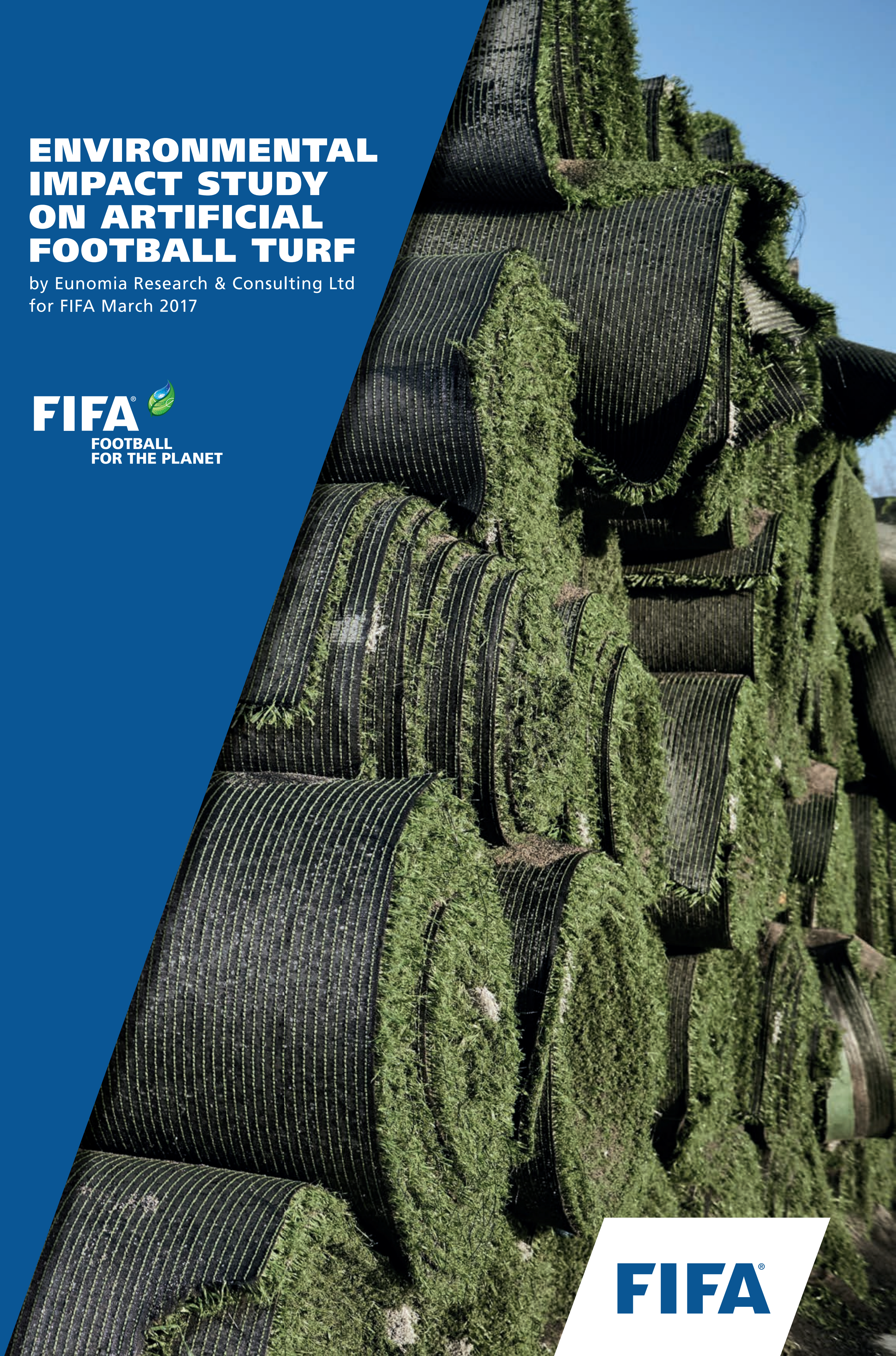
ENVIRONMENTAL IMPACT STUDY ON ARTIFICIAL FOOTBALL TURF

by Eunomia Research & Consulting Ltd
for FIFA March 2017

FIFA
FOOTBALL
FOR THE PLANET



FIFA

EXECUTIVE SUMMARY

FIFA, in particular through its Quality Programme for Football Turf, sets a standard for the use of artificial turf in the game of football. Through constant research, it aims to offer the best alternative to natural grass when this is not available. Two types of certifications exist: FIFA Quality Pro for the elite level and FIFA Quality for community level.

In total, 3,437 pitches have been certified since 2006 in 149 countries.

With increasing numbers of field replacements all over the world and the volume of waste resulting from it, FIFA is looking to offer insights on the best possible way of disposing of used fields and therefore commissioned this study to analyse the environmental impacts of producing, removing and disposing of football turf as well as looking at the current recycling and reuse options.

Whilst 3G turf products can vary in terms of their design and manufacture, they generally all share common components. The turf pile itself is usually made from polyethylene (PE) with a primary backing material of polypropylene (PP) that provides the structure and spacing that the pile is woven into. A secondary backing of a liquid polyurethane (PU) or latex is applied and allowed to set in order to bind the pile to the backing.

A stabilising infill (mostly sand) is used to weigh the carpet down, and a performance infill provides the characteristics offering a similar feeling to natural grass. In some cases, there is also a shock pad underneath which reduces the amount of performance infill.

There are three main factors which have the greatest influence over the environmental impact of artificial football turf, which are:

- Choice of infill material;
- The decision regarding whether to use a shock pad or not; and
- the type of treatment used at the end of life.

For the choice of infill there are several key considerations:

- Virgin polymer infills have a larger environmental impact than (recycled) rubber crumb.
- Organic infills have a smaller environmental impact than polymer infills.
- The installation of a shock pad can greatly reduce the environmental impact when used alongside virgin polymer infills due to the reduction in the need for infill by 50–60%.

For the end of the turf life there are also key considerations:

- Where a shock pad is used, it is very beneficial to leave it in place for reuse when a new turf is installed.
- If recycling is not available, the preferable route for polymer material is landfill, whilst for organic materials it is incineration

The use of cork as infill is identified as environmental suitable alternative to plastic infills, but may also have wider benefits both environmentally and socially for a number of Mediterranean countries that rely on cork farming.

Recycling of artificial football turf is not widespread. The majority of the manufacturers interviewed for this study claimed their products are ‘recyclable’, but none are taking significant steps to make sure this happens in practice.

Technologies to remove, separate and clean the main components of the turf are still being perfected and at the moment the best processes are still ‘open-loop’. A full ‘closed-loop’ process is yet to be developed and this will certainly require more support from the turf manufactures to implement.

Despite these issues, recycling is a viable option particularly in Europe. The close proximity to a recycling facility and the proliferation of (expensive) incineration means that there is very little justification for pitches located in Western Europe to not be recycled. In other parts of the world where the disposal of waste is far less strict (and therefore cheaper), and the long distance to recycling facilities adds to the cost, it is less likely that pitches will be recycled.

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GLOSSARY

ACRONYMS

SBR	Styrene-butadiene rubber
TPE	Thermoplastic elastomer
EPDM	Ethylene propylene diene monomer
PE	Polyethylene
PU	Polyurethane
PP	Polypropylene
EfW	Energy from Waste
LCA	Life Cycle Assessment

TERMS

Elastomer	A natural or synthetic polymer with elastic properties.
Football Turf	Artificial turf that means the FIFA Quality standard for an artificial playing surface.
Open Loop Recycling	The conversion of a waste material into a new product, involving a change in the properties of the material which often results in a degradation in quality.
Closed Loop Recycling	A product waste is used in making another product that is the same or similar
Municipal Solid Waste (MSW)	Refuse (trash, garbage, rubbish etc.) that is discarded by the public.

INTRODUCTION

This study comes at a time when artificial turf use for football is experiencing a period of unprecedented growth worldwide. FIFA stand at the forefront of quality standard setting, but there is a lack of information for specifiers and field owners on the environmental impacts of modern 3G turf systems. The increasing number of installations means an increasing amount of waste that will need to be dealt with. Only now are we beginning to see the pitches installed a decade ago–as artificial turf took off–become a waste that needs to be addressed now. This is driving the need for improved and effective recycling across the world. This study looks at the environmental impacts of the current materials and systems, what the current disposal options are, and how to make the best decisions so that in ten years' time, today's pitches are not causing more environmental issues.

This report is split into four sections as follows;

- **Section 1.0 – FIFA Certified Football Turf Global Usage**
  This Section provides a statistical analysis of FIFA data to show where football turf is installed and what types of playing surface are being specified across the world.
- **Section 2.0 – Environmental Impacts of FIFA Certified Football Turf**
  In this Section, we present the results of a Life Cycle Assessment (LCA) of the environmental impacts of the most common types of football turf.
- **Section 3.0 – End of Life Options for Football Turf**
  This Section considers the end of life options for football turf, along with the costs and environmental benefits of the most common options.
- **Section 4.0 – Best practice Examples**
  This section provides guidance for specifiers and pitch owners who want to make the best environmental choices; it brings together the previous sections into a clear set of decision making guidelines.

Figure 1: Artificial turf at the Olympic Stadium in Montreal

1.0 FIFA CERTIFIED FOOTBALL TURF GLOBAL USAGE

Artificial turf was first introduced in 1966 in Houston, Texas but gained global acceptance in football with the third generation (3G) systems at the end of the same century. Identifying the surface as a credible alternative to natural grass, FIFA launched the Quality Programme in 2001 which would move on to become an industry standard. In 2005, the standard was refined to cater to professional and community use separately. Following the latest update of the regulations, the FIFA Quality Pro and FIFA Quality levels reflect two decades of research into the topic.

Since the first certification in France in 2001, the quality Programme has seen a huge increase both in numbers (Figure 2) and geographical spread (Figure 3).

As of 2016 certified turf has been installed in all continents, including many countries in Africa and Asia. The market is currently dominated by Europe (including Turkey), however, with three quarters of the current installations being located there. Many of the manufacturers and installers are also based within Europe. In total, 149 countries have installed a FIFA certified turf pitch, 87 of which have fewer than five pitches.

3,437 pitches certified since 2006 in **149** countries.

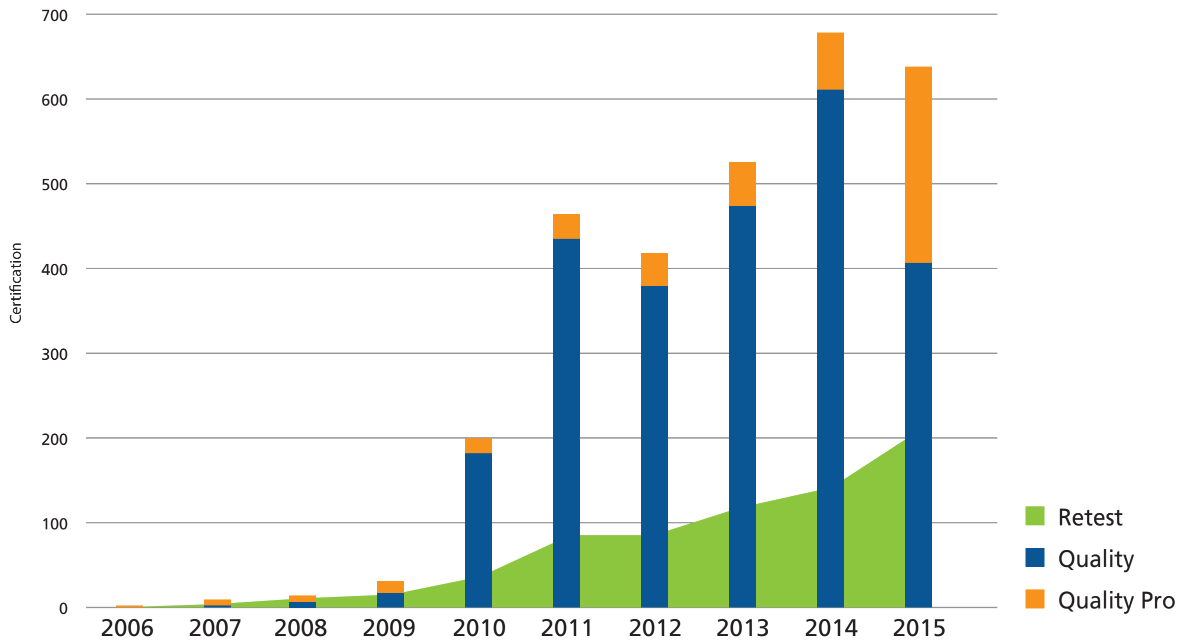


Figure 2: FIFA Quality Certifications by Year

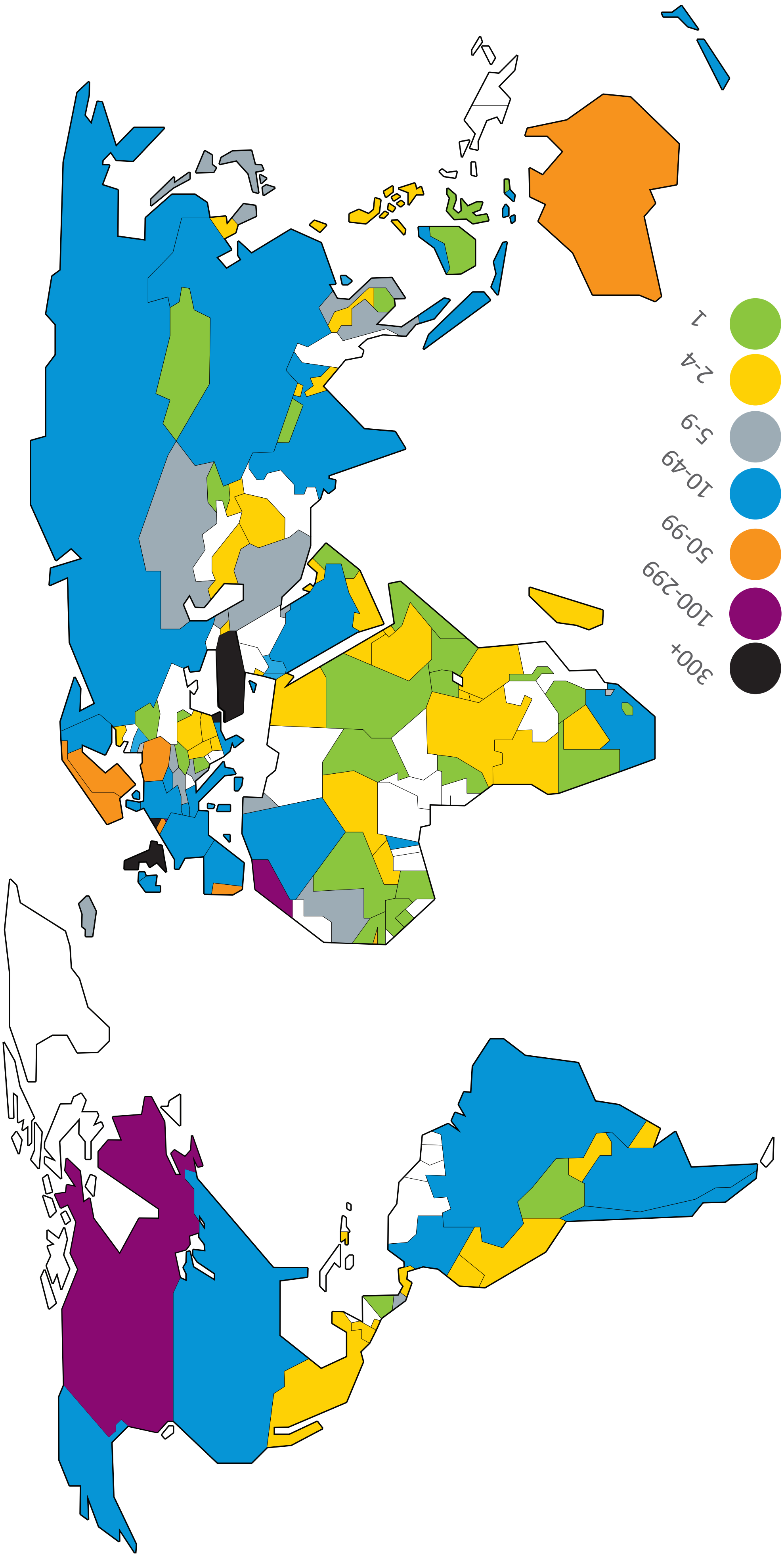


Figure 3: The Global Reach of the FIFA Quality Programme (number of certified turfs per country)

1.1 COMPONENTS OF FOOTBALL TURF

Whilst 3G turf products can vary in terms of their design and manufacture, they generally all share common components (see Figure 5). The turf pile itself is usually made from polyethylene (PE) with a primary backing material of polypropylene (PP) that provides the structure and spacing that the pile is woven into. A secondary backing of a liquid polyurethane (PU) or latex is applied and allowed to set in order to bind the pile to the backing.

A stabilising infill is used to keep the PE fibres vertical during use, and a performance infill provides the correct level of impact resistance to reduce injuries and provide a similar feeling to natural grass. In some cases, there is also a shock pad underneath which reduces the amount of performance infill.

An average artificial turf pitch of 106 x 71 meters with styrene-butadiene rubber (SBR) infill (the most common infill type) weights around 36 kg per square meter. This means that the total pitch weighs around 274 tonnes. As shown in Figure 4, around half of this is the sand stabilising infill and 44% is the SBR infill. The remainder is the plastic-based turf itself.

The environmental impacts of these components – which is discussed in Section 3.0 – are therefore often dominated by the

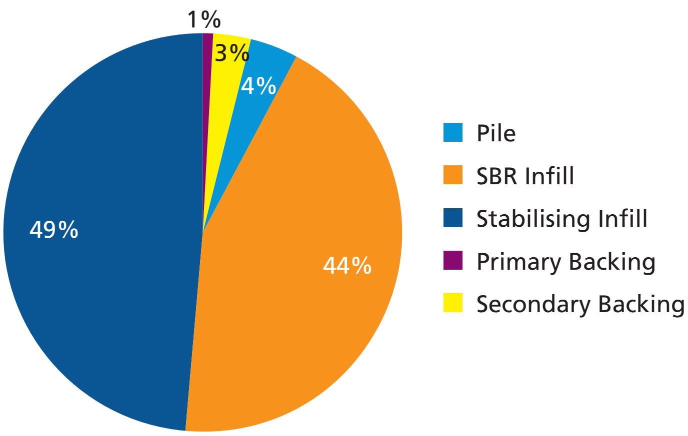


Figure 4 – Typical Turf Composition by Weight

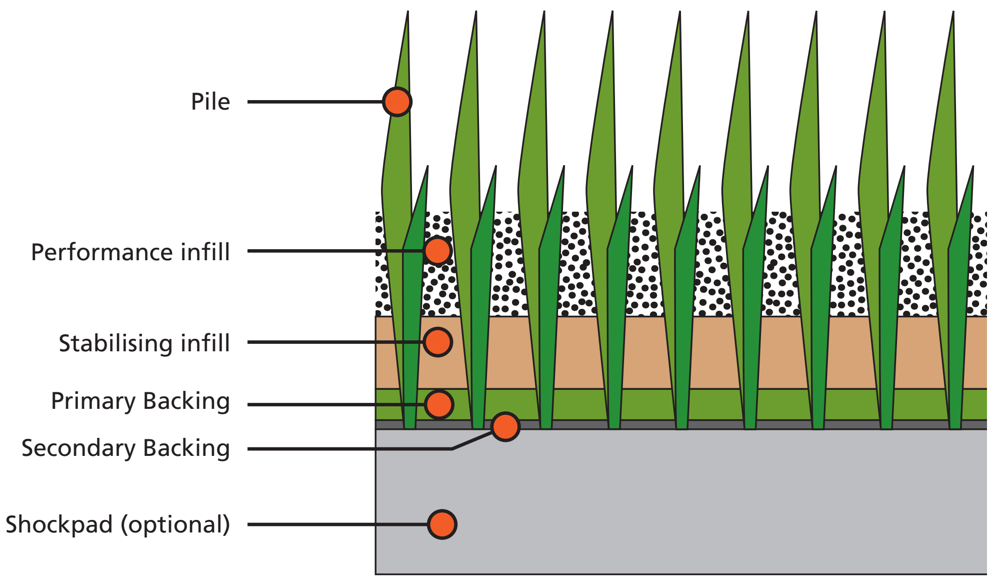


Figure 5 – Typical Components of a 3G Artificial Football Turf Installation

infill material. Similarly, the use of a shock pad can reduce the need for infill material and therefore, also has a large bearing on the environmental impact of the turf system.

Whilst sand is also a large component of the 3G turf system, it requires significantly less energy and processing compared to the other – mostly fossil based – materials.

The performance infill market is dominated by SBR – a rubber crumb that is made from used tyres – with around 83% of installations incorporating this material (see Figure 6). Both EPDM (Ethylene propylene diene monomer) and TPE (thermoplastic elastomer) are synthetic rubber compounds that use virgin material to produce the infill. EPDM is similar to SBR in that it is a thermoset plastic that cannot be reformed (melted) into other products, whereas TPE is a thermoplastic which can be melted and re-melted as required. These properties will often help to define the type of recycling route that is required, or feasible, when the turf is removed at the end of its life.

Organic infills are also used which are comprised primarily of natural cork. Other variations also include mixtures of cork and coconut fibres in various blends that are specific to individual manufacturers. Although this market it believed to be growing, it still comprises less than 3% of the current market for FIFA certified turf.

A shock pad can also be used to either provide more shock resistance or to reduce the need for infill. Figure 7 shows the proportion of installations that utilise a shock-pad underneath the turf to absorb the impacts during play. Just under two thirds of installations do not utilise a shock pad, with the remaining mainly comprised of polyethylene (PE) or a blend of recycled SBR bound and polyurethane (PU).

SBR installations generally tend not to include a shock pad since the costs of incorporating a sufficiently thick layer of infill to provide this function are relatively low for SBR. EPDM and TPE installations are more likely to include a shock pad, partly due to the higher cost of these materials. By introducing a shock pad the infill density can be reduced whilst retaining similar performance characteristics.

Organic infills are also more likely to incorporate a shock-pad. The choice of material varies, although a PU/SBR mix is less likely to be used which may be due to the perceived environmental and health issues related to SBR which resulted in the decision to use organic infill.

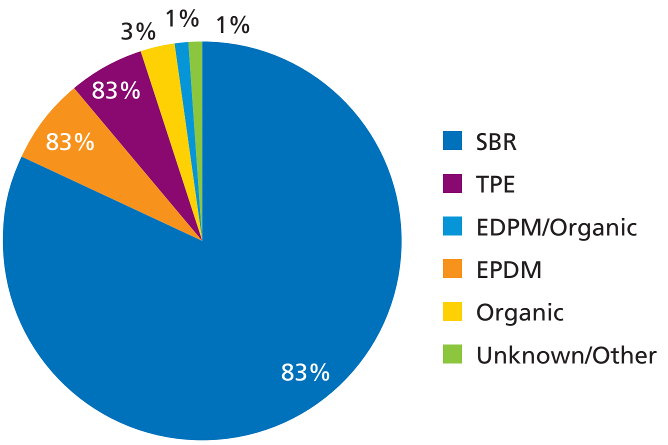


Figure 6 – Performance Infill Use

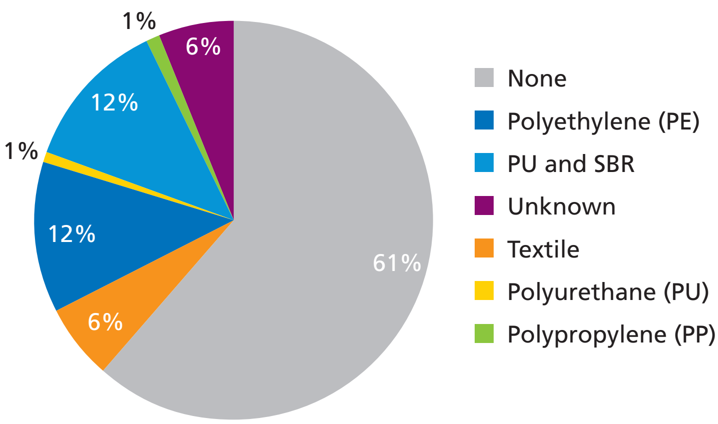


Figure 7: Shock-pad Installations by Material Type

2.0 ENVIRONMENTAL IMPACTS OF FIFA CERTIFIED FOOTBALL TURF

2.1 GOAL AND SCOPE

The goal of this study is to provide an overview of the environmental impacts of artificial football turf. This overview has been undertaken as an independent analysis of the environmental 'hotspots' throughout the lifecycle of the turf. This involves identification of the materials, processes or lifecycle stages (raw material, manufacture, transport, disposal etc.) that contribute most to the overall level of environmental impact. In this way, those who specify football turf installations can better understand where their decisions can help to minimise their overall impact.

The scope of this study is limited specifically to artificial turf that meets either the FIFA Quality, or FIFA Quality Pro standards under the FIFA Quality Programme. As such, it reflects the higher end of the market, and because all the turf included meets a certain threshold of quality, it allows environmental impacts to be compared for turf with broadly equivalent functionality (as opposed to where lower and higher quality products are compared). The results may have application beyond the turf included here, but the quality of non-FIFA Quality 3G turf is reportedly hugely variable, and as a result, it is extremely difficult to compare the environmental impacts of these products, recognising that they do not really offer the same performance.

This study does not document the difference in environmental impact between natural grass and artificial turf.

The product data used to identify the material usage comes from the data FIFA holds on approximately 3,500 FIFA Quality certified installations to date. The data is averaged out to identify the most common materials, and the installed density of each material per square meter of the pitch. Therefore, it is important to recognise that this study does not compare individual pitches or products from specific suppliers, but seeks to identify differences between the main types of turf, based on typical (rather than specific) product components, to provide an overview of the environmental impacts of installed FIFA quality turf.

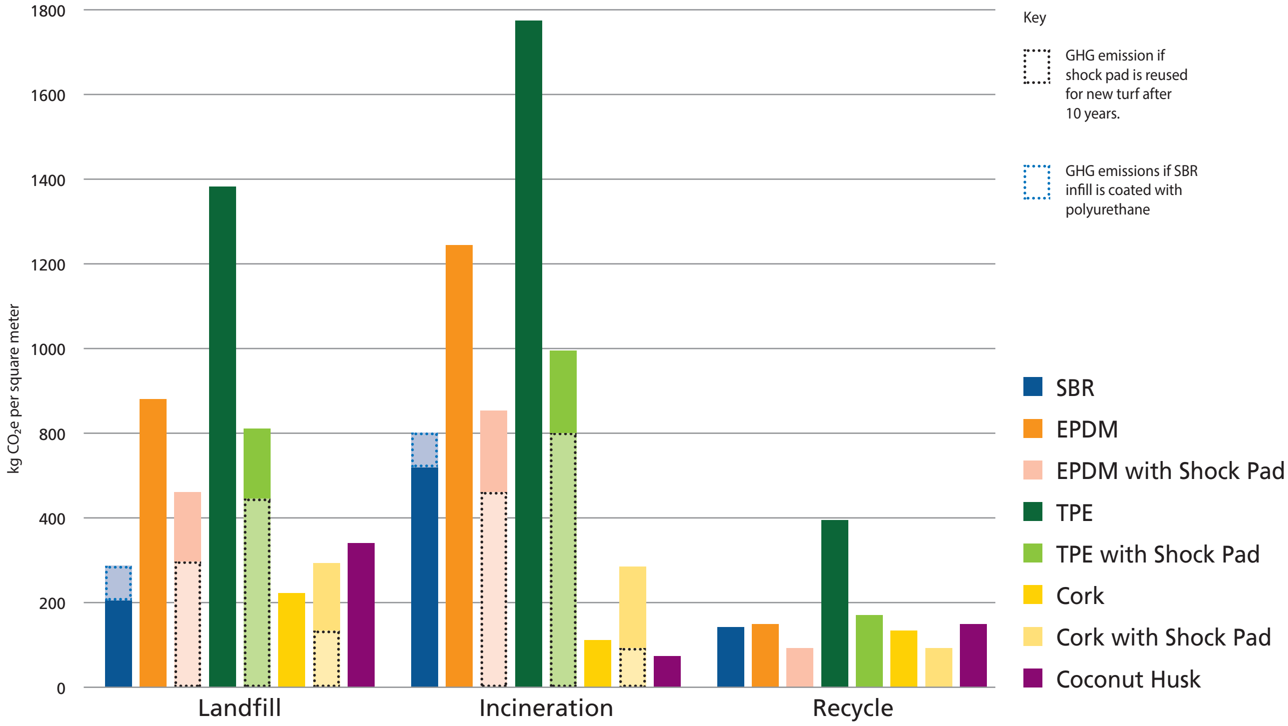


Figure 8: Climate Change Comparison between Turf Containing Different Infill Materials

Each of the flows of materials and process inputs are scaled based on one square meter of turf installed. Where these apply to a whole pitch – i.e. maintenance and installation – the flows are divided by a standard pitch size of 106 x 71 meters (7,526 m^2). It is assumed that all pitches have a lifespan of 10 years.

2.2 RESULTS

There are three main factors which have the greatest influence over the environmental impact of artificial football turf, which are:

- Choice of infill material;
- The decision regarding whether to use a shock pad or not; and
- the type of treatment used at the end of life.

Figure 8 shows the results of a comparison between different formulations of turf, each containing one of the five main infill types, for each of the potential disposal routes. It displays the greenhouse gas (or 'carbon') emissions over the life of each product per square meter installed. Although there are many ways to indicate and compare the environmental impact, carbon emissions are given as an example that is broadly representative of many of the other environmental impacts such as air pollution or toxicity in humans or ecosystems. This life cycle includes the raw materials, manufacture, transport, installation, maintenance and disposal options at the end of life.

The graph also shows how the introduction of a shock pad and the associated reduction in the need for performance infill affects the results. Both EPDM and TPE pitches see a significant reduction in GHG emissions associated with the use of a PE shock pad, and this holds for all disposal scenarios. Conversely, pitches with cork infill only witness environmental improvement from using a shock pad in the recycling scenario (there was insufficient data on shock pads for coconut infill). This scenario assumes that the shock pad will be left in place and reused rather than uplifted and recycled, as they are usually capable of being directly reused at least twice. The other cork pitch disposal scenarios (landfill and incineration) assume that the shock pad is taken away for disposal, however if it is left in place (whilst the rest of the materials are landfilled/incinerated) this does become a more preferable option, as demonstrated on the graph.

Whilst SBR appears to be the preferred polymer infill material for all disposal options, if it is coated with polyurethane, the impact increases significantly and becomes a less attractive option when incineration is used as the end of life treatment.

Where the turf is recycled, the analysis suggests that if recycling is carried out effectively, in this idealised situation, many of the infill options (with the exception of TPE) have a similar environmental impact.

It was also found that latex is environmentally preferable to polyurethane for use as the secondary backing. This is despite the need to use more latex to achieve the same function. The environmental difference is small, however, and therefore should be considered when all other impacts have been reduced as far as possible.

2.3 ORGANIC ALTERNATIVES

As well as looking at the quantifiable environmental impacts it is also useful to recognise other less immediately quantifiable issues. Often organic alternatives to plastic based products come with their own problems–for example the growing of non-food crops to produce products can displace food production, and ultimately extend the agricultural frontier, leading to reduced biodiversity. This is why it may be not be feasible to replace all oil-based plastics in the world with bioplastics, for example.

The main organic alternative for the performance infill is cork. This material has been farmed for hundreds of years predominantly in Portugal and Spain for use as wine bottle stoppers. Unlike normal tree felling, cork is harvested by harmlessly removing the bark every 9 to 12 years and is regarded as a uniquely sustainable practice employing over 100,000 people.

Cork oak landscapes also support one of the highest levels of biodiversity among forest habitats, including globally endangered species such as the Iberian Lynx, the Iberian Imperial Eagle and the Barbary Deer.

The cork industry in this region has been threatened due to competition in the market as alternatives such as plastic stoppers or screw tops have become popular. If cork is not harvested, the forest is at risk from fire, overgrazing, conversion and degradation. WWF has noted[1] that the consequential reduction in cork forest due to reduced demand has a number of negative impacts such as the increase in desertification and a reduction in biodiversity, including the endangered species that are unique to the area. Widespread use of cork as infill, may not just be a suitable alternative to plastic infills, but could also have far-reaching wider benefits both environmentally and socially for a number of Mediterranean countries.

2.4 MARINE MICROPLASTICS

Another less quantifiable impact is the issue of microplastics – defined as plastic particles smaller than 5mm in all directions. These have been highlighted as a potentially significant problem for aquatic ecosystems. As an emerging science, it is currently difficult to quantify the problem, but it is recognised that these small particles can and do get ingested by various marine animals and can progress up the food chain causing various chemical and physical effects.

More recently plastic infill (including SBR, TPE and EPDM) has been identified as a possible source for microplastic marine pollution. Infill can get washed away during rain or stick to clothing and boots before being put in a washing machine. In colder countries, the infill can also be removed during snow clearance and if not managed correctly can also be washed into surface waters. It is estimated that 1–4% of plastic infill is lost and replaced every year.

Figure 9: Harvested Cork Forest in Spain

The plastic infill and fibre losses for all FIFA Certified installations (3,283 pitches) are estimated to be between 4,400–16,500 tonnes annually. To put this in perspective it is estimated that FIFA certified turf accounts for less than 10% of the overall sports turf market.

However, these figures are not the amount that is expected to be released into rivers and oceans, but the total predicted losses. It is clear, therefore, that more research is needed to identify and quantify these pathways in order to calculate how much of the material ends up in the marine environment.

Measures to reduce the potential losses include;

Improving snow removal and storage procedures, storing infill in designated inside storage areas and cleaning and disposal procedures in the changing rooms to can all help to reduce the potential for the valuable infill to become lost to the environment. Organic infills can also be used as an alternative to plastic infills which would provide a simple solution to the problem for those pitches that decided to use these materials.

2.5 CONCLUSIONS

As the scope of this project focuses specifically on the data collected by FIFA around Quality Standard turf, the results should not be used as an absolute measure of the environmental impacts of the products on study (i.e. to suggest that turf containing SBR causes X kg of CO_2 emissions). Despite this, there are some clear observations that can guide anyone who decides to use this study to help make decisions around specifying artificial turf:

- For all products that contain a polymer infill, it is the manufacture of that material and its disposal which will have the largest environmental impact.
- Virgin polymer infills have a larger environmental impact than (already recycled) SBR.
- Organic infills have a smaller environmental impact than polymer infills.
- The installation of a shock pad can greatly reduce the environmental impact when used alongside virgin polymer infills due to the reduction in the need for infill by 50–60%.
- Where a shock pad is used, it is very environmentally beneficial to leave it in place for reuse when a new turf is installed. Reusing it need not impact performance quality of the pitch. A test should be performed to assess reusability.
- With all other parametres equal, latex is marginally preferable to polyurethane for the secondary backing .
- SBR coated with PU is environmentally worse that SBR that is uncoated, but still preferable to virgin infill.
- Recycling is the most preferable end of life route for all products, although the gain is small for organic infills when compared with incineration.
- If recycling is not available, the preferable route for polymer material is landfill. For organic materials it is incineration because on landfill it would cause a significantly bigger impact on climate change.

[1] http://assets.panda.org/downloads/cork_rev12_print.pdf

3.0 END OF LIFE OPTIONS FOR FOOTBALL TURF

There are four main end of life options that are commonly used for football turf:

- Re-use;
- landfill;
- incineration; and
- recycling.

Particularly in the US, "re-use" is often referred to as 'recycling'. Whilst this option was not assessed in the LCA–as there is little data to support inclusion or evidence that it is widespread– it should be recognised as a potential choice.

3.1 RE-USE

Re-use is often erroneously referred to as recycling by some of the many businesses that specialise in turf removal. In this context re-use is when the turf (or its component parts) are removed and re-used in a new installation with the same, or similar function. Recycling of materials generally involves some form of processing before the material can be used again. Although some companies have designed their own innovative methods of removing and rolling the turf, the equipment for turf removal has become readily available in recent years. The 'turf muncher' for example, rolls the turf tightly whilst removing the infill and depositing it in a hopper.

Removal of the infill on site is a common practice, but is comes with its own issues. Interviews with some of the large manufacturers of turf suggested that when removed onsite, the infill could easily be re-used directly in a new pitch. Despite this, the practice does not appear to be widespread. One of the biggest issues for recycling (and re-use) is the contamination by the sand infill. Its small particles are very difficult to remove even in an industrial process. The–usually SBR–infill removed on site would be mixed with sand and separation of these two components on site–as is often claimed –is unlikely to be very effective. It is also unclear what secondary markets would accept infill (rubber crumb) with a low purity level if it is not suitable for football turf. The Synthetic Turf Council list a large number of uses for rubber infill, such as various flooring or sound barriers in industrial or construction settings. These are listed as

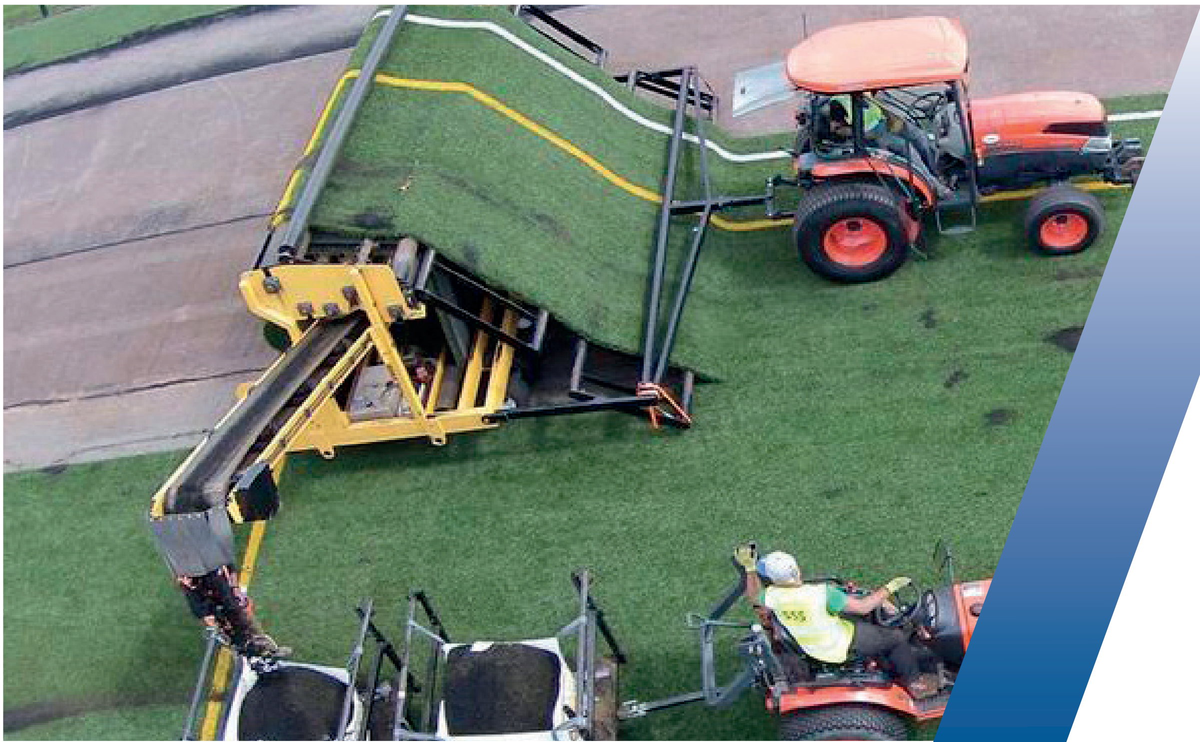


Figure 10 – Turf Muncher

theoretical markets, but in practice there is no evidence that a significant market exists for the material beyond re-use in turf–a study[2] for CalRecycle in California found that only 25–50 per cent of SBR infill was reused, the remainder going to landfill. The study also did not find any specific examples of recycled rubber crumb being used in the manufacture of new products and concluded that there was a lack of information for field owners around how to most effectively and efficiently deal with their fields at the end of their life.

Although typically re-use is generally viewed as a more preferable alternative to recycling for many products, this does not appear to be the case for artificial turf. The lack of evidence for a clear end market and the apparent fact that any re-use will have to be in a lower value application means that the argument for re-use is weak. Re-use of the turf by cutting it into smaller sections for domestic use is often viewed as a good end-of-life option, but when compared with recycling it may not be. Once the turf is cut up, it will almost certainly not be recycled after its second use. It is difficult to capture and efficiently recycle large pitches, therefore small geographically scattered installations are even less likely to be recycled. This means the material will eventually be lost to landfill or incineration. Re-use of artificial football turf would therefore only be acceptable if there is no recycling option available and there is a viable market for the re-used product.

3.2 RECYCLING

Research suggests that there are very few, if any recyclers of artificial turf that can gain a high purity in their material outputs. Material contamination from the use of sand infill is very difficult to separate from the other materials in the turf. This, combined with the turf being comprised of several different plastics, means that the recycled material is often used for lower grade applications.

This is known as 'open-loop' recycling which is in contrast to 'closed-loop' recycling which can–in theory–mean that the recycled material can be used to make the same product. These low grade recycled material applications are suitable for road cones, rubber tiles and pallets and boxes which will always use some form of recycled or low grade alternatives.

The ultimate goal is to create pure enough streams that the resultant material can be used to create new turf. This isn't currently possible due to technical constraints and the construction of the turf involving permanently bonding different materials together.

More recently 'hot-melt' backing has been developed to bind the pile fibres. This promising technology may allow the materials to be separated during recycling by re-melting, but this is unproven in practice and this type of turf construction is not yet widespread.

Recycling plants have been built and trialled in both North America and Europe, but due to;

- issues with contamination;
- lack of turf input;
- competition from other disposal operators; and
- the lack of support from turf manufacturers, many have since closed.

It has been proven that the typical processes used to recycle carpets–such as shearing off the fibres–are not as effective for turf due to the high levels of contamination from sand.

[2] Louis Berger Group (2016) Recycling and Reuse of Crumb Rubber Infill Used in Synthetic Turf Athletic Fields, Report for CalRecycle, March 2016

CASE STUDY – RE-MATCH

Re-Match, based in Denmark is a recycler of artificial turf which has independently proven that they can gain a high enough purity in their material outputs to allow 99% of the turf materials to be recycled. The recycling process ends up with four materials streams;

- sand,
- infill (typically SBR),
- polypropylene (PP) and polyurethane (PU)/latex from the backing, and
- polyethylene (PE)/polypropylene (PP) from the pile.

The process involves steps of grinding into smaller parts, drying the material and then separating it using a centrifugal cyclone process which can separate by material density.

The resultant material is a fairly pure mix of PE and PP and a separate stream of PP with the PU/Latex backing still attached. Neither of these low grade streams is currently suitable for use as replacements for equivalent virgin material, although the (usually SBR) infill is often high enough quality that it can now be used as infill on new pitches.

Due to the innovative nature of their technology and the prevalence of illegal dumping, Re-Match have decided to differentiate themselves by having their claims verified under a European scheme: the Environmental Technology Verification (ETV). Whilst there are currently no standards for turf recycling (other than local generic waste regulations), schemes such as this help to increase the credibility of recycling processes where no regulation exists currently. This can help pitch owners to dispose of their pitch responsibly, but even these types of voluntary standards are far from the industry norm currently.

The high cost of transport and disposal and the general lack of knowledge around how to deal with turf as a waste has also lead to instances of illegal disposal. As the cost of disposing of a pitch can be anywhere from $10,000–$50,000 there is a great deal of pressure to reduce this cost. If waste disposal companies are offering to remove and dispose of a pitch for $30 per tonne (around $8,000 for a pitch), this will be the driving force behind any decision. With this price reportedly being charged in parts of Europe, the pitch will not end up in landfill or incineration and it is very unlikely that recycling will be viable. This means that there may be a significant issue with the illegal dumping of waste pitches and this issue will only worsen as an increasing number of pitches will need to be disposed of in the coming years.

3.3 LANDFILL AND INCINERATION

Although there is no data that shows where turf will end up when it is disposed of, it is most likely to become part of the waste stream that is dominant in the country of disposal. Both incineration and landfill exist in many countries although the dominant method of waste disposal in the majority of countries is landfill.

Outside of Europe–and in most of Eastern Europe–landfill is the dominant form of disposal for all types of waste. Other key countries in terms of football turf installations, such as Canada, USA and Australia, have very little incineration and comparatively low recycling of household waste. Morocco and Turkey also have a large number of pitches installed, but the majority of their landfills are unregulated dumps. If landfilling is not taxed, and especially if disposal is allowed to take place at unregulated dumps, then the cost of disposal will be very low. In such situations, it is likely that, unless there are drivers specific to the artificial turf industry which are designed to encourage recycling, the pitches will end up in the landfills at the end of their useful life since the recycling process itself is not costless.

Many of the countries which install the most football turf in Western Europe rely more strongly on incineration as their primary form of managing unrecycled waste. This is a result, typically, of the deployment of landfill taxes and bans, often jointly, but sometimes with

Figure 11 – Active Landfill in Australia

one or the other used as the primary driving mechanism. Several European countries – such as Denmark, Sweden, Norway, Austria, Belgium and the Netherlands – have implemented a ban on landfilling many wastes, as well as a landfill tax to support the ban, so that they now incinerate almost all waste which is not recycled. Germany has banned all untreated waste from landfill but has no landfill tax in place, and this also results in complete reliance on alternatives to landfill–such as incineration–for waste that is not recycled.

The UK has one of the highest landfill taxes in the world at around $100 per tonne.[3] This has driven the requirement for more alternatives to landfill, such as incineration. Some states in Australia – such as New South Wales (NSW) – also have high landfill taxes, but because neighbouring states (such as Queensland) have lower taxes, or no tax, waste moves to the cheaper landfills outside the state of NSW.

Since most incinerators now generate energy from the waste they treat, and since they usually sell this energy on to users of energy, the price charged for treating waste at such plants–commonly known as the 'gate fee' or 'tipping fee'–depends significantly on the revenues that can be derived from the sale of energy. The higher the energy revenues are, the lower the necessary gate fee required for commercial operation can fall. Energy revenues are sometimes supported by incentives for the generation of renewable energy, and the revenues are sometimes raised by the use of energy taxes on other fuels (such as heating fuels) whilst exempting heat generated from waste from any equivalent tax (this is known as an implicit subsidy).

3.4 COSTS OF DISPOSAL

The cost of disposing of waste to landfill and treating it through incineration varies hugely across the world and is likely to have a significant influence on the fate of the turf in any given country, assuming that those responsible will tend, in the absence of any other measures, to seek the cheapest way of dealing with their turf at its end of life.

As already mentioned, a standard pitch containing SBR infill could weight around 274 tonnes. This is the amount of material that will need to be disposed of or recycled when the pitch reaches the end of its life. Figure 12 provides an overview of the costs of disposal per tonne based upon the gate fee charged, the local taxes applied and transport of the material. The disposal options are split by type and technology level into the following categories:

UNREGULATED LANDFILL (DUMPS)

Up until as late as the 1970's this was the most commonly found type of waste disposal throughout the world and is still the fate for much, if not all, of unrecycled waste in most developing countries today. This includes illegal dumping, which essentially costs nothing other than the fee paid to a land owner to allow dumping on their land. There is no government regulation.

REGULATED LANDFILL–LOW TECH

This is very similar to the previous category, but in some countries, these sites are recognised as locations for disposal (usually when there are no alternatives) and so there may be some form of government regulation and control regarding what and how such sites are operated.

REGULATED LANDFILL–HIGH TECH

These sites must observe strict government regulations and therefore usually need to control leachate–the liquid that passes through the landfill picking up chemicals along the way. Mechanisms to capture gases that are generated as the process of degradation takes place will also tend to be included. Such 'gas capture' systems can make use of the methane in the biogas that has been generated to create electricity, or it may be flared on site to convert methane to the less potent greenhouse gas, carbon dioxide. The landfill operator must also be responsible for the site for a number of years after closure. These requirements result in a higher gate fee for this type of disposal. This

[3] Exchange rate 1.25 USD to 1GBP

is representative of all of the European Union and North America, though regulation still varies somewhat. As noted above, landfill taxes are also applied in some countries although this is mostly confined to Europe at present. The final cost of disposal will therefore be the sum of the gate fee and all applicable taxes.

INCINERATION

Incineration of waste takes place mostly in developed countries as they are very capital intensive to build and tend to be more expensive than landfilling. The lowest gate fees are usually found at newer facilities where the cost of financing is low (publicly funded), high efficiencies of electricity and/or heat generation, and with government intervention in the form of subsidies (explicit or implicit) for energy. The highest fees are found where facilities are privately financed, and where the revenue from energy generation is low. The type of funding and the revenue from energy sales can cause the gate fees to vary by as much as a factor of four even within one country, and so, it is very difficult to make country wide generalisations on costs.

RECYCLING

The Recycling of the turf is based on the gate fee from Re-Match. They charge between $30 and $60 per tonne depending upon where the turf is coming from–the lower gate fees are charged to remain competitive in overseas markets such as the US where the cost of sea freight has to be factored in.

TRANSPORT

The transport of the material is most significant for the recycled option due to the lack of local recycling facilitates outside of Europe. The costs for Trans-Atlantic shipment of the turf by 40ft container will vary, but can be found in the region of $50–$80 per tonne (or around $2,000 per container) with economies of scale generated from the need for around 10–15 containers per pitch. Local road freight also varies hugely in price, although it is generally more expensive than sea freight over a given distance. Local transport for a pitch to be transported to the nearest landfill or incinerator is assumed to be around 100 km by road at a cost of $0.15 per tonne/km.

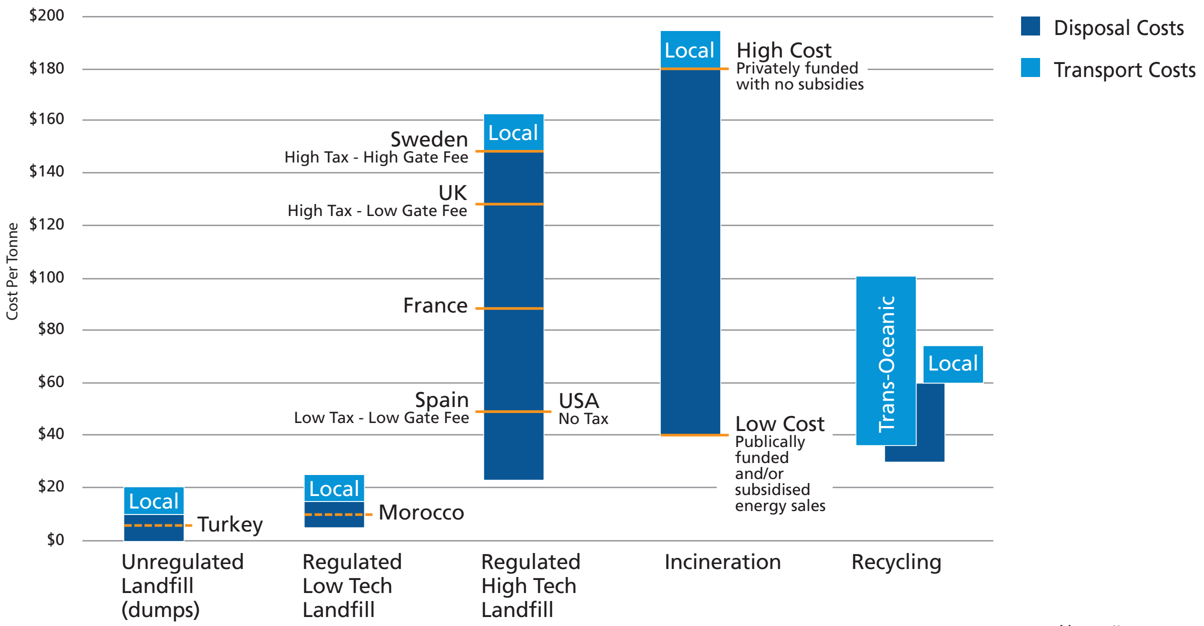


Figure 12 – Costs of Disposal Options by Technology (per tonne)

[4] https://www.epa.gov/climatechange/social-cost-carbon

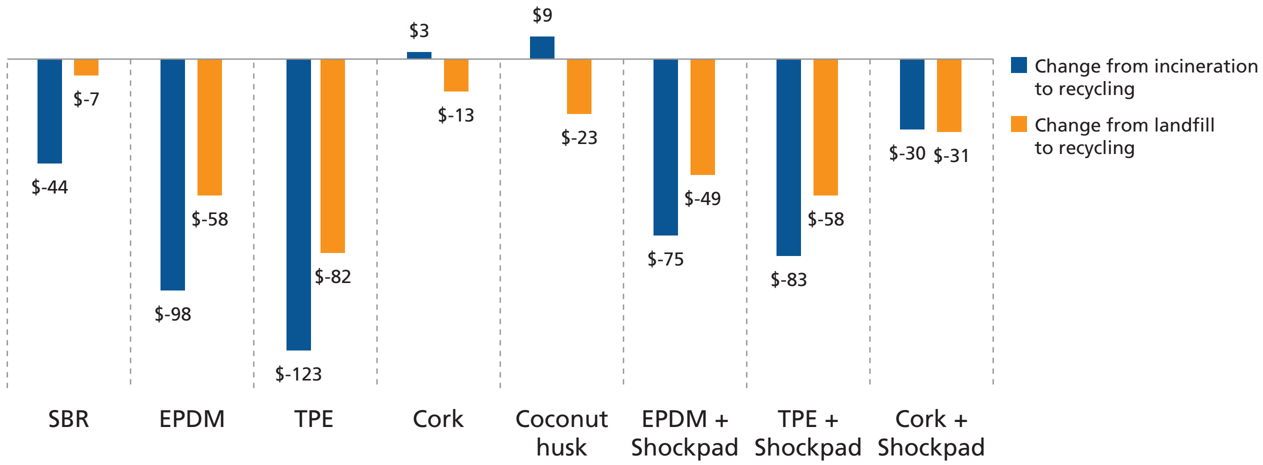


Figure 13 – Monetised Carbon Benefit from Moving to Recycling per Tonne

3.5 ENVIRONMENTAL COSTS

The environmental costs are calculated by multiplying the GHG emissions from the waste treatments (Figure 8) by the 'Social Cost of Carbon' (SCC). The SCC is a method from the USEPA[4] to value the damaged to society caused by the effects of climate change; this is given as $42 per tonne of CO_2 for 2020.

As seen in Figure 13, recycling turf results in a large benefit for all except the organic turfs. This is because the emissions generated from processing the organic infill by separating it from the turf outweigh the benefits of using the resulting 'recycled' material as an alternative to compost. There are no reports of organic infill pitches being recycled at present, however. The largest benefit comes from TPE and EDPM when either is moved into recycling from incineration. This is because of the large amount of CO_2 generated during burning (essentially burning oil) and the energy intensive nature of their manufacture.

It is also important, therefore, to take into account the wider societal benefits for recycling as well as the direct costs of disposal. For example, in the USA, landfill costs around $50 per tonne, and it would cost around $100 per tonne to ship the turf to Europe and recycle it (see Figure 12)–$50 more. If the societal costs from Figure 13 are also taken into account, turf with EPDM and TPE infills would therefore benefit from being sent to Europe for recycling–costs of $8 and $73 less, respectively.

3.6 CONCLUSIONS

It is clear from the research that recycling of artificial football turf is not widespread. The majority of the manufacturers interviewed for this study claimed their products are 'recyclable', but none are taking significant steps to make sure this happens in practice.

Technologies to remove, separate and clean the main components of the turf are still being perfected and at the moment the best processes are still 'open-loop'. A full 'closed-loop' process is yet to be developed and this will certainly require more support from the turf manufactures to implement. The promising development of 'hot-melt' secondary backing may improve this, but as new technologies will take at least a decade to filter through to the waste system it will be a while before this is tested in real life.

Despite these issues, recycling is a viable option particularly in Europe and using the Re-Match process. The close proximity to the recycling facility and the proliferation of (expensive) incineration means that there is very little justification for pitches located in Western Europe to not be recycled. In other parts of the world where the disposal of waste is far less strict (and therefore cheaper), and the long distance to recycling facilities adds to the cost, it is less likely that pitches will be recycled.

There is also the issue of illegal dumping which no alternative can possibly compete with on price. Without much needed legislative action, the best way to improve this situation is through education of the specifiers and pitch owners. An understanding of the implications of turf disposal will help with this. It should also be encouraged that contracts for installation be extended to the end of life removal so that the supplier/installer is responsible for the pitch throughout its life.

4.0 FOOTBALL TURF ENVIRONMENTAL BEST PRACTICE

The following section of this report focuses on the key decision points and the options available at those points that impact the environmental impact of football turf disposal. The decision flows diagrams are based upon the analysis of the environmental impacts in Section 2.0 and the end of life options discussed in Section 3.0.

The key to reducing the environmental impact of football turf throughout its life is to begin with the specification of the pitch before it is installed. There are also steps that can be taken to reduce the environmental impact of pitches that have already been installed and require disposal.

The guidance does not look to suggest which materials provide the best performance of suitability for a particular need–there are such a large variety of products and specifications that this would not be feasible. When specifying a pitch, the performance characteristics should come first. Environmental decisions can then be made based on the required specification. If there is a choice to be made between two materials that will provide equal performance, this guide will help to make the most informed decision.

Step 1 — Investigate the local end of life disposal options

When specifying a pitch or a current pitch requires disposal it is important to be aware of the disposal options available in your region.

- Is local recycling available?
  - **No** → Are there viable overseas recycling options?
    - **No** → Where is the pitch located?
      - Western Europe → Incineration*
      - Rest of the World → landfill*
    - **Yes** → Ask your recycler the following... (Can the turf be pooled with other local pitches to reduce transport costs?)
  - **Yes** → Ask your recycler the following...

Ask your recycler the following...

- What proportion of the pitch will be recycled? – less than 80% is poor, over 95% is good.
- If the infill is re-used, how is the contamination from sand removed and how pure is the resulting material?
- Where will the remainder go? Landfill or incineration?
- Can they prove their claims independently?

Go to step six if this is a current installation

* You should confirm your local situation by asking your disposal contractor or turf installer.

Step 2 — Investigate best environmental infill material options

The material choice for infill has the greatest effect on the environmental impacts, but the best environmental choice is also dependent upon the expected method of disposal.

Increasing Environmental Impact ↓

Incineration

- Organic (all)
- Virgin Plastic with Shock pad re-use*
- SBR
- Virgin Plastic

Landfill

- Organic with Shock pad re-use*
- SBR
- Organic
- Virgin Plastic with Shock pad re-use*
- Virgin Plastic

Recycling

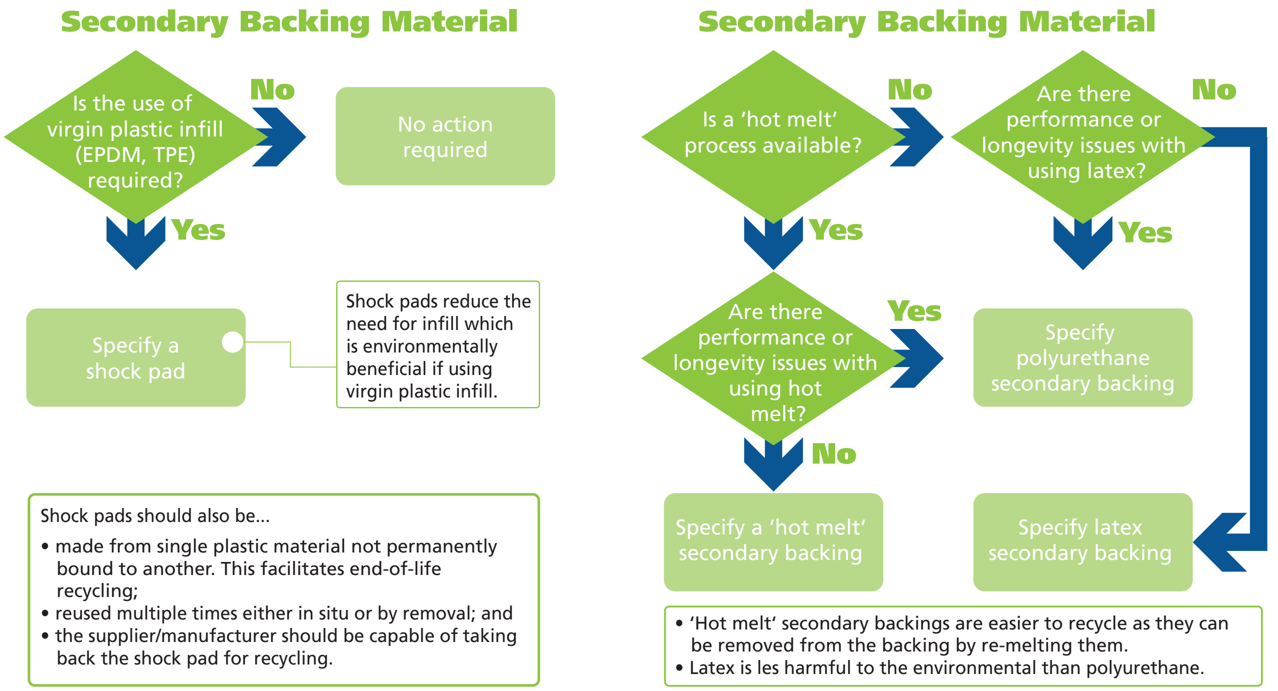
All infill options similary benefical

Virgin plastic commonly includes EPDM and TPE

* See ***Step 6*** – in situ re-use of a shock pad significantly reduces the environmental impact

Step 3 Investigate other material options

After the infill material, there are other material specifications that can be made to improve environmental performance further.



Step 4 Request supplier environmental certifications

Material quality and environmental control is of the upmost importance.
Hold your supplier to high environmental standards.

- Specify that all components of the pitch should come from a supplier/manufacturer who is ISO 14001 compliant – the international standard for environmental management. This is especially important for suppliers who buy infills on the open market rather than through relationships with existing suppliers.
- Turf recyclers should also provide ***independent verification*** of their process to verify their claims. As there is no standard verification or certification process for turf recyclers it is recommended that that specifiers ask for an ***Environmental Technology Verification (ETV)***[5] or similar. This is a European scheme that will help you to determine whether their claims can be substantiated. It does not, however, determine whether the performance is acceptable. As a minimum, the recycler/disposer should provide documentation from the end treatment facility to prove the waste has been dealt with legally.
- SBR is a generic term for recycled rubber crumb. Ask your supplier where it comes from; recycled material from varied and unknown origins can cause problems for effective recycling.

Step 5 Consider how to maintain your turf

Once the pitch is installed, it will require maintenance to function correctly and increase its lifespan.

The infill material will need to be topped up therefore it is important to use the same type of infill and grade as is already installed. This can be achieved by;

- asking the pitch installer to manage the maintenance and specify that the same grade of infill must be used throughout; or
- requesting a product specification sheet from your infill installer that can be used to specify future infill purchases.

Recycling is most effective if all materials come from a known source to a known specification.
This will also reduce the cost to send the turf for recycling as the recycler can make more money from purer materials.

[5] http://ec.europa.eu/environment/ecoap/etv_en

Step 6 Investigate the best end-of-life disposal option

It is important to take control of where your turf ends up. Small decisions about the fate of the turf can make a large difference.