

Lifecycle Assessment Scenario Comparison

Far Field, Highgate School



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Introduction

Overview

Highgate School has appointed Eight Versa to provide a Life Cycle Assessment comparison study for the proposed artificial pitch at far field playing field.

The current field has limited use due to flooding and weather issues. The pitch is also a grass pitch which limits the type and number of sports it can be used for. Because of this usage rates of the pitch are limited, and the only school pupils use it. In our baseline (scenario 1), we have accounted for drainage works to keep the pitch operational for 25 years but expect the usage rates to remain similar due to the pitch not being used for a range of sports. The synthetic pitch in scenarios 2 and 3 will have much higher usage rates. Firstly, this is due to synthetic pitches having good weather and flood resilience but also because a wider range of sports and activities can be played. The school has also expressed their interest to open the pitch up to host competitions and host local teams during non-school hours.

The assessment compares the total lifecycle carbon for the existing pitch (including the construction of drainage to keep the field operational for a 25-year period) and the proposed synthetic grass pitch. An ideal management scenario has also been assessed where the replacements times for the turf have been extended beyond industry averages based on current management practices at the school.

The assessed scenarios are listed below:

- Scenario 1: Existing playing field: natural turf pitch: 13,950m².
 - Grass pitch with constructed drainage below and 5-year drainage maintenance intervals.
- Scenario 2: Proposed playing field: synthetic turf pitch of 14,000m²
 - Synthetic turf with under pitch drainage and 7-year replacement intervals for turf.
- Scenario 3: Ideal management proposed playing field: synthetic turf pitch of 14,000m²
 - The same construction as scenario 2 but with extended lifetime for the synthetic turf based on the school's management and lifetime of other synthetic turf playing fields. End of life has also been assumed as recycled or reused rather than plastic landfill for the synthetic turf.

The proposed development can be seen in Figure 1.



Figure 1 Proposed development

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Methodology

Due to the nature of the development a bespoke methodology has been used to best reflect the performance of the three scenarios.

Carbon emission factors have been obtained from eTool LCD, UK government GHG emissions factors, and related studies/research on artificial and natural turf.

The study period for this project is 25 years.

Lifecycle modules A-C have been considered under BS EN 15978. These have been recategorized into 3 stages as listed below.

The study boundary includes:

- Construction stage: Material production, transport to the construction site and construction
- Use stage: Use (including transport to alternative sports field), maintenance, and replacements
- End of life stage: Deconstruction/demolition and waste

The functional units used in the assessment for Global Warming Potential (GWP) is expressed in kgCO₂eq and kgCO₂eq/hour of use.

Various assumptions have been made for this assessment and these can be seen in Appendix A.

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Results

Existing pitch - Scenario 1

As seen in the table below, the construction stage associated with keeping the existing pitch usable for 25 years accounts for 72% of the lifecycle emissions. This includes excavation, constructed drainage, infill, and site levelling. The end-of-life accounts for 21% while the in-use stage only accounts for 7%.

A more detailed review of the lifecycle stages (see to the right) shows that the building products themselves only account for 10% of the total emissions while 62% of the emissions are from the assembly and transport of these materials. Because of this the only feasible way to effectively reduce emissions for construction in this scenario would be local procurement and leaner construction methods.

Reviewing the lifecycle impact by each element or process, in the table to the right, shows that the alternative travel (coach and minibus travel) and upkeep of the pitch (aeration, decompaction, fertiliser, herbicide, mowing, annual water use) account for a very small percentage of emissions (~3%). The rest of the emissions come from constructing and maintaining the drainage and surface of the pitch. Because of this there is little benefit from changing existing maintenance practices to reduce lifecycle carbon.

Impact	kgCo2eq	% of impact
Construction	1308096	72%
Use	134211	7%
End of Life	379251	21%
Total	1821558	

Impact	kgCo2eq	% of total
Coach travel (to alternative locations)	996	0%
Minibus travel (to alternative locations)	1483	0%
Aeration - Annual	2632	0%
Decompaction - Annual	2632	0%
Fertiliser - Annual	3094	0%
Herbicide - Annual	3094	0%
Mowing - Annual	16451	1%
Under-pitch drainage pipes	25797	1%
Redraining - Infill	32340	2%
Annual water use (irrigation)	35253	2%
Redraining - Excavation	36234	2%
Levelling of subsoil	89497	5%
Excavated soil (waste) (module C only)	251786	14%
Excavation impacts (non-waste)	359333	20%
Stone infill layer (Bottom layer)	446878	25%
Sand layer (top layer)	514056	28%
Total	1821558	

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Proposed design - Scenario 2

The table below shows that the construction stage accounts for approximately half of the lifecycle emissions. Although annual upkeep of the synthetic turf is minimal the use stage accounts for 35% of the lifecycle emission. This is due to the 7-year replacement cycle which means the product needs to be manufactured and installed three times across the lifetime. The end-of-life stage accounts for only 10% of the emissions.

Impact	kgCo2eq	% of impact
Construction	2811108	56%
Use	1766219	35%
End of Life	464009	9%
Total	5041337	

A considerable proportion of the lifecycle emissions come from manufacturing and replacing the construction products ,mostly from the synthetic turf (See table below and to the right). Transport of materials and waste (13% and 8%) and installation/assembly (13%) are also significant proportion of emissions.

Impact	KgCo2eq	% of impact
Product stage	1897817	38%
Product transport	634357	13%
Installation/Assembly	278934	6%
Use	0	0%
Maintenance	14436	0%
Replacement	1751783	35%
Waste transport	378239	8%
Waste disposal	85770	2%
Total	5041337	

The pitch surface (shock pad and artificial turf) account for over 70% of emissions. This is a key impact area which can be focussed on when looking at procuring specific products. Similarly, since annual

brushing and cleaning accounts for negligible emissions, procuring sustainable and low emission products as a whole will make a large difference in the lifecycle emissions.

Impact	kgCo2eq	% of total
Brushing and Cleaning - Annual	14436	0%
Drainage - Poly storm pipes (300mm)	82225	2%
Asphalt base	323205	6%
Excavation	339718	7%
Permeable infill - aggregate (washed stone)	688722	14%
Rubber shock base (18mm)	1257321	25%
Floor Covering - Artificial Turf (PET/Nylon)	2335711	46%
Total	5041337	

Proposed design, Ideal maintenance - Scenario 3

In scenario 3 the replacement intervals of the turf have been extended in line with the replacement cycles of existing pitches at Highgate School. From conversations with Highgate school, we know it is also their intent to use contractors who will recycle and reuse the turf at its end of life. These differences result in reduction the in-use emissions by 33%. This is a significant reduction in a key impact area.

Impact	kgCo2eq	% of impact
Construction	2811108	63%
Use	1179682	26%
End of Life	462353	10%
Total	4453144	

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Proposed vs. Existing

Figure 2 highlights the total lifetime emissions for the three different scenarios. When looking at absolute emissions, the existing pitch has lower lifetime emissions than both proposed options. This is down to the smaller construction and maintenance emissions of the designs.

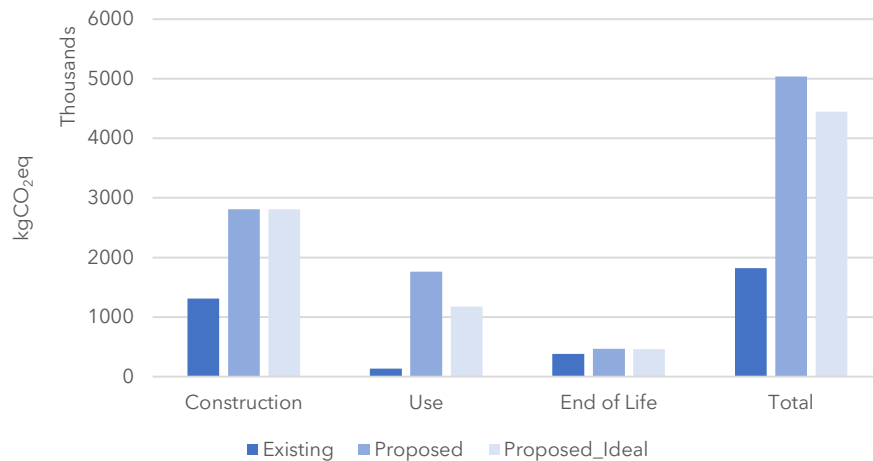


Figure 2 Total lifecycle emissions scenario comparison

Proposed vs existing per use

A useful insight to the real performance of the scenarios is to look at the emissions per hour of use. The following graphs show the emissions of each scenario accounting for the hours that the pitches could be used. The data is presented in kgCO₂eq/hour of use.

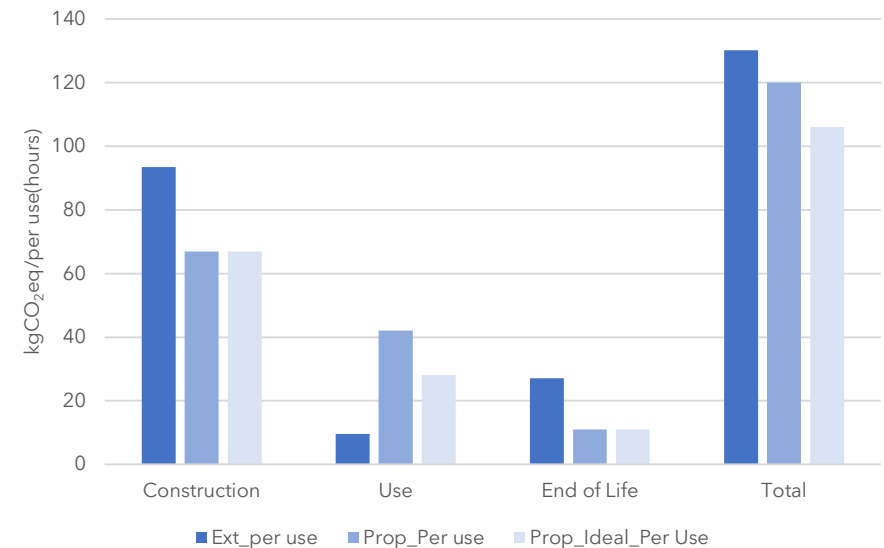


Figure 3 Total lifecycle emission per use scenario comparison

When looking at the results per use (see Figure 3) the emissions of the proposed design are more favourable. Especially when looking at the ideal management scenario where up to 20% of emissions can be saved when compared to the existing scenario.

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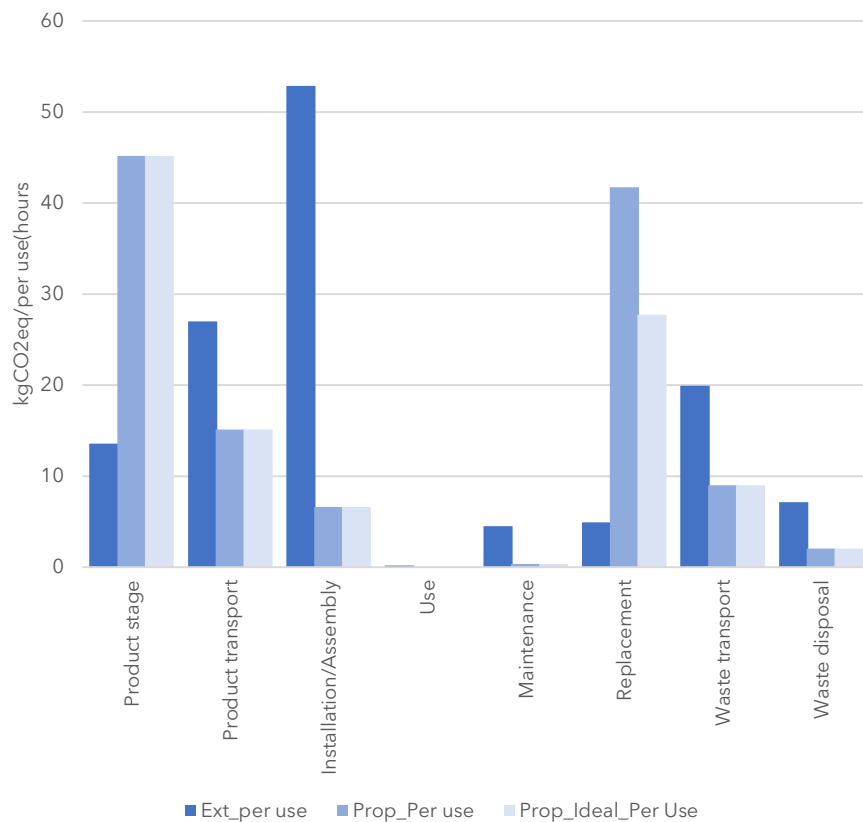


Figure 4 Total lifecycle emissions (detailed) per use scenario comparison

When analysing the lifecycle stages in more detail (see Figure 4) the main difference is the following:

1. The manufacturing of the products for the proposed design are more carbon intensive than the existing scenario
2. Installation and assembly of the existing design creates far more emissions than the proposed design
3. Replacement of construction products in the proposed design are far higher than the existing even when considering the good management practices of the school.

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Discussion

Total emissions

The total emissions for the existing scenario are lower than the current proposed design. This is partly due to the emissions from the construction products in the synthetic turf pitch but also because of the high emissions associated with replacing the turf during the lifetime of the pitch.

In the proposed design, most emissions come from the rubber shock pad and synthetic turf. This study has used industry average data for synthetic turf however, there are a range of low carbon product available on the market. for example, Polytan. Polytan claim to have low emission synthetic turf and are working on a net zero turf for the Paris 2024. Should this claim be verified, and a net zero product be taken to market there is an opportunity to dramatically reduce the impact of replacing turf by using a certified net zero product in the future. Highgate School are considering using these low carbon products. When finalising the design of the pitch it should be considered how different products of turf could be used on the foundation and shock base.

Emissions per use

When looking at emissions per use, the proposed design has lower emissions, especially when considering an ideal management scenario where the replacement timescales are extended due to proper maintenance. Ultimately, the aim of the pitch is to enhance the school's ability to provide a diverse sports facility, not only for its students, but also for the wider local area. Grass pitches inherently have lower usage rates and there is the potential for flooding and weather to further reduce usage. Taking this into account the proposed design does has lower emissions.

Wider sustainability benefits

This life cycle assessment has solely considered the lifecycle carbon emissions from the existing and proposed scenarios. However, sustainability covers a wider range of impacts, and these should also be considered when comparing the scenarios.

Flood risk

Results from the Flood risk assessment conducted by Corner Water Consulting, July 2022, show that the proposed design has a positive effect on the sites ability to resist flooding and manage surface water runoff. The two hydro-brake vortex flow controls allow the highest proportion of water storage and protect the site against future climate change scenarios. The implications towards flooding in scenario 1 have not been fully assessed.

Biodiversity

In line with Biodiversity net gain, the assessment by Applied Ecology, December 2022, shows that the proposed design will not have a negative effect on biodiversity. The existing field consists of grassed areas, and individual trees. The proposed design, while adding a large area of unvegetated land provides a rich perimeter of hedgerows, trees and flower patches. The proposed design also encourages birds and bats through installing nesting boxes and has invertebrate nesting piles as well.

Other wider sustainability benefits

While no formal assessment has been carried out it can be assumed that there are other sustainability benefits of the proposed design. Avoiding journeys by coaches and minibuses from the school will reduce congestion and improve air quality in the surrounding areas.

The extended use hours of the pitch mean that the social benefits of the pitch can be expanded to the whole local area not exclusively the school. It could be argued that without the proposed pitch another grass-based pitch would need to be created in the local area to service demand. This could result in higher emissions and perhaps not included the wider sustainability benefits aforementioned.

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Conclusions and Recommendations

While total emissions are lower for the existing pitch the proposed design has lower emissions when the usage rates are considered. There are a range of opportunities within the proposed design to further reduce lifecycle carbon emissions and there are wider sustainability benefits to be considered.

The results show that the proposed design, especially under the ideal management scenario, results in lower emissions per usage rate. To achieve a low carbon design, we would recommend the following:

- A large proportion of emission occur at the construction stage. Therefore, we recommend that the products used in the construction are procured considering the following:
 - Can products be produced locally, reducing transport emissions?
 - Can recycled aggregates be produced for the subbase and are there any other recycled or reused materials that could be used?
 - Can any verified low carbon products be used for the shock base or synthetic turf?
- The synthetic turf has a very large proportion of the emissions, firstly due to its initial impact but also the replacement frequency. An informed and well-planned maintenance and management strategy should be created by the school to make sure that the lifetime of the turf can be extended in line with other synthetic turf pitches at the school which have lasted over 10 years.
- Similarly, the pitch should be designed so that other synthetic turf products can be used at replacement intervals. The sports turf market is transitioning towards net zero and by the time turf needs replacing there may be products with very good environmental credentials which should be favoured.

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Appendix A

Element	Assumption	Source
Existing Pitch - Drainage pipes	Polypipes - 100mm diameter	Assumption
Existing Pitch - Drainage maintenance and replacement	Drainage will be maintained through re-digging drainage channels and replacing infill.	Assumption
Existing pitch - annual sand topping	Medium grain sand applied at a rate of 10 tonnes per 1000m2	Grounds Management Association, Football Pitch Maintenance: End of Season: shorturl.at/fptzV
Existing pitch - Fertiliser	Carbon emissions associated with fertilizing per m2 of pitch has been assumed based on a previous study as 0.0017 kgCO2eq/m2	Sustainability of Artificial Turf Fields - Comparative life cycle assessment of artificial and natural turf fields., Mikael Säberg, 2021.
Existing pitch - Herbicide	Due to lack of industry data herbicide has been assumed to have an equivalent impact per m2 of pitch as fertilizer.	Assumption
Existing pitch - water requirements	Assumed 6 months watering period at a rate of once per week. 350L per week	Highgate School
Existing pitch - General maintenance	General maintenance such as line marking, edge strimming etc. have been excluded due to difficulty in quantifying rates, and emissions.	Assumption
Existing pitch - alternative pitch transport	Estimates for future need for alternative pitches has been based on current data from the school. An alternative pitch is assumed to be used 36 times per year. Vehicles are assumed to be 57-seater coaches and a 16-seater minibus. Outbound and return journeys by coaches from the coach depot to school have been accounted for. The school owns the minibuses.	Highgate School
Engine efficiency for	Engines run at 50% efficiency and operate for 3 hours per run	Assumption

motors for maintenance		
Proposed design - Drainage pipes	Polypipes - 300mm diameter	Assumption
Proposed design - Brushing and cleaning	Assumed electric engine driven at 50% efficiency. 3 hours per run.	Highgate School/Assumption
Existing pitch - Pitch Usage rates	The current pitch is only used by the school and is limited to 560 hours of use per year	Highgate School
Proposed design - Pitch usage rates	The proposed pitch is anticipated to be used by the school and third parties. The school intends to have the pitch used by a larger number of pupils and during weekends for competitions for the school and local teams. The anticipated number of hours of use is 1680	Highgate School
Proposed design - Ideal management scenario assumptions	Highgate school has management and maintenance synthetic turf pitches in the past and from their experience they can maintain turf beyond the industry average rates. Similarly, the school is keen to be as environmentally friendly as they can and intent to recycled used turf at its end of life and will ensure those contracted with the removal of waste abide by this. The lifetime of the turf has been assumed to be 12.5 years. The end-of-life scenario of turf is assumed to be 100% recycled.	Highgate School/Assumption
General assumptions	Gird decarbonisation has not been accounted for.	Assumption
General assumptions	In both the existing and proposed design, it has been assumed that usage rates will remain constant across the 25-year study period.	Assumption