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COMPARATIVE ANALYSIS OF MAJOR COMPANIES WITHIN ARTIFICIAL TURF RECYCLING AND TREATMENT

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COMPARATIVE ANALYSIS OF MAJOR COMPANIES WITHIN ARTIFICIAL TURF RECYCLING AND TREATMENT

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Prepared by	**LOA**
Checked by	**BEBH**
Approved by	**LOA**

Ramboll
Olof Palmes Allé 22
DK-8200 Aarhus N
Denmark

T +45 5161 1000
F +45 5161 1001
https://ramboll.com

Rambøll Danmark A/S
DK reg.no. 35128417

Member of FRI

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Appendix 1
Explanation of parameters in table 1 and 6

1. SUMMARY AND CONCLUSION

Over the past 20 years the market for artificial turf has accelerated and created a similar increased demand for environmentally friendly treatment of old and worn-out artificial turf pitches because they are composite plastic products containing sand and rubber infill material. According to TV2 Norway[1] one artificial pitch weighing 240 MT alone is the equivalent of 1.4 million plastic bags and can be recycled. The pitches represent a source for spreading microplastic into the environment due to the wear and tear over the years of use. The infill rubber material often consists of SBR-rubber from old tires containing heavy metals and different organic components as PAH and softeners. The size of the infill rubber granulate is less than 5 mm and therefore also regarded as microplastic that must be prevented from being spread to the environment. In the turf industry the general focus has been on sand due to the weight that it represents, but in fact it is the 30-40% polymer and rubber content that should be the main concern for key decision makers when evaluating artificial turf treatment and recycling. All handling and treatment of artificial turf pitches should reflect these environmental issues.

Artificial turf is recyclable to almost 100%
An artificial turf pitch is in fact recyclable to almost 100 % depending on the procedure. In a hierarchical approach, the most environmentally friendly way of handling the pitches is to create a fully circular loop that will enable circular economy and produce a minimum of waste. Secondly, specific reuse is preferred. But reuse is not very likely because the state of the discarded artificial turf often does not allow reuse for the same purpose. However, the different materials can be separated and recycled to new products, downcycled to products where the material can only be used one time or used as infill material e.g. in building material or road constructions which is not considered recycling.

Lack of transparency
The European market for recycling artificial turf pitches is, although the legislation in Europe is based on the same directives, not fully transparent regarding processes and recycling of materials nor regarding classification for shipment between countries. The result is a market characterized by undocumented claims of recycling and many EU countries have experienced cases where municipalities are being promised by contractors that their artificial turf pitch is being recycled. In the reality they are left behind without trustworthy documentation for the recycling process or with sites accumulating waste that is not treated for recycling. Due to lack of transparency, municipalities having acted in good faith, see themselves ending up in a precarious situation following extensive broadcastings by the Dutch TV-show Zembla and TV2 Norway documenting what has actually happened with their worn-out turf pitches.

Set-up and objective of this report
The objective of this study is to collect actual treatment process documentation, thereby equipping public and private decision makers with a full transparency analysis that will allow them to consciously decide if they want to do recycling, downscaling or just waste treatment. To ensure validity and even playing field, all vendors in the study have been presented with their respective conclusions of the report, allowing them to forward new documentation that would warrant an update of the conclusions of the report. The intent is furthermore to regularly update the report as the different vendors mature and develop their treatment processes, so that key decision makers are aware of the most recent legislation and vendor profiling.

[1] https://www.tv2.no/a/10690574/

This study has collected official information about six major actors in the field of treating artificial turf pitches in Denmark, Germany and the Netherlands in order to examine the different available processes and technologies and assess the level of recycling. In future versions new regions and turf treatment suppliers will be added to the comparative analysis.

Most important findings

Having had access only to the environmental permits (or parts hereof), newspaper articles, televisions broadcasts and other official documents and company websites, the study shows that:

- Most of the processes focus mainly on the initial separation of the infill from the carpet and do not attempt to take on the whole process of the recycling of materials into new recyclable products. Most of the companies sell the materials to subcontractors to fulfil the process. The traceability is not described as part of the permits.
- The big amounts of plastic only seem to be processed for recycling into recyclable products by one of the companies, while other companies are downcycling the polymers, using it for energy production or selling the turf pitches regardless of the fact that they are still to be classified as waste.
- The municipalities are authorized to classify the waste for treatment and shipment across borders and they have the possibility to assign a specific treatment for the waste as well as the authority to monitor local recycling facilities.
- The municipalities seem to be unaware of the needs for qualifying requirements in the tenders for replacement of pitches. Also, the possibilities they have as owners of facilities to both control the waste treatment and limit its environmental impact seem to be underestimated when considering their role as authority on waste treatment.

Through the available information about the 6 biggest companies specialising in treatment of artificial turf pitches it is found that only Re-Match has a third-party verification on a full recycling process. The process is only mechanical and thermal and without use of water or chemicals in the process.

TUF, VINK and GBN in the Netherlands all have a waste treatment process based on different technologies to remove the infill materials. It is unclear and not documented if the materials are recycled instead of being downcycled into building materials or otherwise disposed of. The polymer fibers do not appear to be the focus of recycling.

ASIE has no processing plant but sells worn artificial turf for reuse/recycling. Reuse is only legal if artificial grass pitches meet specific quality standards and are used for the original purpose, which is rarely the case for worn-out pitches. KRB in Germany is also selling half or fully emptied rolls for recycling purposes (landscaping etc.).

Response

The data on the companies has been presented to the companies to achieve a review and possible corrections and documentations of the processes and performance regarding the waste hierarchy which could lead to another summary of capabilities than presented in chapter 5. Only VINK, ASIE and Re-Match have responded, Re-Match being the only vendor to document the recycling applications. This report will be open for documented reviews by all the companies.

The different assessed parameters are summarised in the table 1 below.

Nordic Alpha Partners is offering that the substance can be reviewed, updated and assessed specifically together with the vendors in this sector in order to maintain an overview of the different waste treatment possibilities available.

Table 1: Comparision of parameters regarding recycling

Overview of company capability regarding treatment of artificial turf pitches and recycling							
Parameters ((A-E) explanations in appendix)	**Source**	**ASIE**	**GBN**	**KRB**	**Re-Match**	**TUF**	**VINK**
Environmental permits	Authority	-	Yes	Yes	Yes	Yes	Yes
Validated total recycling concept	Authority	No	No	No	Yes	No	No
EU ETV Certification	ETV	No	No	No	Yes	No	No
Other process verification than EU ETV	Company	No	Aiming for BRL	No	Aiming for ISO	No	No
Proven recycling plant in operation (A)	Authority/ permit	No	No	No [2]	Yes	No [2]	No [2]
Chemicals used in process	Authority/ permit	No	Yes	No	No	No	Yes
Water used in process	Authority	No	Yes	To reduce dust	No	To reduce dust	Yes
Registered waste collector and/or processor	Authority	Yes NL	Yes	Yes	Yes	Yes NL	Yes
Crossborder shipments permits for EU	Authority	-	N/A	N/A	Yes	Yes	N/A
Traceability of Fields in storage (B)		No	No	No	Yes	No	No
Full circular traceability (C)		No	No	No	Yes	No	No
Mono-stream output of the process (specific separated material) (D)	Permit	-	Yes	Yes	Yes	No [1]	Yes
	Company	No [2]	No [2]	No [2]	Yes	No [2]	No [2]
% Polymer and rubber recycled (E)		0 [2]	0 [2]	0 [2]	>90	0 [2]	0 [2]
Fibres (avg. weight % - dry) (% of total volume)		N/A	N/A	N/A	6-8	N/A	3 - 4
% Recycling		0	0	0	90	0	0
% Downcycling		0	0 [3]	0 [2]	10	0 [2]	0 [3]
% Waste handling/incineration		0-100 [4]	100	0-100 [4]	0 [6]	100	100
Rubber (SBR/EPDM/TPE) (% of total volume)		N/A	N/A	N/A	19 - 32	N/A	5 - 32
% Recycling		0 [2]	0 [2]	0 [2]	92	0 [2]	0 [2]
% Downcycling		0 [2]	0 [2]	0 [2]	8	0 [2]	0 [2]
% Waste handling/incineration		100	100	100	0	100	100
Sand (% of total volume)		N/A	N/A	N/A	47 - 57	N/A	60 - 90
% Recycling		0 [2]	0 [5]	0 [2]	95	0 [2]	0-100
% Downcycling		0 [2]	0-100	0 [2]	0	0 [2]	0-100
% Waste handling		100	0-100	100	5 [7]	100	0-100

[1]) The permit does not describe this directly
[2]) The company was not able/willing to provide documentation
[3]) Deploying fibres for drainage is rather waste disposal than downcycling
[4]) Selling artificial turf roles for reuse without proper treatment will rarely qualify for reuse.
[5]) GBN has not included a drying step into their permit application. If a drying step is included, the GBN will have the capability to sieve the dry sand and the infill
[6]) Backing and dust represent 3,3-3,7 %. The backing can be used for energy recovery.
[7]) The total waste handling includes metals, wood, stone etc.

2. FRAMING THE ANALYSIS

Throughout the last 20 years the amount of installed pitches has increased enormously worldwide, and the amounts of waste are increasing heavily year by year.

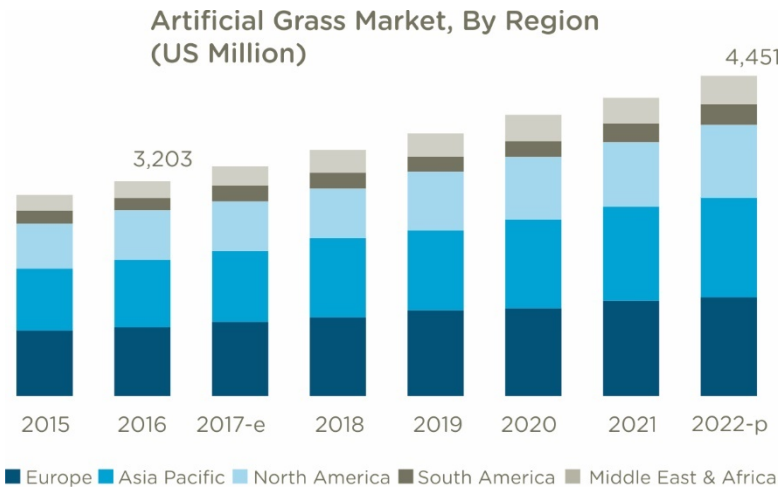

Figure 1 The estimated market for artificial grass - https://www.marketsandmarkets.com/Market-Reports/artificial-grass-market-238480246.html

Along with the growing market different companies have started offering replacement and treatment of the old artificial turf pitches, but in several countries the activities in the waste treatment facilities have led to news articles, TV broadcasts etc. about accumulation of waste without treatment or disappearance of grass rolls that were commissioned to be recycled.

The reason for the increasing focus on the treatment of the pitches is that they contain a huge amount of plastic, rubber and sand that can be recycled, and they represent a source for emission of microplastic (both rubber and parts of the grass-fibers) into the environment. The rubber granule infill consists of particles under 5 mm and is therefore considered to be primary micro-plastic, while the small parts of the plastic grass fibers which wear off during usage are secondary microplastics[2].

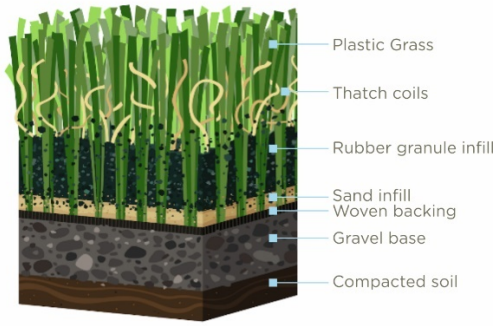

Figure 2 - Principal constructions of artificial turf pitches (without shockpad) (https://www.sustainlv.org/focus-on/what-is-synthetic-turf/).

[2] Lassen, C. et al. (2015). Miljøprojekt nr. 1793, 2015, http://www2.mst.dk/Udgiv/publications/2015/10/978-87-93352-80-3.pdf

Ramboll has been commissioned by Nordic Alpha Partners ApS (NAP), a European growth equity fund who actively invests in the global climate transformation and therefor sees itself spearheading market clarification in the industry to identify rollup investments but also to ensure consistency at the highest environmental standards in their investment cases. For this study the target has been to map the biggest players in the market and current available technologies and processes for recycling and treatment of artificial turf pitches.

NAP is in need of clarification on how the artificial turf waste must be handled when treatment facilities want to import the waste from other countries. This is done in order to assess the level of recycling and environmental considerations associated with the recycling process and the level of verification of applied technology.

It is the aim of this study - through publicly available information and documentation from the companies - to assess the available options that municipalities, sports clubs, etc. have for achieving a traceable and environmentally documented process for substituting old pitches - both regarding reuse of infill materials and recycling of other components from the old pitches.

Ramboll has also been commissioned to present an overview of the legislation and the conditions for respectively the reuse and the recycling of artificial turf pitches. In addition this study will also present some of the possible requirements that the municipalities can use in the tenders in order to receive better documentation of high-level waste treatment and recycling.

Worldwide, Ramboll is engaged in various projects on environment and sustainability with a staff of environmental consultants and other experts in the fields of buildings, infrastructure etc. counting 15,000 experts in 300 offices and 35 different countries. Ramboll is considered one of the world’s leading environmental and health consultancies.

3. WASTE AND RECYCLING

3.1 The EU Waste Framework Directive

According to Article 6 (1) and (2) of the Waste Framework Directive 2008/98/EC, amended by directive 2018/851, certain specified waste shall cease to be waste when it has undergone a recovery operation (including recycling) and complies with specific criteria to be developed in line with certain legal conditions, in particular:

- the substance or object is commonly used for specific purposes;
- there is an existing market or demand for the substance or object;
- the use is lawful (substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products);
- the use will not lead to overall adverse environmental or human health impacts.

Artificial turf pitches are considered waste when removed from their original place of use, classified in the European List of Waste (LOW) under the European Waste Code 17 09 04 "mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03" [3].

Transportation and treatment of the waste calls for approved collectors, transportation and facilities permitted to store and handle the pitches, whether they are meant to be recycled or treated in other ways. This includes cross-border shipment for treatment at foreign facilities, that must be notified and classified due to EU legislation. The cross-border shipment of waste and its control are harmonized throughout the EU under the Waste Shipment Regulation (EC) No 1013/2006.

3.2 Legal judgements on classifications

The study has also included an attempt to uncover how the authorities in the different countries classify removed artificial turf pitches as well as the different materials from the recycling processes.

3.2.1 The Netherlands

Human Environment and Transport Inspectorate (ILT) in The Netherlands has made these statements about classifications of the different materials including emptied pitches:

- If the infill is removed the remaining plastic grass may not contain more than 2 % other components (also the back of the grass is made of plastic). For sampling in case of an administrative measure the Measure and Sampling Team use the Dutch/European norm for sampling waste NEN-EN 14899:2005. Only in cases where the treatment process fulfils the requirements to meet the limit values of 2 % the waste artificial turf classify it as B3010 (List code for plastic) according to classification of waste for shipment (WSR).

- The classification of the rolls of artificial grass depends on the next step of treatment. If they are recycled into granulate it is a green listed waste B3010, in case the company can prove that it will be reused as a new field it can get the status end-of-waste. An application of such statement can be submitted to RWS/Leefomgeving (the waste

[3] https://ec.europa.eu/environment/waste/framework/list.htm

department of Rijkswaterstaat), who verifies the claim of the end-of-waste status[4].

- The rolls of artificial grass remain waste until clear evidence is available that the material fulfils the end-of-waste criteria of article 6 of the Waste Framework Directive (including location where it will be used).

3.2.2 Denmark

The Danish Environmental Protection Agency announces the following about reuse contra recycling:

To be considered reuse, the artificial grass must be used for the same purpose as was before it was removed from its original pitch. (Statutory Order on waste §3, par. 30) For example, the artificial grass can be reused on ball courts where a lower standard is enough to meet the current need. If the artificial grass is used for e.g. golf courses, horse riding facilities, etc. it is recycling and not reuse. In this situation, the artificial grass will be waste and must be handled in accordance with the waste legislation.

In cases where there is doubt as to whether the artificial grass is waste, the municipalities have the final say in how the artificial grass should be classified. To assess whether a used pitch is suitable for reuse, standards for testing the properties are available that can be used to determine whether reuse will be appropriate.

The Danish Environmental Protection Agency considers that artificial turf pitches that have served their purpose as pitches are classified as waste. In their opinion the pitches with infill can be classified with waste code 17 09 04. Removed infill can be classified with waste code 19 12 04 based on the remaining plastic and rubber, due to the official guidelines from the agency. However, it is the municipality that is the supervisory authority to classify the specific waste.

If the producer of waste artificial turf is a municipal body (e.g. municipal schools) the municipality can choose to assign a specific treatment route for the waste, and hence direct the used turf pitches to specific recycling facilities.

In connection with shipment across national borders, it is the opinion that the pitches – with or without infill – should be classified as unlisted waste according to the WSR/Basel Convention and are thus subject to notification. If the pitches can be broken down so that it is only the plastic part, i.e. without E-layer/shock-pad to be exported, it can be transported as green listed under the Basel code B3010.

3.2.3 Germany

The producer is basically responsible for the classification of the waste. In the approval notice the applicant assigns the waste code of the treatment plant to the waste code number (ASN) 17 02 03 as part of the approval process. It is checked and confirmed by the authorities for plausibility. The ASN must be concretised in a special application, as has been done here (17 02 03 sanded artificial turf, partly with rubber granulate, etc.).

[4] https://www.afvalcirculair.nl/onderwerpen/afval/toetsing-afval/webtoets-afval/

In principle, the classification of the waste must be based on origin, so that in the present case a declaration was selected from category 17 ... for construction waste in a broader sense.

The end of the waste status is regulated by Section 5 of the Recycling Management Act (KrWG) of February 24, 2012 (Federal Law Gazette I p. 212), as last amended by Article 2 Paragraph 9 of the Law of July 20, 2017 (Federal Law Gazette I p. 2808) - (see also section 3.1).

The criteria mentioned must demonstrably be fulfilled in order to be able to confirm a product status. The Lower Waste Authority checks the necessary evidence.

3.3 Summary on classification

Table 2: Summary of classifications

Country	Type	Artificial Turf roles	Roles without infill (< 2 %)	Removed infill material	Recycled polymers
Denmark	Classification (LOW)	17 09 04	17 09 04	19 12 04	The specific municipality
	Shipment code	Unlisted	Unlisted	Unlisted	B3010
Germany	Classification (LOW)	17 02 03 17 09 03* /17 09 04	19 12 11* /19 12 04	19 12 11* /19 12 12	N/A
	Shipment code	Unlisted	Unlisted	Unlisted	N/A
The Netherlands	Classification (LOW)	N/A	N/A	N/A	N/A
	Shipment code	Unlisted	B3010		B3010

*) If the specific case is considered as hazardous waste

3.4 Reuse, recycling, downcycling or energy recovery

Reuse

According to the waste hierarchy for waste treatment, reuse is the second-best option. Reuse is assumed to be possible if the product is not yet considered to be waste. To fulfill this criterion of reuse the pitches need to be assessed whether they have the quality to be reused for the same purpose. This must be done according to technical standards related to the different sports[5]. It is not very likely to happen as they are worn out and need replacement.

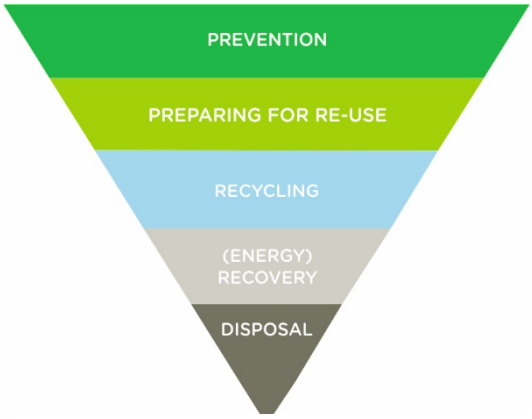

Figure 3: The European Waste Hierachi

[5] THE SMART GUIDE TO SYNTHETIC SPORT SURFACES THIRD EDITION - 2014

Table 3: Overview of different quality standards

Sport	Governing Body Responsible for Synthetics	Standard Name	Standard of Play/Use
1. Football (Soccer)	FIFA	• FIFA Quality Program for Football Turf – community and stadium / professional levels	• Community Use FIFA 1 star • Professional & Stadium Use FIFA 2 star
2. Rugby Union	IRB	• Regulation 22	
3. Rugby League	RFL (UK) & NRL (Australia)	• Guide to synthetic turf pitches for Rugby League	• Community • Stadium
4. Australian Rules Football	AFL	• AFL/Cricket Australia Synthetic Turf Program	• Community Use
5. Hockey	FIH	• Global • National • Multi-sport	
6. Tennis	ITF	• Court Pace classification Program • ITF Recognition Program • ITF Recognised Supplier	
7. Cricket	Cricket Australia/AFL		• Community
8. Multi-sport 'One Turf Standard'	One Turf Standard IRB with FIFA; FIH; AFL; GAA; NRL		• Community

Otherwise, treatment of removed artificial turf pitches can only be referred to recycling, recovery or disposal processes. Since the pitches are considered suitable for recycling, incineration with energy recovery or disposal on landfills is not relevant.

Recycling

According to the Waste Framework Directive recycling is defined as any recovery operation where waste materials are re-processed into products, materials or substances, whether used for the original purpose or for other purposes. This includes reworking of organic material, *but not energy utilization and reworking materials to be used for fuel or for refilling operations*[6].

Recycling means e.g. separating the pitches into each of their original materials so that they can be processed as separate materials, e.g. separated infill sand and rubber as new infill, PE/PP polymers for new fibers etc. The materials also fulfil the recycling criteria if they are processed into other products, e.g. SBR rubber used in mats and underlayers as long as they replace virgin or similar high quality material and can be recycled again in a future recycling process.

Recycling is often assessed based on quality. The general understanding of recycling is when the recycled product quality allows it to be reused for the same application or similar high-quality application substituting virgin material. Processing materials into products that cannot be recycled again is often called "Downcycling", as the circularity may be limited to one single circle e.g. in building material or constructions.

[6] Waste Framework Directive (Directive 2006/12/EC)

In 2017 The Synthetic Turf Council published a report[7] with technical guidelines for recycling, reusing, repurposing (e.g. landscaping) and removing artificial turf pitches presenting an overview of treatment options.

Synthetic Turf System Components	Recycle Options	Reuse Options	Waste to Energy Options
Synthetic Turf			
Polyethylene	✓	✓	●
Polypropylene	✓	✓	●
Nylon	✓	✓	●
Infill			
Crumb Rubber	✓	✓	✓
EPMD	✓	●	●
TPE	✓	✓	●
Organic Infill	✓	✓	
Silica Sand	✓	✓	
Coated Silica Sand	✓	✓	
Stock Pad Underlayments			
PCV/NBR foam	✓	✓	●
Polypropylene Composite	✓	✓	
Post-Consumer Tire Rubber	✓	✓	
Elastic Layer Underlayments			
Post-Consumer Tire Rubber	✓		●
Combination Drainage Mats/Stock Pad Underlayments			
Expanded Polypropylene	✓	✓	●
Cross-linked Polyethylene	✓	✓	●
Draninage Mats and Strip Drains			
Polypropylene	✓	✓	●
TPO		✓	

● Technically feasible but not commercially practiced

Figure 4: Possible treatment options – taken from the STC-report.

[7] STC: A guideline to: RECYCLE, REUSE, REPURPOSE AND REMOVE SYNTHETIC TURF SYSTEMS, 2017

4. ETV AND ISO

In 2014 the EU established a guideline for verification called "Environmental Technology Verification" (ETV). The purpose of this is, that companies can be certified regarding the extent to which their applied specific technologies are documented to prevent environmental pollution.

The verification process is a dynamic process involving the proposer as much as the entities responsible for the verification tasks aiming at[8]:

- an independent proof of verifiable performance parameters
- a way to validate innovative technological features which satisfy specific user needs
- a tool to demonstrate an added value for the environment

Verification under ETV is concerned with the technical design of a technology, not with the production series of industrial products.

So far, the list includes 15 companies – all providing technologies for "Materials, Waste & Resources". Only one artificial turf recycling company is on the list, namely Re-Match.[9]

In 2016 the International Standard Organization ISO has adopted ISO-standard nr. 14034:2016 for the opportunity to get the ETV-process certified on international guidelines.

5. MAJOR EUROPEAN COMPANIES FOR TREATMENT OF ARTIFICIAL TURF PITCHES

On the European market we have identified six major companies situated in Germany, The Netherlands, Estonia and Denmark, all promoting themselves as recyclers of artificial turf pitches.

These companies are:

ASIE based in Estonia, operating in different countries.
GBN in the Netherlands
KRB in Germany
Re-Match in Denmark, operating in different countries.
TUF in the Netherlands
VINK in the Netherlands

These companies, their facilities, technologies and level of environmental permits are briefly presented here.

[8] https://ec.europa.eu/environment/ecoap/etv/technology-proposers_en
[9] https://ec.europa.eu/environment/ecoap/etv/documents/159_en

5.1 ASIE

Betooni 15, Tallinn 11415, Estonia

The public Website is: https://sportsinstallations.com

Advanced Sports Installations Europe AS is a company specialising in the handling of synthetic turf fields. ASIE only operates on the local sites where the pitches are dismantled and therefore has no processing facility. They operate with mobile equipment in order to empty the pitches from the infill materials on location and roll-up of the empty pitches[10]. ASIE emphasizes that it operates locally and with local recycling centres where possible because it reduces the environmental impact from transportation. The company website presents a mobile/semi-mobile process with 100% recycling but also presents the artificial turf pitches for sale for other purposes.

In 2019 ASIE was the subject of a series of broadcasts in Norwegian television regarding failure to fulfil the requirements from the municipality with regards to the recycling of their old pitches. Instead, an artificial turf pitch that did not have the quality for reuse was traced to Zagreb where it was re-installed at a school while the treatment fee specified that the worn-out pitch would not be used for re-installment [11]. The company in Estonia was inspected by the authorities and found in compliance with the permits. Thus, the director stated that the company has gathered artificial turf pitches for several years but is going to recycle them when it can be deemed to be cost-efficient for the company.

It has not been possible to gather further or more detailed information about the processes and workflows of ASIE's operations, including the handling of the empty pitches and the infill materials.

Sub-conclusion: ASIE does not have a documented process enabling recycling of artificial turfs components. The company does initial separation only and offers emptied artificial turf pitches for sale.

ASIE has declined the possibility to review and document the described process and application of products.

5.2 GBN, The Netherlands

GBN - Artificial Grass Recycling BV, Westkanaaldijk 2, NL-3542 da Utrecht.

The public Website is: https://www.gbn-agr.nl/

GBN is operating in the region of Amsterdam. Its full name is GBN Artificial Grass Recycling BV and is part of the group of companies of Grondbank Nederland (GBN). The company website states that the company plans to start a facility in 'het Westelijk Havengebied' in Amsterdam in the spring of 2020.

According to the permit documents the maximum supply of artificial turf products will be 200,000 tonnes per year. The maximum supply consists of approximately 150,000 tonnes of artificial turf rolls and 50,000 tonnes of foundations.

[10] https://sportsinstallations.com/projects/sarpsborg-case-study/

[11] https://www.tv2.no/a/10925105/

The process includes use of water for separating the infill material. The estimated use of water by the facility is 16,920 m^3 per year which is accumulated into a water buffer basin for process water. The system includes filtration through a water-permeable geotextile to separate resting sand and SBR rubber from the wastewater and separation in a coalescence collector combined with a sludge trap. The basin with the geotextile can be emptied and cleaned manually. The system is described in the application documents of GBN 'Notitie watervergunning lozen' on a conceptual level and without any information about the amounts of sludge etc. for disposal or treatment. The water permit is not available.

The environmental permit does not describe the details of the wet separations process, e.g. use of chemicals, or the composition of the wastewater.

The discharge of surface water per year amounts to 16,660 m^3. Drainage can take place via a discharge point to surface water (a ditch along the Santorini road) or the water buffer basin. The solution will be decided together with the municipality.

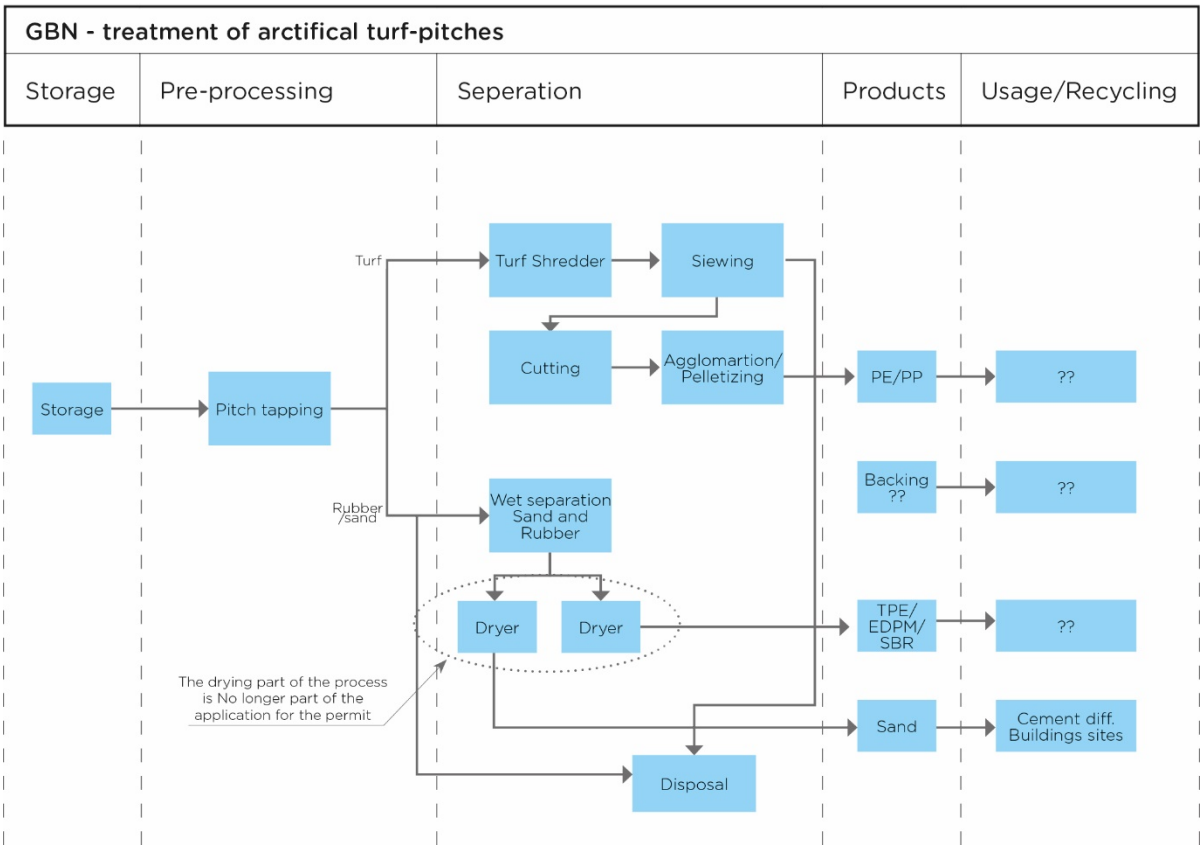

Figure 5, Flowchart of GBN´s process on artificial turf pitches

GBN has revised their June 2019 processing application in September 2019 eliminating the drying process after the wet separation of sand and rubber so that this step is no longer part of the process flow diagram. The process of re-qualification of those components at that stage is unclear and does not reveal the way the infill and sand will be recycled.

GBN has access to the construction company Strukton BV enabling the recycling of different types of sand qualities.

It is not possible to determine the percentage of recycling because the process has not been demonstrated or validated. According to the permit the company refers to transporting materials to processing plants. GBN however seems to sort out the rubber and sand for different purposes, e.g. through collaboration with CEYES and with the production of stormwater retention panels as destination.

The company is aiming for a BRL-certificate. A BRL describes the technical and organisational requirements an organisation or product must meet in order to obtain a certificate. The BRL certificate gives clients and supervisors the assurance that the products and services meet the technical requirements and wishes of the market. An accredited institution like TÜV Nederland or Kiwa Sports provides a BRL certification by assessing the organization and processes based on the requirements in the assessment guidelines. The BRL-certificate does not state the level of recycling from the waste treatment.

Sub-conclusion: GBN does not have a documented process enabling recycling of each artificial turf component. The process involves only the initial separation of infill and the processing of product mixtures by downcycling. The available information does not confirm that GBNs process enables recycling of the rubber material that is used by CEYES other than the partnership announced on the websites.

GBN has declined the possibility to review and document the process and application of products. At the moment GBN will not join the study. The main reason for this is that GBN is fully focused on finishing the new recycling factory in Amsterdam. In the future GBN offers to jointly work on a study regarding Artificial Grass Recycling.

5.3 KRB, Germany

KBR Otto Lilienthalstraße 20, D-04758 Oschatz.

The public Websites are: www.krb-group.de and http://kunstrasen-billiger.de/

KRB Unternehmensgruppe was established in 2007. They got their approval of construction and operation in January 2011. The treatment consists of separating, shaking, and shifting the material. KRB holds an environmental permit for the facility in Oschatz. In Germany, facilities for waste treatment must follow annex 4 in 5th BImSchV (Federal ordinance "Bundesimmissionschutz-Verordnung").

Unavoidable dust emissions from stored goods are to be minimized by them being showered/doused directly with water. All waste resulting from the operation of the plant is to be collected separately and disposed of appropriately. Waste may only be treated if proper transport is ensured.

Due to the environmental permit the maximum supply of artificial turf will be 250 ton per month and 3,000 ton per year with a maximum of 25 ton per month in storage. The available part of the permit does not explain the process. It is stated, that the treatment consists of separating, shaking, and shifting the material and ends up in four different elements:

- 56 ton artificial turf (AVV-ASN 191204)12,
- 444 ton Quartz sand (AVV-ASN 191209),
- 50 ton underlay (AVV-ASN 170203),
- 40 ton rubber granulate (AVV-ASN 191204)

[12] Reference to the European List of Waste/Waste codes

Back in 2014 the company only stored all the pitches without further treatment (Leipziger Zeitung)[13].

Through a website KRB sells used turf with different amounts of sand and infill.

It is not possible to find official information on recycling of separated materials.
The available information leads to this process diagram for KRB.

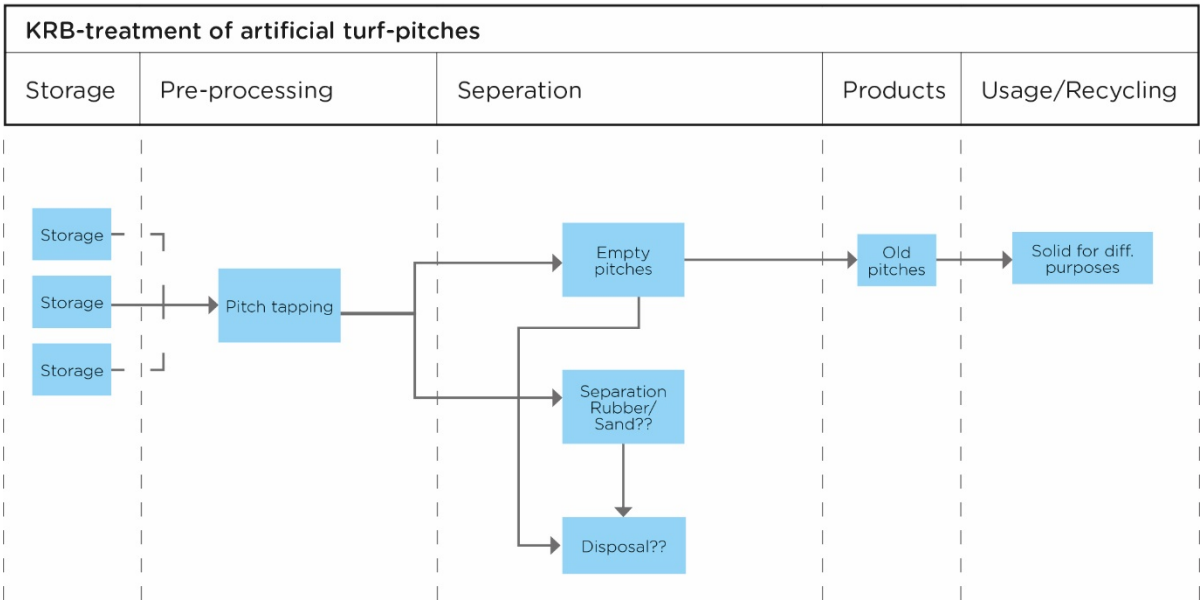

Figure 6, Flowchart of KRB process on artificial turf pitches

Sub-conclusion: KRB does not have a documented process enabling recycling of artificial turf components. The company does initial separation only.

KRB has not responded on the possibility to review and document the process and application of products.

5.4 Re-Match, Denmark

HI-Park 415, DK-7400 Herning.

The public Website is: https://www.re-match.dk/

Since 2016 Re-Match has processed and recycled artificial turfs. Re-Match´s process takes place on this one site. Re-Match holds a permit that enables the company to handle 30,000 ton artificial turf pitches a year with a storage of 20,000 ton.

Re-Match is actively seeking building permits for new factories in the Netherlands, France, the United Kingdom and the United States.

In the patented process the artificial turf pitches are downsized using a shredder, the materials are dried and afterwards separated in 4 fractions:

[13] https://www.lvz.de/Region/Oschatz/Fliegerhorst-Angst-vor-verseuchtem-Grundwasser

- Fibers (Polyethylene/polypropylene and nylon/polypropylene)
- Backing (Latex, Polyurethane, Polypropylene (primary and secondary backing)
- Rubber (SBR - Styrene Butadiene Rubber – also known as granular from recycled tires), EPDM (Ethylene Propylene Diene Monomer), TPE (Thermo Plastic Elastomer)
- Sand (Quartz sand and Flex sand – coated sand, primarily used in the United States)

No hazardous waste is produced during the processes. However, small amounts of oil waste may appear in the maintenance activities of the company's plants and machines. In connection with the separation process, any impurities are removed from the artificial grass pitches. These may be stone, glass shards, capsules, etc. These materials are disposed to landfill. In terms of volume, this fraction is expected to be less than two per thousand of the totals. This corresponds to an annual volume of up to 60 ton, which is delivered as non-combustible waste for landfill.

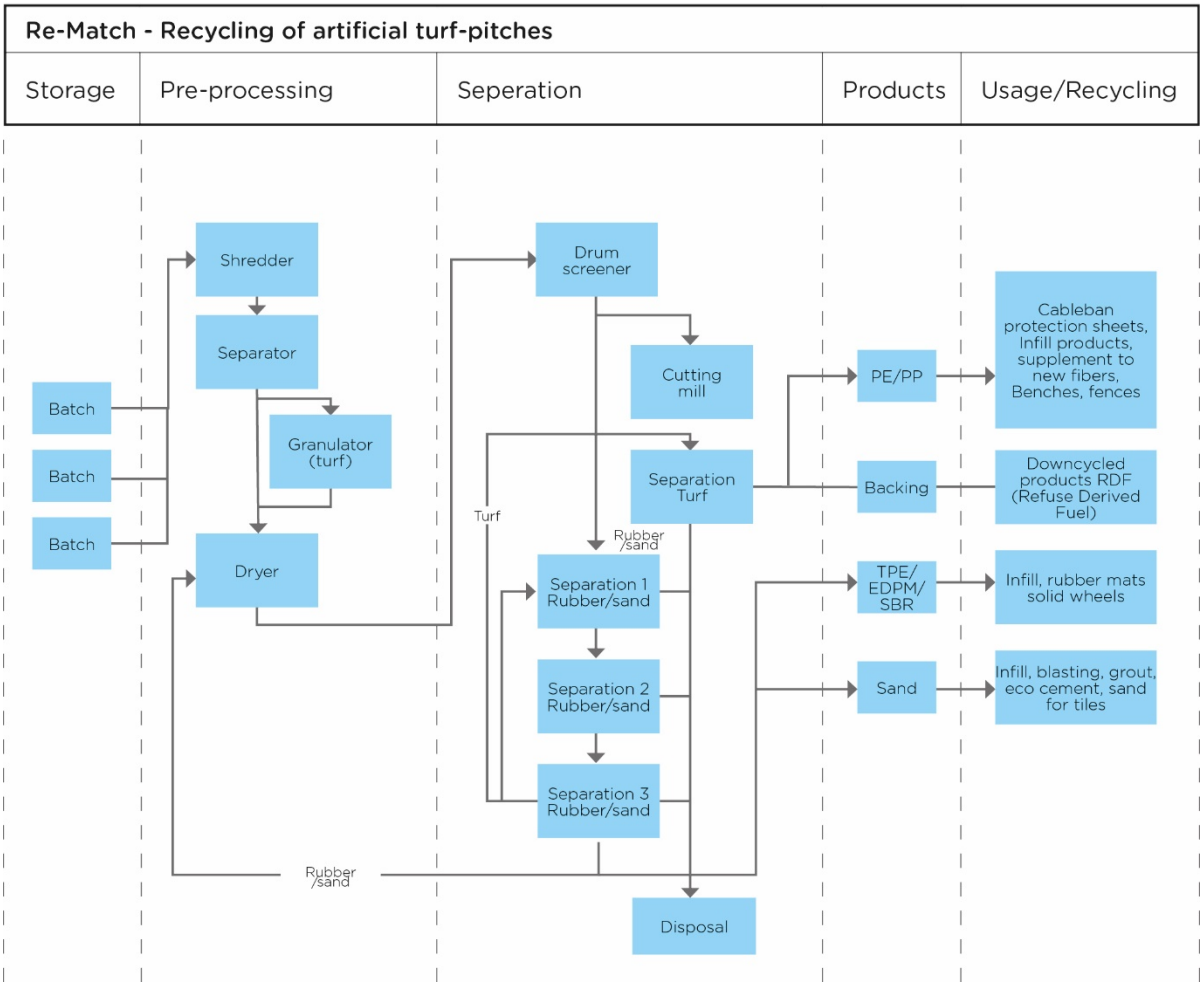

Figure 7, Flowchart presenting the Re-Match process on artificial turf pitches

Waste for incineration consists of small, combustible waste. Residual waste is expected to be collected from cleaning, canteen and other welfare facilities.

In 2020, Re-Match is planning an upgrade of the Herning facility which will solve the need for reprocessing some of material (rubber/backing mix not being perfectly separated following "separation step 3"). The upgrade will improve the yield of specific steps in the separation process

and increase capacity. This is done with a view to increase the share of clean and directly sellable products exiting the process.

Re-Match holds an ETV certificate from 2017[14] which is an environmental technological verification confirmed by the Danish Environmental Protection Agency and the EU. The verification was achieved before ISO published their international standard ISO 14034:2016 Environmental Technology Verification (ETV) for the ETV process.

Re-Match offers traceability of the batches of worn-out turf so that the customers can have the full documentation of the recycling process of each delivered artificial turf pitch including the documented tests of the materials and their further application.

The process at Re-Match enables the company to perform the following on recycling:

Tabel 4: Distribution of materials (dry weight)

Percentage distribution on handling of dry-weight material:	Fibre	Rubber	Sand	Backing/Dust/other
Recycling	6-8	19,4 - 29,8	47-57	0
Downcycling	0,8 - 1 (*)	0,7 - 2,8 (**)	0	0
Recovery (energy)				3,3 - 3,7 (***)
Waste handling	0	0	0	4,8 (****)

(*) Fibres ending up in backing
(**) Fine rubber below 0,2 mm
(***) Backing going into heat recuperation
(****) Additional processing waste (Dust, Metal, Wood,..)

Sub-conclusion: Re-Match is an artificial turf recycler that holds a third-party verification on a full recycling process and has one factory in operation today. The quality of the recycled materials is on par with virgin materials and can be used as infill in new artificial turf pitches or in alternative applications such as the Green Matter side boards made out of recycled synthetic grass and used to preserve infill & prevent the spread of microplastics at artificial turf pitches.

5.5 TUF-Recycling BV, The Netherlands

TUF Recycling BV, Vierbundersweg 15, 5107NL, Dongen, in the province of Noord Brabant.

The public Website is: http://tufrecycling.nl/

On the site in Dongen TUF Recycling is authorized for the following:

- Artificial grass (rolls) 10.600 ton
- Cut loss/rest (example landscaping) 100 ton
- Infill (separated from carpet) 5,000 ton

[14] https://ec.europa.eu/environment/ecoap/sites/ecoap_stayconnected/files/etv/files/documents/eu_etv_verification_statement_re-match_20170926_signed.pdf

On the site TUF Recycling has the following treatment operations:

- Collection of grass under EU Waste code 17 09 04
- Separation of grass and infill

It has not been possible to gather further or more detailed information about the processes from the authority. TUF Recycling is cooperating with several other companies along the recycling chain, but according to their homepage TUF Recycling processes the materials until those can be sold for recycling or energy production. Some pitches are prepared for re-usage. The state of quality and the rate of recycling is unknown. The company is heavily criticized for illegal waste handling and for only storing the pitches.[15]

According to the website descriptions[16], the process can be described as follows:

- Sand and rubber is removed from the mat
- Sand and rubber is separated
- The clean sand can be used again.
- The rubber is offered to the market for further recycling.

If possible, the artificial grass is made suitable for reuse. If reuse is not an option, the dismantling and recycling of the artificial turf follows. After the artificial grass mat has been fully unravelled, the plastic and latex is separated. The latex is used for energy generation.
The plastic is then used for:

- Casing drainage pipes,
- Infill products made from artificial grass
- Re-granulates for the production of new artificial grass

No water is used for recycling the artificial grass

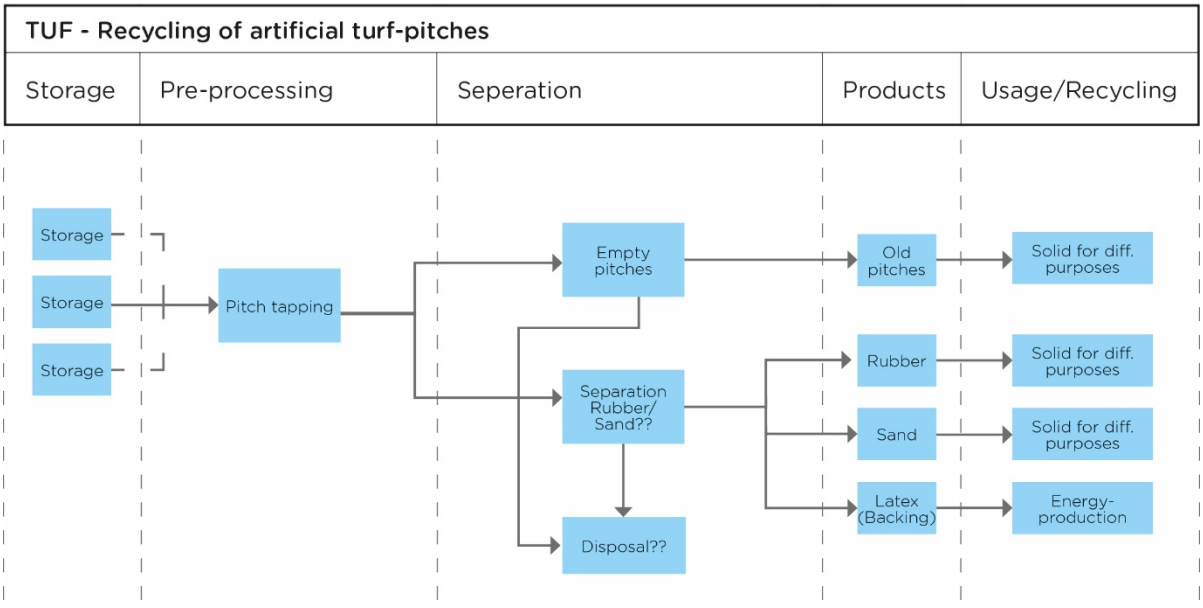

Figure 8, Flowchart presenting the TUF process on artificial turf pitches

[15] https://www.bnnvara.nl/zembla/artikelen/the-artificial-turf-mountain
[16] http://tufrecycling.nl/het-proces/

In 2019 TUF was the subject of a broadcast in Norwegian television regarding failure to fulfil the requirements from the municipality with regards to the recycling of their old pitches. Instead, the pitches were only stored on the site in Dongen[17].

Sub-conclusion: TUF-Recycling does not have a documented process enabling recycling of artificial turfs components. The company is heavily criticized for illegal waste handling and for only storing the pitches.

TUF has not responded on the possibility to review and document the process and application of products.

5.6 VINK, The Netherlands

VINK Recycling, Hanzeweg 7, 3771 NG Barneveld.

The public Website is https://vink.nl/recycling/recycling_kunstgras/

The local company is called Afvalwerking VINK BV (Vink), located in Barneveld, Gelderland, The Netherlands. The parent company Vink Holding BV was established in 1927 and has since ventured into many fields including tug, asphalt and waste management. The company holds certifications ISO 14001 and ISO 9001. According to Vink the newly developed artificial turf recycling facility has a processing capacity of 40,000 ton of mats per year. 95 % of the material can be reused. The recycling method separates the sand and rubber from the mats and the artificial grass fibers are made suitable for reuse. One of the current applications of recycled artificial grass fibers is casing for drainage pipes, which are used, e.g. for new fields to be laid.

The pitches are brought into the facility in Barneveld where they undergo infill removal. Afterwards, they are shredded and placed around plastic piping for water excavation purposes. High quality artificial grass mats will be sold for reuse. The plant has been operating since 2013.

The company has a valid Environmental Permit that was renewed (Revisievergunning) 27 November 2018. The maximum throughput supplies 100,000 ton per year. The maximum storage capacity unprocessed (such as from the truck) at any time is 40,000 ton per year. Maximum storage capacity after processing at any time is 40,000 ton per year.

Vink annually produces the following materials as result of processing the artificial grass:
a. Recycled artificial material: 12,000 ton
b. Quarts sand: 70,000 ton
c. Rubber infill: 15,000 ton
d. Residue: 3,000 ton

According to the permit the storage requirements of the artificial grass rolls are as follows:
The storage of grass mats must be realised by means of a compartmentalization according to the conditions:

- storage takes place in a frame with a maximum length of 50 meters;
- the compartments are separated from each other by concrete walls in the form of stackable blocks with a height of at least 5 meters;
- the depth of the compartments is a maximum of 7.5 meters insofar as they can be reached from one side and a maximum of 15 meters if they are accessible from two sides;

[17] https://www.tv2.no/a/10692379?referral=tv2v

- within the compartments, stacking up to a maximum of 7 meters on both sides descending to a maximum of 5 meters towards the partition walls;
- the sections are accessible in the longitudinal direction via a path with a width of at least 3.5 meters.

The site uses 29,650 m^3 water per year of which 6,667 m^3 is used for the cleaning of the artificial turf.

According to VINK the separation and cleaning of the carpets and fibres was in 2017 changed from a wet to a dry process while sand and rubber is still separated in a wet process with use of chemicals (flocculants). The newly developed dry process has been running for 3 years separating the fibres from the carpet. The fibres are delivered to the drainage industry and the plastic industry.
The waste products during the process is dust, adhesive residues, parts of adhesive strips and the backing from the dry process and the sludge fraction from the extractive cleaning from the infill.

VINK has delivered the following data on distribution of the products from the process but does not want to document it further.

Table 5: VINKs data on separated materials - Percentages artificial turf recycling.

Description	Weight percentages
Artificial turf rolls with infill	100%
Artificial turf without infill	5 % – 10 %
Infill	90 % – 95 %
Cleaned fibre	3 % – 4 %
Sand (depends on type of pitch and the used infill)	60 % – 90 %
Rubber (depends on used type of rubber)	5 % – 32 %
Residues (dust, sludge, etc.)	< 5 %

The process at VINK can be overall illustrated like this:

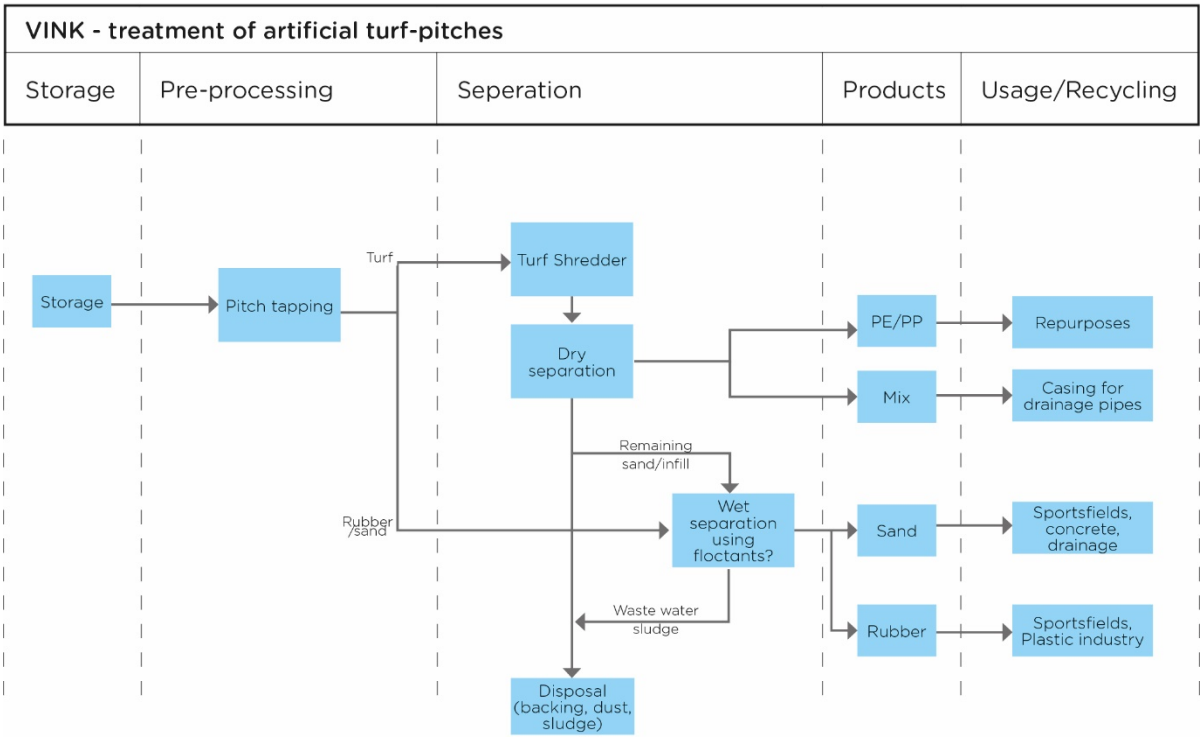

Figure 9, Flowchart presenting the VINK process on artificial turf pitches

Sub-conclusion: VINK does not have a documented process enabling recycling of artificial turf components. The company has been heavily criticized for violating storage permits. VINK has announced in 2018 that they ceased taking in artificial turf material while they are processing current inventory. VINK announces that they are still not taking in new orders on recycling artificial turf pitches but now applies with the permitted conditions.

VINK has responded to the opportunity to document the process and application with further details on the separation processes but without documentation other than using the fiber fraction for drainage pipes.

5.7 Comparison of parameters regarding recycling

Table 6 Comparison of parameters regarding recycling

Overview of company capability regarding treatment of artificial turf pitches and recycling							
Parameters ((A-E) explanations in appendix)	**Source**	**ASIE**	**GBN**	**KRB**	**Re-Match**	**TUF**	**VINK**
Environmental permits	Authority	-	Yes	Yes	Yes	Yes	Yes
Validated total recycling concept	Authority	No	No	No	Yes	No	No
EU ETV Certification	ETV	No	No	No	Yes	No	No
Other process verification than EU ETV	Company	No	Aiming for BRL	No	Aiming for ISO	No	No
Proven recycling plant in operation (A)	Authority/ permit	No	No	No [2]	Yes	No [2]	No [2]
Chemicals used in process	Authority/ permit	No	Yes	No	No	No	Yes
Water used in process	Authority	No	Yes	To reduce dust	No	To reduce dust	Yes
Registered waste collector and/or processor	Authority	Yes NL	Yes	Yes	Yes	Yes NL	Yes
Crossborder shipments permits for EU	Authority	-	N/A	N/A	Yes	Yes	N/A
Traceability of Fields in storage (B)		No	No	No	Yes	No	No
Full circular traceability (C)		No	No	No	Yes	No	No
Mono-stream output of the process (specific separated material) (D)	Permit	-	Yes	Yes	Yes	No [1]	Yes
	Company	No [2]	No [2]	No [2]	Yes	No [2]	No [2]
% Polymer and rubber recycled (E)		0 [2]	0 [2]	0 [2]	>90	0 [2]	0 [2]
Fibres (avg. weight % - dry) (% of total volume)		N/A	N/A	N/A	6-8	N/A	3 - 4
% Recycling		0	0	0	90	0	0
% Downcycling		0	0 [3]	0 [2]	10	0 [2]	0 [3]
% Waste handling/incineration		0-100 [4]	100	0-100 [4]	0 [6]	100	100
Rubber (SBR/EPDM/TPE) (% of total volume)		N/A	N/A	N/A	19 - 32	N/A	5 - 32
% Recycling		0 [2]	0 [2]	0 [2]	92	0 [2]	0 [2]
% Downcycling		0 [2]	0 [2]	0 [2]	8	0 [2]	0 [2]
% Waste handling/incineration		100	100	100	0	100	100
Sand (% of total volume)		N/A	N/A	N/A	47 - 57	N/A	60 - 90
% Recycling		0 [2]	0 [5]	0 [2]	95	0 [2]	0-100
% Downcycling		0 [2]	0-100	0 [2]	0	0 [2]	0-100
% Waste handling		100	0-100	100	5 [7]	100	0-100

[1]) The permit does not describe this directly
[2]) The company was not able/willing to provide documentation
[3]) Deploying fibres for drainage is rather waste disposal than downcycling
[4]) Selling artificial turf roles for reuse without proper treatment will rarely qualify for reuse.
[5]) GBN has not included a drying step into their permit application. If a drying step is included, the GBN will have the capability to sieve the dry sand and the infill
[6]) Backing and dust represent 3,3-3,7 %. The backing can be used for energy recovery.
[7]) The total waste handling includes metals, wood, stone etc.

6. TENDER REQUIREMENTS FOR RECYCLING

The broadcasts of cases where the artificial turf pitches have not been recycled according to the contracts have shown that many municipalities rely on the company's statements about having a full recycling process for the artificial turf pitches. This may have been required in the public tender, but the cases have shown that the specific process and its outcome must be documented in order to guarantee the municipality that their contractors are complying with the obligations.

It will obviously be in the interests of the municipalities that they can obtain the necessary documentation for recycling without having to devote many resources in comparing the offers themselves. Similarly, the municipalities will often not have the opportunity to perform more detailed assessments of the technologies offered, so the tender requirements must be simple and unambiguous regarding expected recycling.

The requirements can be put into three categories: Documentation and descriptions in the offer, contractual obligations and financial regulations.

6.1 Documentation and descriptions

It will be reasonable to claim that the vendors as a minimum shall describe and document how the artificial turf pitches are being treated from time when the rolls are picked up on site until the separated materials are distributed to specific recycling production. The companies should be able to document how thoroughly they separate the materials (Polymers, rubber and sand) and to what extend these materials are recycled (high quality or downcycling).

It can be considered that the documentation should be a third-party report (e.g. an audit report not more than one year old or a monitoring report from the municipality stating that the company complies with their permit and transborder shipment obligations. As part of the obligations, the municipality who wants to take out an artificial turf field and is responsible for the condition of the field should be able to provide its tender material with information and specific analysis of the contents, e.g. of heavy metals that will be relevant for the different waste treatment technologies to deal with.

6.2 Contractual obligations

The municipality can consider how many of their sports fields they want to renew over a given period in order to allow the tender material to cover a framework agreement with obligations for one responsible company for the whole process and period. This will encourage the most serious companies to establish a comprehensive management of the waste treatment process and the ordered documentation.

It is possible to work with further obligations:

- Require photo documentation of the removal and packing of the grass rolls that prevents spillage of microplastic
- Require documentation of processing the batches of grass rolls after each recycling operation
- Having the right to inspect the recycling process
- Operating with time limits on documentation

6.3 Financial regulations

The municipality can incorporate a settlement model that allows them to withhold payments for the work if it does not meet the requirements for environmental protection and recycling.

Disclaimer

The conclusions presented in this report represent Ramboll's best professional judgment based upon the information available and conditions existing as of the date of this report. In performing its assignment, Ramboll must rely upon publicly available information, information provided by the Client and information provided by third parties. Accordingly, the conclusions in this report are valid only to the extent that the information provided to Ramboll was accurate and complete. This review is not intended as legal advice, nor is it an exhaustive review of site conditions or facility compliance. Ramboll makes no representations or warranties, expressed or implied, about the conditions of the site.

Ramboll's scope of work for this assignment did not include collecting samples of any environmental media. As such, this review cannot rule out the existence of latent conditions including contamination not identified and defined by the data and information available for Ramboll's review; however, this report is intended, consistent with normal standards of practice and care, to assist the Client in identifying the risks of such latent conditions.

APPENDIX 1
EXPLANATION OF PARAMETERS IN TABLE 1 AND 6

(A)	Proven recycling plant in operation	Full recycling process in operation today, where the majority of the waste materials are re-processed into products, materials or substances of a quality, that allows it to be reused for the same application or similar high-quality applications substituting virgin material. (The process needs to be independent of other companies' treatments processes).
(B)	Traceability of Fields in storage	Indicates that it is possible for the costumer to get documented traceability of the fields in storage.
(C)	Full circular traceability	Indicates that the company provides traceability of fields as well as all the specific processed materials and their applications.
(D)	Mono-stream output of the process (specific separated material)	Indicates if the process results in separated and clean, recycled materials that can be used for production of new recyclable products, i.e. the quality allows reuse for the same application or similar high-quality applications substituting virgin material.
(E)	% Polymer and rubber recycled	Indicates the level of recycling for new recyclable products. (Polymer and rubber are the most difficult materials to recycle and represent the biggest risk to the environment).