction:

Waste Producers: The Danish Environmental Protection Agency, in collaboration with the consultancy firm Viegand Maagøe, is mapping the key issues in the Danish tyre scheme. The current fee and subsidy scheme, outlined in Executive Order No. 1660 of 13/11/2020 for the recovery of end-of-life tyres, is facing challenges and requires adjustment.Your response to the questionnaire will support an analysis of the treatment of end-of-life tyres in terms of environmental, market, economic, and system aspects, as well as explore how best to incentivize increased recycling. The questionnaire consists of 23 questions; all responses will remain anonymous, and data will only be presented in aggregated form.Thank you for taking the time to complete this survey.

Collectors: The Danish Environmental Protection Agency, in collaboration with the consultancy firm Viegand Maagøe, is mapping the key issues in the Danish tyre scheme. The current fee and subsidy scheme, outlined in Executive Order No. 1660 of 13/11/2020 for the recovery of end-of-life tyres, is facing challenges and requires adjustment. Your response to the questionnaire will support an analysis of the treatment of end-of-life tyres in terms of environmental, market, economic, and system aspects, as well as explore how best to incentivize increased recycling. The questionnaire consists of 43 questions; all responses will remain anonymous, and data will only be presented in aggregated form.

Thank you for taking the time to complete this survey.

Appendix 3.2 Questions

TABLE 21. Questions.

Waste producers (Tyre centres/car repair shops)		
	Collection and remuneration	
1	If you pay for the collection of end-of-life tyres, what do you pay per tonne of passenger car tyres?	a) _____ -100-0 kr. per tonne of passenger car tyres b) _____ DKK 0-100 per tonne of passenger car tyres c) _____ DKK 100-200 per tonne of passenger car tyres d) _____ DKK 200-300 per tonne of passenger car tyres e) _____ DKK 300-400 per tonne of passenger car tyres f) _____ more than DKK 400 per tonne of passenger car tyres g) N/A
2	If you pay for the collection of end-of-life tyres, what do you pay per tonne of van tyres?	a) _____ DKK -100-0 per tonne of van tyres b) _____ DKK 0-100 per tonne of van tyres c) _____ DKK 100-200 per tonne of van tyres d) _____ DKK 200-300 per tonne of van tyres e) _____ DKK 300-400 per tonne of van tyres f) _____ more than DKK 400 per tonne of van tyres g) N/A

3	If you pay for the collection of end-of-life tyres, what do you pay per tonne of agriculture and truck tyres	a) _____ DKK -100-0 per tonne of agriculture and truck tyres b) _____ DKK 0-300 per tonne of agriculture and truck tyres c) _____ DKK 300-600 per tonne of agriculture and truck tyres d) _____ DKK 600-900 per tonne of agriculture and truck tyres e) _____ DKK 900-1100 per tonne of agriculture and truck tyres f) _____ more than DKK 1100 per tonne of agriculture and truck tyres g) N/A
4	What is your contractual relationship with the fundraiser?	(a) Fixed-price contract per tonne of tyre type collected (b) To be determined at each collection per tonne of the type of tyres collected; c) other contract, please describe _____
6	Do you find that there are tyres that the collector does not want to include?	a) Always b) Often c) Sometimes d) Rarely e) Never
7	If you find that the collector does not include tyres, describe the types of tyres	a)_____
8	What percentage of end-of-life tyres are not collected from you?	a) 0-5 percent b) 5-10 percent c) 10-20 percent d over 20 percent
9	What do you do with the tyres that collect, do not collect or reject?	a) _____
10	What does it cost you per ton of tyres that are not picked up or rejected?	a) _____ kr. per ton
11	Do you have any other administrative costs associated with handling tyres?	If so, which _____ divided into _____ number of hours per year

Fees and costs

The following deals with the fees contained in the Tyre Order for bringing tyres to the Danish market – if it is not relevant to you, you are welcome to move on to the next section

2	Do you pay a fee for bringing tyres to the Danish market?	a) Yes b) No
3	How much time do you spend registering your company as a waste producer with the Danish Business Authority?	a)_____ hours b) N/A
4	How much time do you spend on calculating and maintaining accounts of the receipt and sale of fee-liable tyres divided into each fee group per quarter?	a)_____ hours per quarter b) N/A

5	How much time do you spend per quarter on reporting the number of tyres subject to a fee to the Danish Tax Agency?	a)_____ hours per quarter b) N/A
6	If you pay fees for bringing in tyres, have you had supervision from the Danish Tax Agency? If so, how much time did you spend on the Danish Tax Agency's supervision per year?	a) Ja____ time. per year (b) No

Change of scheme

The following sets out various possibilities for changes to the scheme. Please consider how a change may affect you and your company

4	What would it mean for you if it became free to pick up end-of-life tyres?	a)_____
5	How could the scheme be changed so that all tyres are collected?	a)_____
6	What would it mean for you if there was a difference in the amount of the subsidy depending on whether the tyre is reused, retreaded or recycled for different types of products?	a)_____
7	What is crucial in relation to whether you hand over tyres for re-treading or collection for reprocessing?	a)_____
8	What would it mean for you if re-treading companies were part of the subsidy for the collectors?	a)_____
9	How do you prevent you from sending tyres for incineration?	a)_____
10	What are the biggest challenges with collectors being able to charge for tyre collection?	a)_____
11	How can these challenges be changed?	a)_____
12	How would you view a scheme such as extended producer responsibility, where, among other things, the Producer Responsibility Scheme is extended to the Producers' Responsibility Scheme? - The costs of handling the tyres at the end of their life must be paid by the tyre importers rather than the current fee. - All tyres must be collected independently of recycling potential - Collection, transport and reprocessing organised by an actor appointed by the tyre importers, e.g. through tenders. - The subsidy is generally paid to the waste producer - The subsidy is environmentally graded	a)_____

13	What is your assessment of your most significant costs in connection with the transition to extended producer responsibility? E.g.: related to control apparatus, documentation, grant applications, fee collection, contract negotiations and tenders.	a) _____kr per year in conversion costs and DKK _____ per year in ordinary operation

Fundraisers - current scheme

Collection

The questions below concern the collection and collection of tyres, payment flow between the waste producer and the collector, and administrative costs

1	If you charge for the collection of end-of-life tyres, what do you charge per tonne of passenger car tyres?	a) _____ -100-0 kr. per tonne of passenger car tyres b) _____ DKK 0-100 per tonne of passenger car tyres c) _____ DKK 100-200 per tonne of passenger car tyres d) _____ DKK 200-300 per tonne of passenger car tyres e) _____ DKK 300-400 per tonne of passenger car tyres f) _____ more than DKK 400 per tonne of passenger car tyres g) N/A
2	If you charge for the collection of end-of-life tyres, what do you charge per tonne of van tyres?	a) _____ DKK -100-0 per tonne of van tyres b) _____ DKK 0-100 per tonne of van tyres c) _____ DKK 100-200 per tonne of van tyres d) _____ DKK 200-300 per tonne of van tyres e) _____ DKK 300-400 per tonne of van tyres f) _____ more than DKK 400 per tonne of van tyres g) N/A
3	If you charge for the collection of end-of-life tyres, what do you charge per tonne of agriculture and truck tyres?	a) _____ DKK -100-0 per tonne of van tyres b) _____ DKK 0-300 per tonne of van tyres c) _____ DKK 300-600 per tonne of van tyres d) _____ DKK 600-900 per tonne of van tyres e) _____ DKK 900-1100 per tonne of van tyres d) _____ more than DKK 1100 per tonne of van tyres f) N/A

4	What is your contractual relationship with the waste percentage?	(a) Fixed-price contract per tonne of tyre type collected (b) To be determined at each collection per tonne of the type of tyres collected; c) Basic price with additional price according to price index d) Other conflict, please describe _____
5	Where do you primarily pick up end-of-life tyres?	a) Garages b) Car breakers and scrap dealers c) Recycling centres (d) Agriculture, hauliers e) Other collectors (d) Other _____
6	How often do you hand over tyres to other collectors?	a) Always b) Often (c) Sometimes d) Rarely e) Never
7	When you collect tyres, what does the distribution of tyre types typically look like?	(a) _____ton passenger car tyres (b) _____ tonnes of van tyres (c) _____ tonnes of agriculture and truck tyres (d) _____ton other e) N/A
8	If you collect tyres from another collector, what do you pay the specific collector per tonne	a)_____ 0-50 kr. per ton b) 50 – 100 kr. pr. ton c) 100 – 150 kr. pr. ton d) 150-200 kr. pr. ton e) N/A
9	How much time do you spend sorting tyres per tonne per year?	a)_____ hours
10	What are your operating costs for collection, including transport, sorting, administration, etc., per tonne of tyres?	a)_____ 200-400 kr. per ton b)_____ 400-800 kr. per ton c)_____ 800-1000 kr. per ton d)_____ 1000-1200 kr. per ton e)_____ over 1200kr per ton
10	How much time have you spent registering your company as a collection company with the Danish Environmental Protection Agency?	a)_____ hours
11	Do you have any other administrative costs related to handling the collection of tyres?	If so, what _____ in the number of hours per year
12	What proportion of your business depends on being able to collect tyres?	a) 10-20 percent b) 20-40 percent c) 40-60 percent d over 60 percent
	Delivery for recycling	

1	Who pays for the return of end-of-life tyres?	a) The collector b) The recycler
2	How much do you get paid for handing in end-of-life tyres for recycling in DKK per tyre type?	a)_____kr. per tonne passenger cars a) _____ kr. per tonne of van tyres a) _____ kr. per tonne of agriculture and truck tyres f) N/A
3	How much do you pay on average to hand in end-of-life tyres for reprocessing in DKK per tyre type?	a)_____ kr. per tonne passenger cars a)_____kr. per tonne of van tyres a _____ kr. per tonne of agriculture and truck tyres f) N/A
4	What is your contractual relationship with the recycling company?	(a) fixed-price agreement per tonne; b) Basic price with additional price according to price index (c) variable and shall be fixed on a time-by-time or monthly basis; (d) other agreement, _____
5	Do you collect tyres that cannot be recycled?	a) Always b) Often (c) Sometimes d) Rarely e) Never
6	What do you do with the tyres that cannot be reprocessed?	a)_____
7	What does it cost you per kg of tyres that cannot be sold for reprocessing?	a) _____ kr. per ton
8	How often do you have to pay fines for delivering tyres that cannot be reprocessed to the recycler?	a) Always b) Often (c) Sometimes d) Rarely e) Never
9	How large a proportion of tyres do you sort out for direct recycling through export?	a) 5% b) 10% c) 15% d) 20% e) ____ %
10	If you export tyres, who do you export to? Please specify the country(s).	a) _____
	Subsidy	
1	Is your company applying for a grant from the Danish Tyre Industry Environmental Fund?	a) Ja b) Nej
2	If your company applies for a subsidy, how much do you receive in subsidies per tonne?	a) Tyre group 1-6 DKK _____ per tonne b) Tyre group 7-8 DKK _____ per tonne C) not applicable

3	What are the main reasons why you are not promised a subsidy?	a)_____
3	How long do you spend on the application for payment of subsidies, including the statement of tyres collected, origin of tyres and waste producer per year	a)_____ hours per year b) N/A
4	How many times a year do you apply for a subsidy?	a) _____ b) N/A
5	Does the size of the subsidy affect the quality of the tyres you supply?	(a) To a large extent (b) To some extent (c) Neither nor (d) To a lesser extent e) Not at all
	Changes to the scheme	
1	What would it mean for you if you could only pick up end-of-life tyres without payment?	a)_____
2	What will it mean for you if the subsidy is reduced by 50%?	a)_____
3	What will it mean for you if the subsidy is increased by 50%?	a)_____
4	What is crucial in relation to whether you hand over tyres for re-treading or for recycling?	a)_____
5	How can a scheme be established so that you hand in more tyres for re-treading?	a)_____
6	What does it take for you to collect all tyres?	a)_____
7	What would it mean for you if there was a difference in the amount of the subsidy depending on whether the tyre is reused, retreaded or recycled for different types of products	a)_____
8	How do you prevent tyres from going to incineration?	a)_____
9	What challenges do you experience in the possibility of charging for the collection of tyres from the waste producer? And how can these be changed	a)_____

10	How would you view a scheme such as extended producer responsibility, where, among other things, the Producer Responsibility Scheme is extended to the Producers' Responsibility Scheme? - The costs of handling the tyres at the end of their life must be paid by the tyre importers rather than the current fee. - All tyres must be collected independently of recycling potential - Collection, transport and reprocessing organised by an actor appointed by the tyre importers, e.g. through tenders. - The subsidy is generally paid to the waste producer - The subsidy is environmentally graded	a)_____
11	What is your assessment of your most significant costs in connection with the transition to extended producer responsibility? E.g.: related to control apparatus, documentation, tender rounds, con-tract negotiations with collectors/processors	a)_____

Appendix 4. Tyre characteristics in the Danish ELT system

Appendix 4.1 Tyre types and categories in the System

This report builds on a variety of different sources of data and information, many of which use different names for different types of tyres. The various categories and definitions cannot be translated exactly one-to-one, but the table below gives a good idea of the difference between the terms used in this report.

Please note, that especially the European categories of C1, C2 and C3 tyres is a bit complex, given that these definitions in the tyre type approval regulation 661/2009[166] Article 8 are based on vehicle types, which are defined in the vehicle type approval regulation 2018/858[167] Article 4. The definitions are used in e.g. the tyre labelling regulation, where special tyres (e.g. for agriculture or construction) are out of scope. In short, the categories translate to the following:

- C1: for vehicles and trailers under 3.5 tonnes, up to 8 passengers. → Loosely translated to Passenger cars
- C2: For vehicles for more than 8 passengers, and vehicles not for passengers, no max weight, but speed category less than N (≤140 km/h) → Loosely translated to Light truck tyres
- C3: As C2, but with either a load capacity index ≥122 *or* a load capacity index ≤121 and speed category less than M (≤130 km/h) → Loosely translated to heavy truck tyres

[166] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32009R0661

[167] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32009R0661

TABLE 22. Tyre types and categories from the various sources used in this report. The translation to European categories is not 1:1, as the definitions are based on slightly different sizes / load indexes, but since C2 must have load index less than 122 (based on C3 having above 122 as criterion), they will fall under Group 1). DBMF (Dæk Branchens Miljø Fond / The Tyre Industry Environmental Fund).

Group according to the Danish regulation		Typical tyres included	Weight used for conversion	DBMF statistics categories	EU definition (C1-C3)
Group 1	Rim size ≤10 inches or load index ≤123 | new tyres	Passenger car tyres and motor-cycle tyres including for special use .	10 kg (worn tyre) 12 kg (new tyre)	PV (Tyres for motorcycles, passenger cars, vans etc)	C1 / C2
Group 2	As Grp 1, re-treaded				
Group 3	Rim size 10-19,5 inches or load index ≥123 | new tyres	Tyres for commercial vehicles, including light trucks and busses	12.0 kg (worn tyre) 14.5 kg (new tyre)		C3
Group 4	As Grp 3, re-treaded				
Group 5	Rim size 19,5-24 inches | new tyres	Tyres for commercial vehicles including heavier trucks and busses	58 kg (worn tyre) 70 kg (new tyre)	LVT (Tyres for lorries and busses, ”Light Vehicle Tyres”)	
Group 6	As Grp 5, re-treaded				
Group 7	Rim size >24 inches| new tyres	Tyres for farming and construction vehicles and other heavy duty, specially constructed tyres.	100 kg (worn tyres) 120 kg (new tyre)	OTR (Tyres for agriculture and construction vehicles etc. “Of the Road Tyres”)	N/A
Group 8	As Grp 7, re-treaded				

Analysis of the treatment of end-of-life tyres regarding environment, market, economy, and system

The Danish system for handling of End-of-Life Tyres (ELT) in Denmark is based on a fee and subsidy system. The aim of this study is to investigate how challenges affect the Danish End-of-Life tyre (ELT) system can be met., investigate potential solutions and provide recommendations for the Danish Environmental Protection Agency.
The study showed that the Danish ELT system has high collection rates and is generally perceived as a well-functioning system by both Danish actors in the system (collectors, recyclers) and interviewees from the Neighbour check countries. The system is very alike an EPR, with DBMF in place of a PRO, but there are legal limitations related to the current authorisation through the Environmental Protection Regulation. The main conclusions from the study: Economically there is a deficit in the system of 38 million DKK in 2023, which arises from increasing gate fees. Also, tyres on new vehicles do not contribute to the system, as they are exempted from fees. The re-treading market is declining. New tyre technologies are emerging in the market which cannot be recycled with the current dominant technologies, and new recycling technologies are not ready to be operated on commercial scale yet.

The Danish Environmental
Protection Agency
Tolderlundsvej 5
DK - 5000 Odense C

www.mst.dk