ARUP

Supported by
Impact on Urban Health

Construction emissions Exemplar sites

Contents

Tables 3

Introduction 4

Air quality baseline 6

Ensuring enforcement of non-road mobile machinery air quality policies 7

NRMM equipment emissions 9

Best practice guidance 12

Exemplar sites 14

Site discussions 14

Tustin Estate 17

Ledbury Estate 20

Cornwall Road 21

Construction Emissions Toolkit 22

Phase 1 22

Phase 2 22

Recognition and awards 28

Next steps and conclusions 30

Next steps 30

Conclusions 31

Endnotes 32

Contact: 34

Tables

Table 3.1 Stakeholder engagement for best practice guidance 8

Table 4.1 Early site discussions 9

Table 4.2 Additional stakeholder engagement 11

Table 5.1 Construction emissions toolkit consultation summary 19

Figures

Figure 1. Project timeline 5

Figure 2. Emissions from construction 7

Figure 3. NRMM zones 8

Figure 4. GLA NRMM construction register information 9

Figure 5. Equipment emissions 10

Figure 6. Equipment emissions 13

Figure 7. Tender question 17

Figure 8. Lessons learned 18

Figure 9. Tustin Estate emission sources 19

Figure 10. Emissions per phase 19

Figure 11. Tender question 20

Figure 12. Lessons learned 21

Figure 13. Toolkit emissions calculation 23

Figure 14. Toolkit available online 26

Figure 15. Toolkit view 26

Figure 16. Toolkit next steps 27

Introduction

Arup was commissioned by Impact on Urban Health to carry out an assessment of how construction sites could reduce emissions by developing guidance to support developers and measure the success/ impact of those activities. This report provides a summary of the work undertaken and shares lessons learned and next steps.

The project, commissioned in March 2021, was one of a series[1] of projects planned by Impact on Urban Health (IoUH) under their 10 year commitment to improve air quality. A summary of the project was provided on their website[2] which set out the following aims:

1. Establish both 'exemplar' (where budget is less of a constraint and where we can improve on what is currently considered best practice) and 'test bed' (as good as can reasonably be expected given budget constraints – more likely to involve the application of current best practice) construction developments that mitigate against exposure to harmful emissions for vulnerable residents and workers in our place (direct impact)

2. Use these partnerships and evidence of good practice to influence the wider construction sector (indirect impact)

Other work commissioned by IoUH which fed into this project included work carried out by the Centre for Low Emission Construction (CLEC) which provided an overview of the sector, identifying the opportunities for changes and how interventions could be enforced[3].

Therefore, the two projects were well placed to work together in terms of identifying and testing solutions to improve air quality at construction sites.

The Arup project evolved during the two year project period, due to lessons learned and outcomes from early engagement as part of the project. As such, the primary aims of the project as set out above were met, along with a number of additional deliverables being provided with the key item being the creation and testing of a Construction Emissions Toolkit.

Due to the evolution of the project, a summary timeline of the work is provided in Figure 1. Engagement with the industry has been on-going throughout the project duration and a number of presentations and sharing of information about the work have been provided, as added value items by the Arup team. A summary of the talks given is provided in section 6.

Whilst the project has evolved in ways which IoUH and Arup may not have envisaged at the start, the flexible approach from both sides has clearly provided a valuable evidence base and a wide range of future opportunities for the sector. Arup would like to take the opportunity to thank IoUH for the flexibility and openness which has allowed us to meet our shared objectives of shaping a better world.

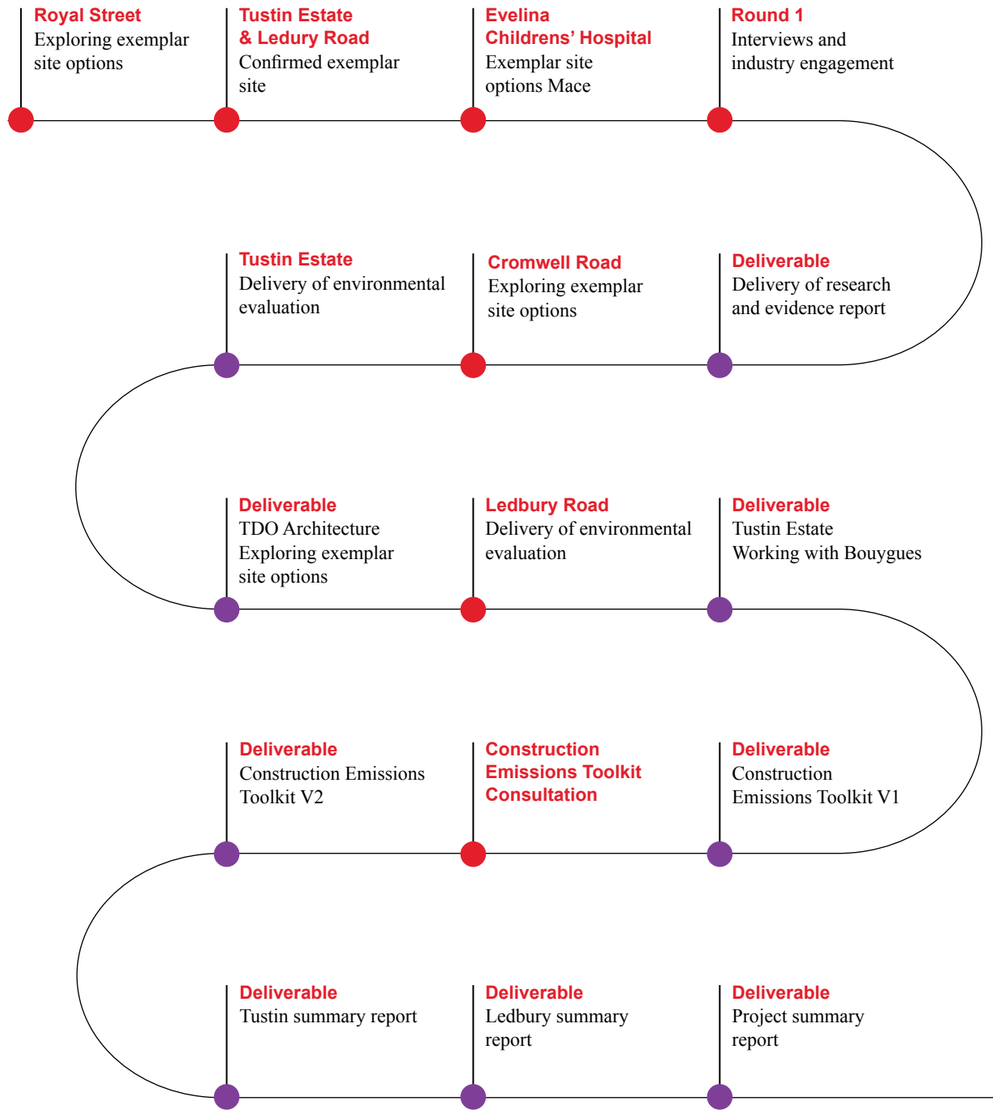


Figure 1.
Project timeline

Deliverables are marked in purple

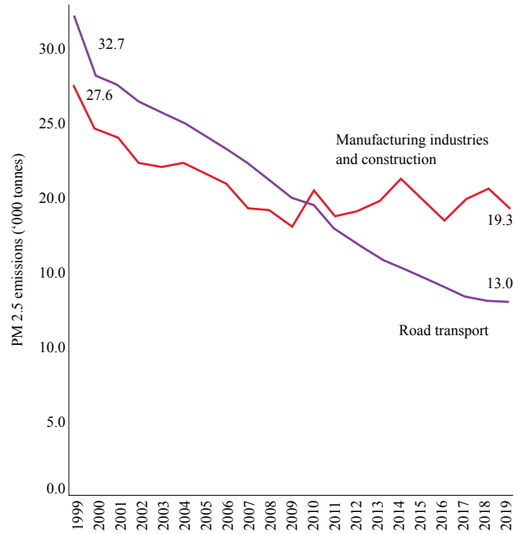
Air quality baseline

A full baseline situation for the industry was provided in the "Construction Emissions, Literature review of emission sources and best practice guidance" (research and evidence report) June 2021. A summary of the baseline situation is provided in this section for context.

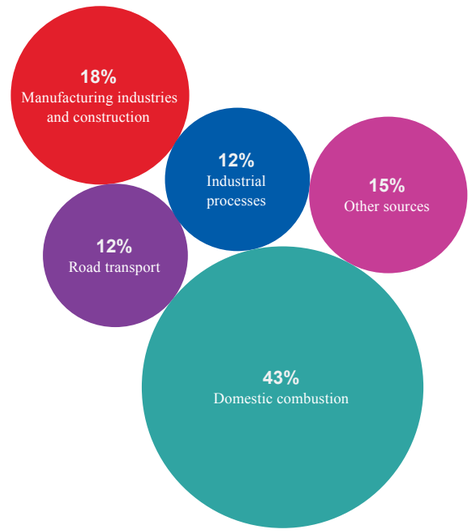
The UK National Atmospheric Emissions Inventory (NAEI) reports annual emissions estimates of air quality pollutants by source. The figures of the emission contributions of oxides of nitrogen (NO_x), particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$) (Figure 2) show a general trend of decreasing total emissions. However, the percentage contribution from manufacturing and construction can be seen to decrease from 1970 to 1990, and then generally increase from 1990 to 2018. This suggests that the rate of decrease in emissions to air from the manufacturing industry and construction is lower than other categories and sectors.

Emissions from the construction sector will increase over time, as a proportion of the UK total, as other sectors are upgrading technology as a result of policy and innovation.

Figure 2.
Emissions from construction
Source: DEFRA © 2021



PM 2.5 emissions over time in the UK by 2 major sources



PM 2.5 emissions by sources in 2019, in the UK

Ensuring enforcement of non-road mobile machinery air quality policies

As emissions fall from road transport, emissions from non-road mobile machinery (NRMMs) are set to grow as a proportion of London's total emissions. The London Environment Strategy sets out a policy for an NRMM Low Emission Zone (LEZ) (with minimum emission standards for equipment used on all major and some minor development sites). The London Policy Plan states that development proposals must show how they comply with the NRMM LEZ. To support the above in relation to construction, boroughs should:

- Include NRMM requirements within local planning guidance
- Include NRMM requirements within planning conditions developments
- Visit sites to inspect and enforce NRMM requirements
- Ensure that NRMM used by boroughs for activities such as road maintenance meets NRMM emission requirements
- Consider if licensing or contract conditions can be used to extend the NRMM LEZ to other sectors such as roadworks and events

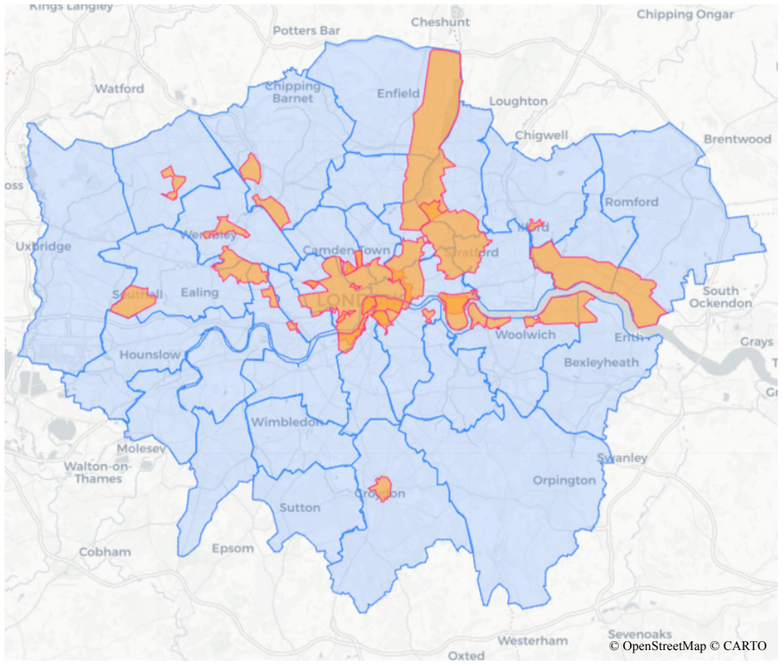


Figure 3.
NRMM Development zones map

Source: london.gov.uk

Key

- London
- The Central Activities Zone and Opportunity Areas (including Canary Wharf)

Currently, the Greater London Authority (GLA) NRMM emission standards[4] apply to all sites in Greater London, including the Central Activity Zone and Canary Wharf (CAZ/CW). This area can be seen in Figure 3.

As of January 1st, 2017, Regulation EU 2106/1628 replaced Directive 97/68/EC. This regulation details the requirement for a reduction of exhaust gaseous and particulate pollutants and identifying the implementation timetable for Stage V emission compliant engines for use in NRMM.

The key requirements of Stage V are:

Reduction of exhaust particulate mass (PM)

From 0.025 g/kWh at Stage IV to 0.015 g/kWh at Stage V

Introduction of an exhaust particulate number (PN)

Limit of 1 x 1012/ kWh for solid particles greater than 23nm ø

Extension of legislation to include

Diesel engines below 19 kW and above 560 kW

All engines above 560 kW fitted to Generators

In addition to the EU regulations, the Mayor of London has identified the following emission reduction actions and timescales:

1st January 2020

All constant-speed engines, such as those typically found in generators, are required to meet Emissions Stage V throughout London either by technology or by retrofit for both NO_x and PM reduction

1st September 2020

Construction machinery operating in the CAZ/CW and Opportunity Areas (OA) are required to meet Stage IV, and stage IIIB in the rest of Greater London

1st January 2025

Engines are required to be at Emission Stage IV as a minimum throughout London

1st January 2030

Engines are required to be at Emission Stage V as a minimum throughout London

1st January 2040

Zero emissions from construction machinery throughout London

NRMM equipment emissions

Understanding the number of equipment types, their use and relative emissions was important to help with the initial evaluation and development of best practices.

The Greater London Authority (GLA) maintain a NRMM register of construction equipment which includes data from 2015. The NRMM register, updated to February 2020, was used to provide an insight to the construction equipment used in London.

Where the NRMM LEZ applies, all major development sites are required to register machinery online. The NRMM register allows for:

– Better understanding of what NRMM equipment is currently being used and allow later assessment to demonstrate the uptake of more stringent emission standards

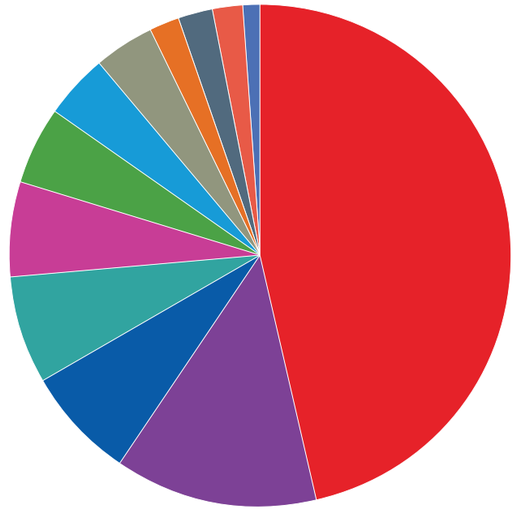
– More accurate emission inventories to be developed

– Acts as a portal for future GLA policy updates

Using the data, the equipment were grouped into main types to allow analysis. Figure 4 displays the main construction equipment, with excavators being the largest at 46% (5,252) of total equipment registered. This is by far the most abundant group of equipment, with dumpers following with 13% (1,488). The equipment making up 99% of the register was analysed further in the research and evidence report.

Although the register is not an exhaustive list of all equipment used on site (not all equipment will be registered, particularly small handheld equipment), the register provides a good indication of equipment used on London construction sites and is expected to capture the main equipment types that contribute to emissions.

Figure 4.
GLA NRMM construction register information



Key (rounded totals)

- Excavator 46%
- Dumper 13%
- Cranes/lifts/platforms 7%
- Power/lighting 7%
- Telehandler 6%
- Forklift 5%
- Piling rig 4%
- Pump 4%
- Compressor 2%
- Compactors/tampers/rammers 2%
- Concrete equipment 2%
- Loader 1%

The NRMM register includes the power rating and EU Stage for the equipment which allows an emissions rate to be calculated (g/hour). The average emissions of NO_x and PM were calculated for each equipment type on the register and the results of the range of equipment are shown.

The following data has been investigated for the equipment:

Power rating

The information provides an indication of the variability in the size/power capacity of different equipment types

EU Stage

This data provides some insight into the variability of emissions in the current market (from 2015 to 2020)

Average emission rate

This data provides a better understanding of the equipment with the greatest polluting potential, because it considers the EU Stage as well as the power capacity

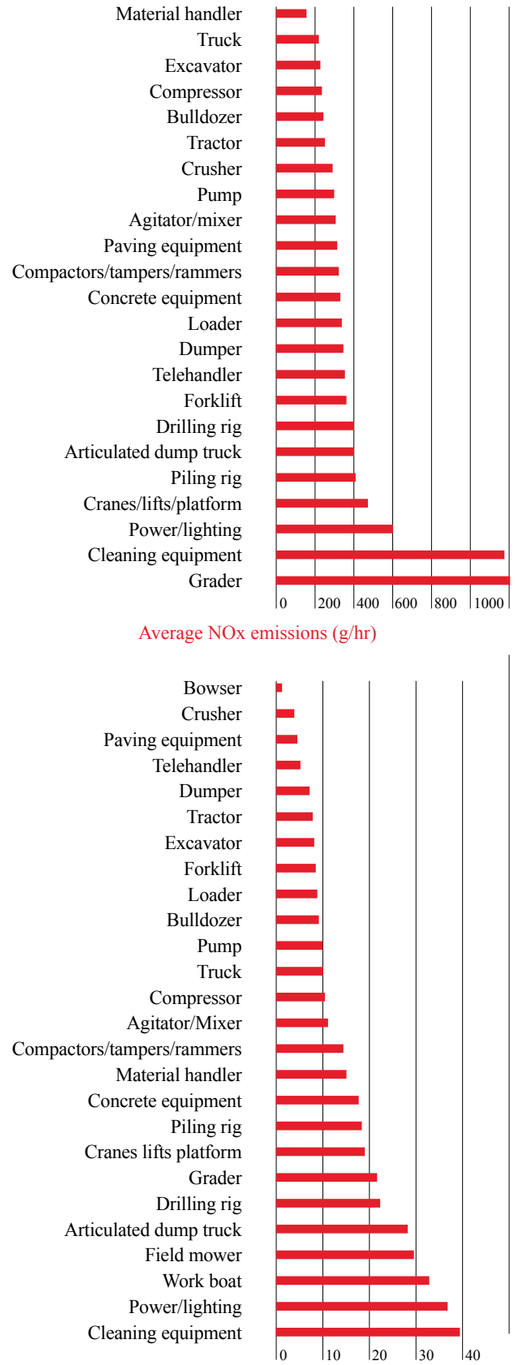
The equipment shown in Figure 5 is presented in order of proportion in the register. This data provided a valuable insight into which equipment would provide the greatest savings if fuel was changed or if electric options were used.

– Excavators were considered to have the greatest potential to NO_x and PM emissions. Although they are considered to have low emission rates, their abundance is 3.5x greater than the next most abundant equipment type (dumpers).

– Dumpers also are considered key potential contributors mainly due to their abundance, much like excavators.

– Cranes/lifts/platforms and power/lighting also feature as a potentially key contributor, but due to the combination of their relatively high emission of NO_x and PM and relative abundance.

Figure 5.
Equipment emissions



Best practice guidance

Having reviewed the industry and engaged with a range of stakeholders, Arup developed best practice to demonstrate how emission reduction can be achieved at construction sites in London.

The full best practice guidance document sets out detail for developers on how to reduce site emissions, and was provided in the evidence packs presented with site environmental evaluation packs for the exemplar sites[5].

Figure 6 shows the hierarchy for mitigation measures on construction sites and considers the likely impact to the emissions from a construction site. However, there are other key considerations for developers and contractors:

Emission impact
The emissions reductions achieved by the measure

Cost
The capital and operational costs of the measure

Market readiness
The availability of the technology selected

The decision hierarchy sets out how the most effective method for reducing emissions on a construction site is likely to be through careful pre-planning, ideally by working with contractors upfront and taking into account project programmes. With suitable planning, emissions could be significantly reduced through consideration of how to provide electricity to the site and to ensure sub-stations can provide the necessary power required. Planning can also identify where phasing is needed to allow grid connections to work for the programme and equipment choices thus, reducing the requirements for on-site emissions.

Where possible, use low or zero emissions equipment; there are a wide range of alternatives now on the market and they have been shown to be cost effective when compared to diesel equivalents.

Where it is not possible to use a low or zero emissions equipment, either due to cost, timescales or availability, then sites should aim to use equipment which meets the lowest possible emissions. Also, aim to minimise emissions through reduced use of equipment, no idling and frequent maintenance.

As noted above, a wide range of stakeholders were consulted during the development of the best practice guidance as summarised in Table 3.1.

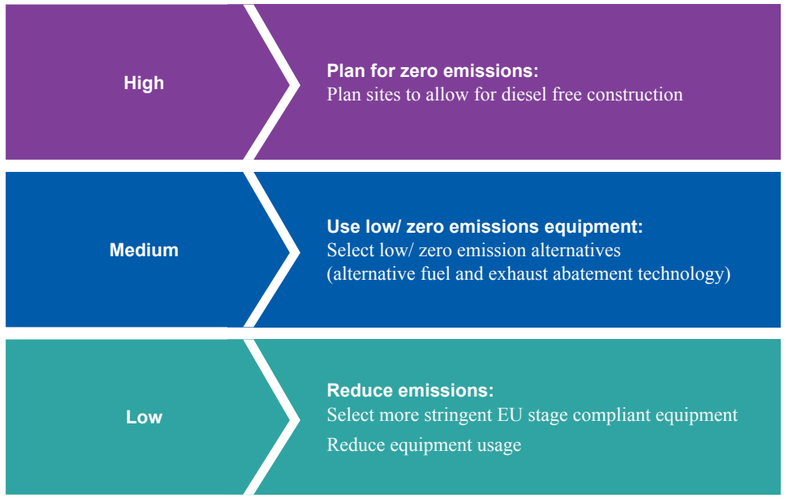


Figure 6.
Hierarchy of measures

Sector	Consultee
Developers	Balfour Beatty, Bouygues, mace, Stanhope, Kier, JCB
Consultants/ Engineers/ Designers	Centre for Low Emission Construction, hs2 engine for growth, ARUP
Local authorities and public bodies	Lambeth, Greater London Authority, Southwark Council

Table 1.
Stakeholder engagement for best practice guidance

Exemplar sites

This section sets out the results from the exemplar sites who were engaged with during the project. There were a number of early engagement pieces with sites which unfortunately did not progress through the full project. These are discussed first, along with lessons learned from those sites. For the sites which progressed further through the 'exemplar site' process, further information is given below to summarise the outcomes and lessons learned.

Site discussions

Discussions were held with the sites shown in Table 4.1 and a summary of actions and lessons learned is provided. Throughout all discussions it was very apparent that developers work within a challenging and competitive environment where cost and time are hugely important factors for their clients. They need targets and technology to help support a level playing field in order to remain competitive, however they were all very willing to engage and consider how they can support with environmental improvements.

In addition to the detailed exploration with the sites detailed in Table 4.1 additional engagement which influenced the best practice guidance, and later work produced as part of this project, was carried out with the organisations detailed in Table 4.2.

Site	Summaries
Royal Street A major development near Waterloo Station. Project managed by Stanhope on behalf of the Guys & St Thomas' Foundation (GSTT)	Outcomes – The site did not progress to being part of the exemplar site process as the early works and site investigation procurement was underway but the planning permission was not completed and the procurement and process for main works contracts was pending. – The developer Stanhope did include key performance indicators within their work to reduce construction emissions from Phase 1 by 40%. Lessons learned – The site demonstrated the need for early engagement with developers and designers. – Embedding reduction targets within environmental procurement requirements makes it easier to persuade developers. While more explanation was needed for Royal Street, it is still encouraging that the developer volunteered to adopt emission reduction targets. – Timing for the project to succeed was made clear as this project missed the timing to feed into the tender process for Phase 1 and later phases were not starting for several years. The discussions highlighted that the commitment to reduce emissions during Phase 1 were not included in the pre-commencement ground works contracts. – The discussions highlighted how long construction periods take and that it is important to develop clear emission reduction targets from the outset which need to cover the duration of the build (possibly across multiple developers and subcontractors). – It was noticed that equipment with emissions was placed near sensitive receptors without considering potential effects or mitigation. Future contractors should prioritise air quality and follow best practices. This is particularly important where a phase 1 contractor may be seen as a smaller piece of work and not have environmental procurement requirements in their tender and may therefore be less cognisant of the need to minimise emissions.
Evelina Childrens Hospital A new hospital development near Waterloo was proposed. Mace were working with the NHS to deliver a plan for the development.	Outcomes – The Site did not progress to being part of the 'exemplar site' project as the development did not proceed but the work did provide a number of very useful contacts for this project. – Mace offered valuable insights into their internal procurement processes for site equipment, as well as discussing challenges related to fuel and equipment availability and costs. – The work provided early engagement regarding the options and possible wording of environmental procurement options within future tenders. – Mace have shown great openness to the challenge of reducing construction emissions and have made broader commitments to work towards diesel-free construction in the future. Lessons learned – The strong link between carbon and air quality reduction was made very clear. The carbon agenda was clearly a way to weave air quality reductions into company targets and bring the risks of only tackling carbon but not air quality into focus. – Links between equipment availability, technology readiness and cost were laid out as part of the work which was able to influence the best practice guidance developed by Arup. – The power of major developers compared with smaller companies was clear from the work with Mace. Larger companies have a greater influence over sub-contractors and suppliers to gain access to equipment and technology earlier than perhaps smaller firms.
TDO Architects An architecture firm in Lambeth working with a wide range of medium scale developments in London.	Outcomes – Discussions provided a new perspective in terms of selling 'why it is important to reduce emissions' to others who are not developers. – The 'sell' around saving time and resources, cost savings, improving quality (in many aspects) and helping with planning approval were discussed. – A deliverable was produced, setting out the potential added value from designing to reduce emissions and from mitigating the residual emissions required for developments to be built. Lessons learned – The new perspective highlighted the need to 'sell' all aspects of emissions reduction activities and explain the benefits (financial, time, health and wellbeing).

Table 2.
Early site discussions

Site	Summaries
HS2	Outcomes – The HS2 air quality team were very open to sharing information and are at the forefront of testing new technology options for reducing construction phase emissions. – The discussions provided valuable inputs in terms of future technology options, current innovations and timescales for market rollout. – There was really positive feedback in terms of the application and aspirations of this project and a willingness to connect further as part of their teams inputs to other construction wide activities through the Construction Leadership Council[7]. Lessons learned – The point about scale and power of larger buyers was very apparent with HS2. As was the need for further support for the industry in terms of innovation funding and testing of technology options. – Challenge for quantifying emissions from construction were discussed and valuable input was provided regarding emission factors and variables for consideration.
GLA	Outcomes – The GLA was pleased to see the process of applying a reduction target through environmental procurement requirements being tested as part of the project. – There are clear benefits which could be gained from a city-wide approach or by bringing the tools being discussed into a centralised database. Lessons learned – There was less immediate interest than was first expected. The public sector has budgetary constraints and the GLA has already done much more than most to tackle construction emissions. – The lesson to be taken here is that the sector cannot rely on policy or public sector influence to lead the way or put in place new requirements.
CLEC	Outcomes – General discussions were held and the outcomes of their research aligned with the discussions held as part of this project. – The challenges around testing and compliance at a site level were discussed along with emission factors and opportunities for site testing. Lessons learned – The need to balance out requirements for developers so that they are achievable and can be provided without significant research or audit costs. – These lessons mainly fed into the Construction Emission Toolkit development discussed in Section 5.
Merton Council (NRMM team)	Outcomes – Early engagement focused on their role auditing sites on the GLA NRMM register. – Challenges around site compliance, electrical provision and design options were discussed. These fed into the best practice design guidance. – Additional discussion was held later in the project regarding the toolkit development. The council noted their own attempts to develop a toolkit, the challenges faced and how they can see value in a suitable toolkit to be used by developers. Lessons learned – The lessons learned mainly fed into the Construction Emission Toolkit development discussed in Section 5.

Tustin Estate

The Tustin Estate became the main 'exemplar site' as part of this project. The Tustin Estate is located to the north of Old Kent Road and west of Ilderton Road. It is made up of three towers and six low-rise blocks, Pilgrims Way Primary School and a number of businesses fronting onto Old Kent Road.

Tender evaluation

Arup worked with the Council's procurement team to develop a sustainability question to be included in the tender pack for the site. Question 12 in the tender pack (see Figure 7) was aimed at demonstrating the targets which were expected to be achieved, along with four sub-sections to help those responding in terms of setting out their expected activity.

A full procurement evidence pack was also provided with the tender to demonstrate how the applicant could meet the target being set. The aim was to hold the applicant's hand on this journey and create a positive outcome from the start.

Three companies bid for the work and each was evaluated, based on their reply to each of the four sections. The overall winning tender was provided by Bouygues, who also scored second highest in terms of their replies to question 12. It was clear from Bouygues reply to question 12 that they had a very clear understanding of the emission target goal and how they could achieve it without additional cost to the project.

A lesson learned for future sites was that none of the tenderers provided a strong response for part D of question 12 about continual improvements. That lesson learned provided an action for improving the evidence pack for future tenders on other projects.

It was great to see from the proposals that despite early perceived concern from the Council about the challenges of implementing a 30% emissions reduction, all companies were able to meet that commitment. A summary of the wider lessons learned from the process are provided in Figure 4.

12. Sustainability (word count 1,500) (8% weighting) Southwark have an aspiration for all Non-Road Mobile Machinery (NRMM) to meet at least Stage IV emission standards1 in line with the Greater London Authority (GLA) requirements for construction sites operating within the Central Activity Zone and Opportunity Areas.

In section 7 of the ITT, Arup have produced a report which evidences options for how the target of a 30% reduction in emissions from NRMM (in the 'Specific Requirements') can be met. Considering the Southwark aspiration for the NRMM Stage IV standard as a baseline for all sites, please detail with examples how you will as a minimum a) meet Southwark's NRMM Stage IV aspiration b) look to meet the 30% improvement in NRMM emissions c) implement a methodology to monitor performance against the target; and d) continually improve emissions performance across the phases of development.

In your examples, please include commentary on any impact on the economic viability of the scheme and how you would protect the overall financial viability.

Figure 7.
Tender question

1. All applicants clearly understood the need for environmental improvements related to NRMM.
2. None of the applicants identified a 30% reduction target as being unfeasible.
3. All applicants confirmed the emission reduction targets could be managed without additional project costs.
4. All applicants confirmed they would achieve the 30% reduction with a mixture of measures including use management and equipment choice.
5. All applicants failed to detail how they would put in place actions around recording emissions and planning for continual improvement (which led to future improvements in the evidence pack in future tender documents).
6. None of the applicants were able to detail how they would quantify the emissions reductions (leading to a clear gap being identified which has been filled with the construction emissions toolkit developed for this project).

Figure 8.
Lessons learned

Tustin results

The results from the current version of the construction emissions toolkit (Q3 2023) demonstrate that the Tustin team are well on track to meeting the targets set and have a clear picture of where the on-site emissions to air are coming from (see Figure 5).

The equipment selection for use on site has been instrumental, with 54% of the kit being used meeting the Euro V standards. This has been particularly meaningful when considering the emissions to air from excavators comprises approximately 45% of the total NOx emissions on-site (mostly Euro V standard).

Hybrid-power[6] options have been used for constant speed engines and some excavators, which has helped to control emissions from these sources.

The majority of equipment on-site was found to be compliant with the GLA NRMM requirements, with just one generator using a hybrid fuel option being non-compliant as it was an older Euro stage IV model, rather than stage V.

Tustin recorded reductions of -55% for NOx and -35% for PM, tracking better than the current 30% goal. This provides confidence in meeting the overall 30% goal by the end of their project in a few years time.

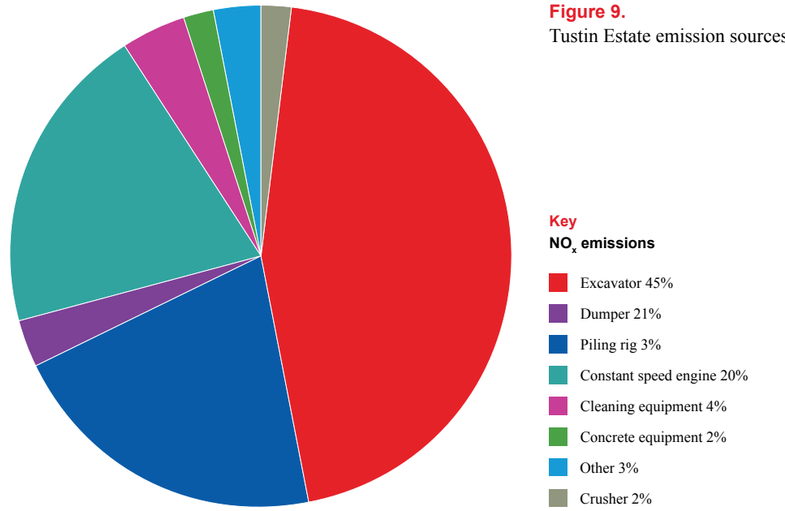
The total emissions to air over time have changed as the project passes through various phases of intensity of work on site. This has given Arup a useful view of where greater savings could be potentially achieved in future (as shown in Figure 6). It is clear that the highest emissions to air arise during the site set-up and demolitions phase. This first phase of work requires significant equipment use and therefore considerations around the value of planning for early electrical site connections are demonstrated.

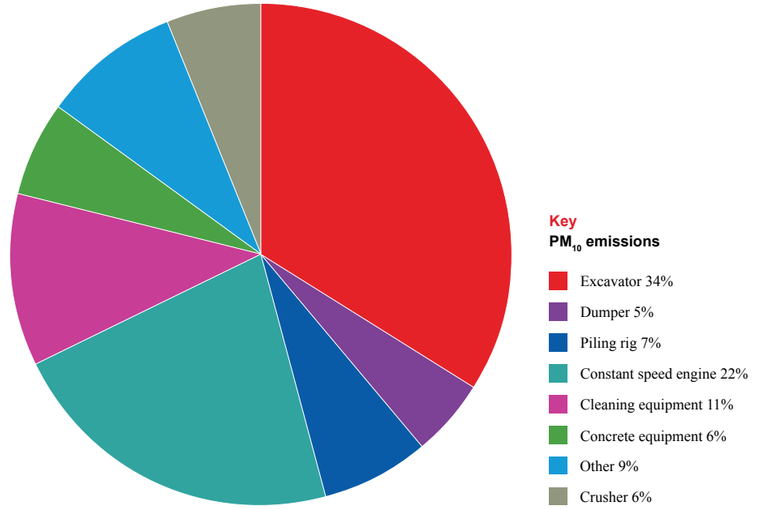
Bouygues have designated an NRMM 'champion' for the site and have proactively managed all sub-contractor procurement to include the emission reduction requirements.

They have recorded reductions of -55% for NOx and -35% for PM, tracking better than the current 30% goal. This provides confidence in meeting the overall 30% goal by the end of their project in a few years time.

The GLA NRMM audit team inspected the site in 2023 and compared the equipment list in the spreadsheet to the equipment being used on site, validating the inputs used in the spreadsheet were correct. This additional validation from the site visit adds confidence to the results being reported.

The application of the tender requirement and subsequent development of the tool and its use has clearly been a success for this site.





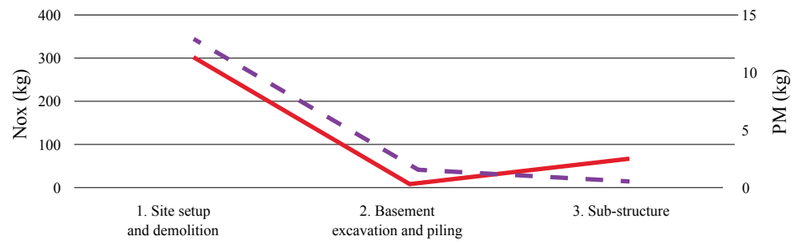


Figure 10.
Emissions per phase
Sum of Project NOx (kg)
Sum of Project PM (kg)

Ledbury Estate

The Ledbury Estate became the second ‘exemplar site’ as part of this project. The Ledbury Estate is located to the south of Old Kent Road in the London Brough of Southwark. It is made up of four 13-storey tower blocks, as well as two and four-storey maisonettes, a community hall and several shops.

Tender evaluation

Arup worked with the Council’s procurement team to develop a sustainability question to be included in the tender pack for the site. Question 12 in the tender pack (see below in Figure 11) was aimed at demonstrating the targets which were expected to be achieved, along with four sub-sections to help those responding in terms of setting out their expected activity.

A full procurement evidence pack was also provided with the tender to demonstrate how the applicant could meet the target being set. The aim was to hold the applicant’s hand on this journey and create a positive outcome from the start.

Two companies bid for the work and each was evaluated, based on their reply to each of the four sections. The overall winning tender was provided by Higgins, who scored highest in terms of their replies to question 12.

Unlike the tender responses to the Tustin Estate, the responses for Ledbury were not as strong on the environmental aspects. It provided an interesting perspective into how different developers would approach the question. It was noted that the percentage of the weighting was reduced from 8% to 5% for the response to question 12. It is not clear how much of a role that had exactly, but the quality of the submissions was lower than the Tustin tender replies. It is possible that the lower percentage weighting contributed to less effort being made to answer each question in detail.

Despite the lower quality of response the companies did both confirm they could meet the minimum emission reduction requirement set in the tender. One key aspect of the question was to confirm if the reduction could be achieved without additional cost, this was not provided. The overall demonstration that the developers understood how to achieve the reduction was a positive.

A summary of the wider lessons learned from the process are provided in Figure 12.

12. Sustainability (word count 2,000, 5% weighting)

London Borough of Southwark have an aspiration for all Non-Road Mobile Machinery (NRMM) to meet at least Stage IV emission standards1 in line with the Greater London Authority (GLA) requirements for construction sites operating within the Central Activity Zone and Opportunity Areas. In section 3 of the ITT, Arup have produced a report which evidences options for how the target of a 30% reduction in emissions from NRMM (in the ‘Specific Requirements’) can be met. Considering the Council’s aspiration for the NRMM Stage IV standard as a baseline for all sites, please detail with examples how you will as a minimum

a) meet the Council’s NRMM Stage IV aspiration

b) look to meet the 30% improvement in NRMM emissions

c) implement a methodology to monitor performance against the target; and

d) continually improve emissions performance across the phases of development. In your examples, please include commentary on any impact on the economic viability of the scheme and how you would protect the scheme’s overall financial viability.

Figure 11.
Tender question

1. All applicants demonstrated they could achieve the reduction but did not include a detailed plan for how it could be achieved.
2. Neither applicant confirmed the commitment could be achieved without additional cost, however it is not clear if that was an oversight as project costs were not reviewed as part of this project.
3. It was noted that clarification regarding what the 30% included could be improved in future wording so that it is explicit it applies to NOx and PM emissions (not carbon).
4. The applicants clearly found the tender evidence pack of value.

Figure 12.
Lessons learned

Ledbury results

The construction emissions toolkit was developed prior to Higgins’ involvement in the project. Therefore, the final version of the toolkit was presented to the Ledbury team in summer 2023. A team call was held to talk through all aspects of the tool and how it should be completed. A copy of the toolkit was provided along with the user guide of completion. A completed toolkit has yet to be provided at the time of writing. Therefore a review of the emissions has not yet been done.

It was valuable to record that the team initially struggled to identify who would be responsible for completing the form as there are inevitably various site managers, environmental managers, plant hire teams and sub-contractors to manage on a project of this scale.

This provided useful feedback for this project as it showed the importance of identifying the right team/ people to complete the toolkit. A lesson learned from the Ledbury work to date is that, even with the engagement at the tender phase, the site team may not have been involved, therefore additional signposting regarding how to complete the toolkit and how to gather that data is important.

Cornwall Road

The Cornwall Road site was lined up to be the third ‘exemplar site’ as part of this project. The site is a new residential-led mixed use development for the private rental sector (PRS) to include a proportion of blind tenure and affordable accommodation. Including 215 apartments, which is comprised of 24 protected tenancies from the original site, 155 PRS apartments, 36 Discounted Market Rent apartments set at percentage discounts to market rents equivalent to London Living Rent levels (11 units) and Local Housing Allowance levels (25 units). Also included in the development is 1,328m2 (GIA) commercial office space and a new space for The Old Vic theatre to rehearse and work. The works will be delivered over two phases and split into four blocks which are structurally independent. The first phase will deliver one block is isolation, with the second phase and remaining blocks to follow directly after.

Tender evaluation

The Cornwall Road project was stalled in 2023 and at the time of writing has not progressed to a stage where the tender including environmental procurement requirements has been sent out.

Lessons learned from the previous projects were applied to the wording of the tender evaluation question and evidence gained from earlier exemplar sites was applied. The key change was to increase the reduction target by ten percent so that a 40% reduction was required. This was agreed with the site directors at Buro Four.

The evidence pack was provided and it is hoped to be used when the project re-starts (expected in 2024).

Construction Emissions Toolkit

During the work with the Tustin Estate, Bouygues' environmental team were very proactive and engaged when starting their commission. Their Environmental Lead was regularly in contact with Arup to discuss how best to record the emissions saving and how to report to the Council. Following discussions with Bouygues, it was clear that a standardised reporting method was required and would provide value for all future sites.

Phase 1

The toolkit was developed by Arup and a full explanation of inputs is now provided with the guidance document which sits alongside the toolkit.

In summary the tool follows the approach shown in Figure 13.

Arup developed a draft Construction Emissions toolkit in March 2022. Working closely with Bouygues, the tool inputs and outputs were agreed and tested. It was hugely beneficial to be able to test the tool on a live project to give direct feedback and lessons learned.

Phase 2

Further informal discussion with stakeholders such as Merton Council and HS2 indicated there was significant value in the development of a tool for developers and the construction sector in general. There was a clear gap in the market between detailed academic research level work such as that carried out by CLEC and auditing work carried out by Merton and funded by the GLA.

In order to provide the construction sector with a tool that met their requirements, a consultation exercise was carried out with feedback being recorded and fed into the updated toolkit design. A copy of the draft tool, an outline of the project and aims and the best practice guidance developed were provided to stakeholders in advance.

A summary of the consultation is provided in Table 5.1. Several of the stakeholders provided similar feedback, to avoid repetition the feedback is not repeated in the table if it has been covered in other sections.

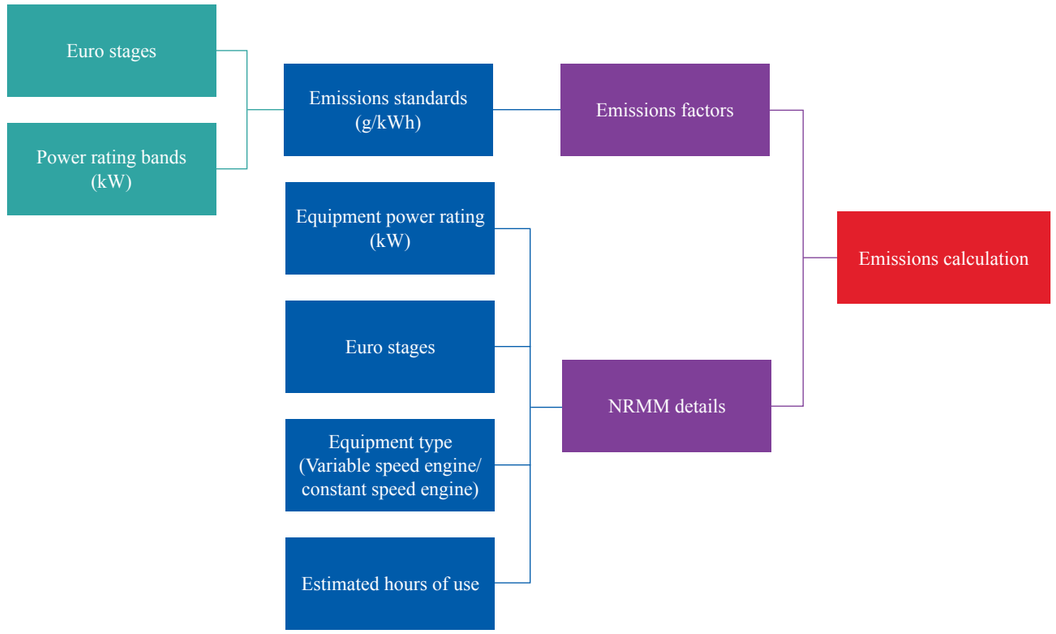


Figure 13.
Toolkit emissions calculation

Stakeholder	Feedback
Bouygues	– Adding a scenario testing option would help with testing options – Adding a carbon calculation methodology – Adding additional fuel variables, engine stages and hybrid options – Creating a check against the Greater London Authority (GLA) Non-Road Mobile Machinery (NRMM) requirements – Creating a guidebook to go with the toolkit – Updating some of the visual aspects of the toolkit
Mace	– Linking with carbon and net zero tools they have internally could be a good fit to support future emission reductions – How can the tool flag where savings can be made – Allow for multiple phases of work to be captured and summarised in the tool – Allow for larger data uploads so information can be brought in from existing NRMM registers
HS2	– Very supportive feedback and highlighted the gap in the market which the toolkit is closing. – Offered to test the toolkit on their existing sites – Provided inputs and discussion on emission factors and use of telematics – Don't over complicate the toolkit – best option is to provide the toolkit which give a reasonable level of accuracy rather than down to the last percentage point – Provided feedback on where the tool could be hosted in future. They noted the Construction Leadership Council[8] had been doing several project mainly focused on carbon but would value air quality input. They also noted organisations and government departments who would be interested such as Defra, BEIS and DESNZ
Balfour Beatty	– Interested in hand held tools and work place exposure – Noted impacts from idling are hard to capture locally – Consider monetisation tab to be added based on Defra Damage Costs – They already have detailed dashboards for carbon saving, idling savings and fuel use, clear opportunity to add AQ
Skanska	– Alternate fuel options are needed to consider the benefits of hybrid technology and fuel options – How to flag barriers such as electrical power availability – Which kit can they switch – link to costs
AQC	– See it as a valuable tool and would value a way to include the duration of specific building phases – Link to any live monitoring data – How are loads considered in the toolkit and the option to moderate load or include hybrid options
GLA	– Clearly a close link with their NRMM work – Data collected if collated could be beneficial for future policy or industry engagement – How would the data be audited – links with their NRMM work
Southwark Council	– Include a dashboard approach at the top to summarise outcomes and results – Include additional information about the site, eg name, area, grid reference and application number – Boroughs will rely on GLA for a steer in terms of wider policy
Lambeth Council	– How to communicate result to the public – Could traffic be an add-on – How is carbon reported (emissions or full life cycle) – Excel is best for now future options could include a website or dashboard component
City of London	– Identified other uses for the tool such as managing impacts from other industries or activities e.g. filming in the City of London
Merton Council (NRMM team)	– The tool solves a series of technical issues they were having – Works well with their audit process – Communicate that benefits can occur even if not moving to zero on site emissions – Add a RAG rating to the outcomes and flag if kit is non-compliant with the NRMM requirements
CEA	– Flagged that the tool would be beneficial for some large organisations such as National Highways or Transport Scotland – CEA manage the tagging system with DataTAG which helps link the equipment audits with emissions specification – Highlighted the benefits of quantifying the solutions to help drive and inspire future technology improvements
DESNZ	– Clear links with net zero and zero emission construction sites – How to aggregate and distribute outcomes
L&G	– How can the tool be managed for a portfolio or used for other emissions such as generator use
British Land	– How can they apply in advance of works to test options and use to procure clean equipment
CLEC	– Clear links with their academic work but the tool is designed to meet the current gaps in the market and availability of quantification metrics

Table 5.1
Construction emissions toolkit consultation summary

Taking the feedback into account, a version 2 of the toolkit was developed. It brought in significant new functionality, visualisation aspects and new options for testing scenarios.

The toolkit is now available for FREE on the IoUH website. The version 2 toolkit was used to calculate the emissions savings from the Tustin Estate and the graphs shown in Figure15 are taken from the updated version.

The toolkit has clearly been identified by the industry (across a wide range of stakeholders) as being valuable. The toolkit is free and available online. There are further opportunities for improvement and data capture available from the use of the toolkit, which are outlined within the next steps section (Figure 14).

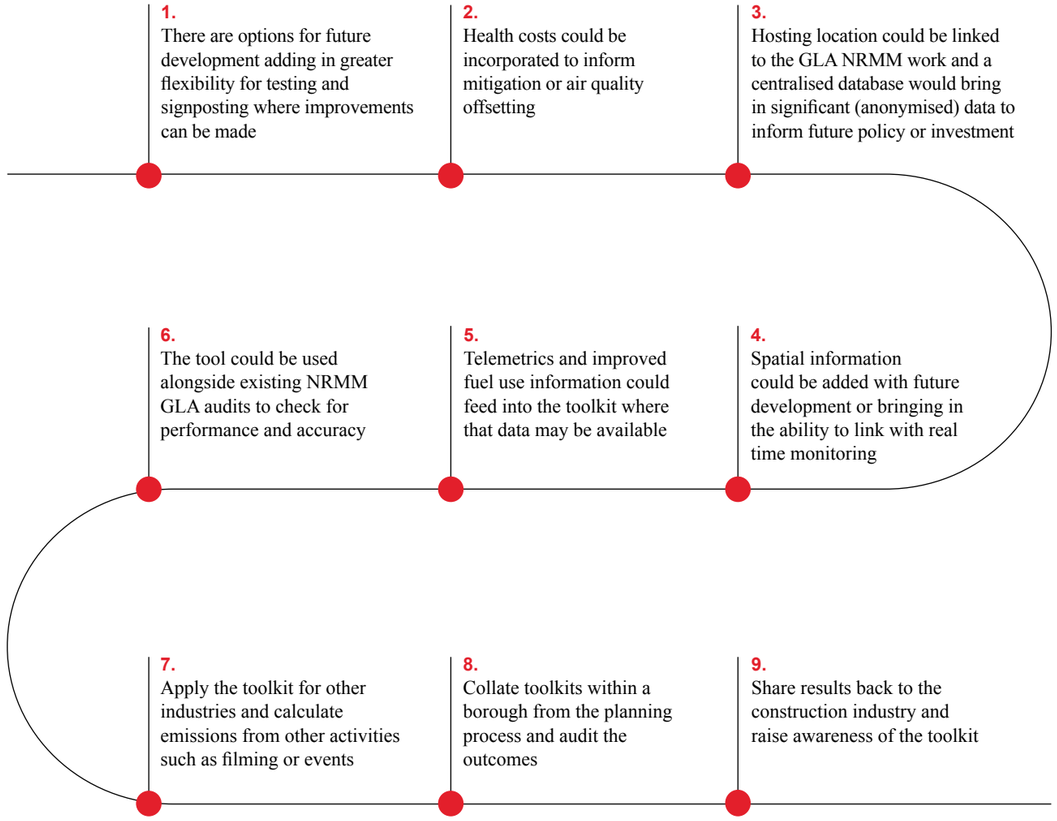


Figure 14.
Toolkit next steps

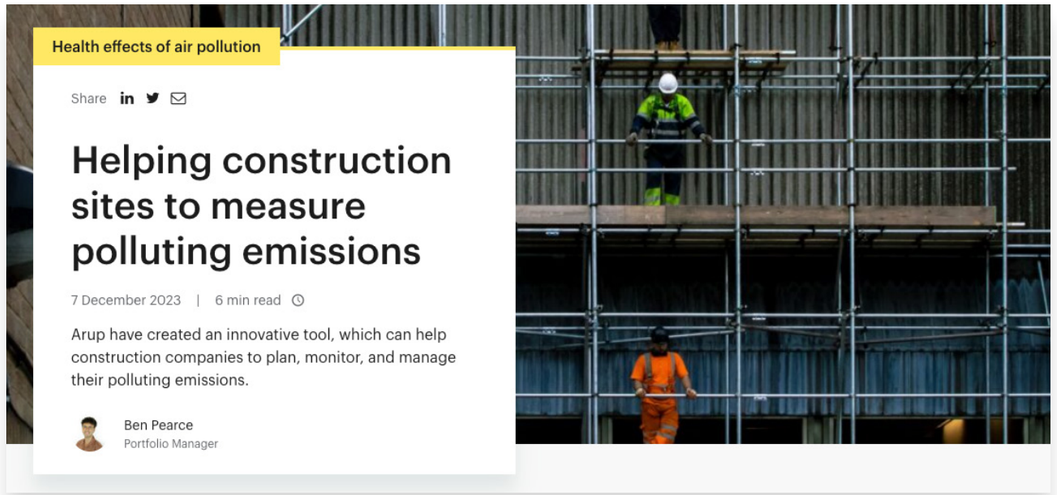
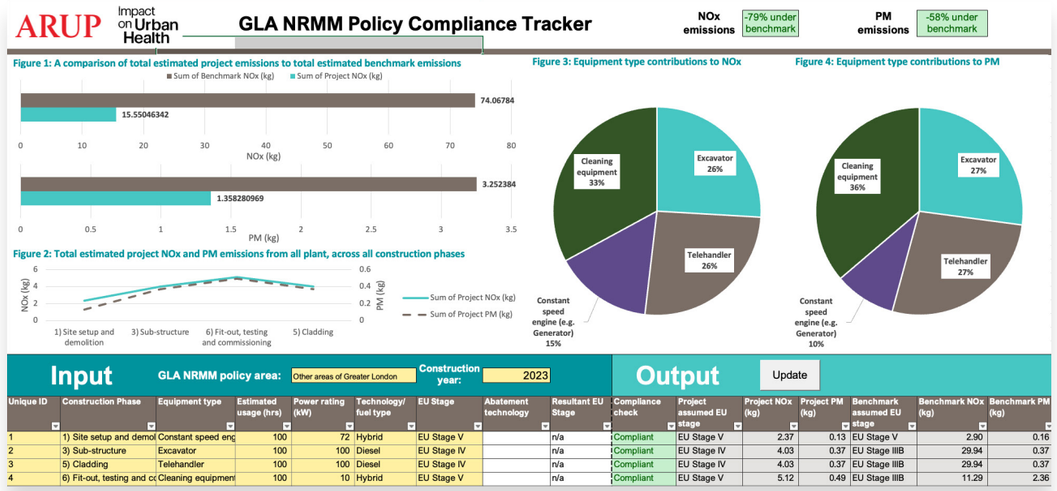


Figure 15.
Toolkit available online



Unique ID	Construction Phase	Equipment type	Estimated usage (hrs)	Power rating (kW)	Technology/ fuel type	EU Stage	Abatement technology	Resultant EU Stage	Compliance check	Project assumed EU stage	Project NOx (kg)	Project PM (kg)	Benchmark assumed EU stage	Benchmark NOx (kg)	Benchmark PM (kg)
1	1) Site setup and demol	Constant speed eng	100	72	Hybrid	EU Stage V		n/a	Compliant	EU Stage V	2.37	0.13	EU Stage V	2.90	0.16
2	3) Sub-structure	Excavator	100	100	Diesel	EU Stage IV		n/a	Compliant	EU Stage IV	4.03	0.37	EU Stage IIIB	29.94	0.37
3	5) Cladding	Telehandler	100	100	Diesel	EU Stage IV		n/a	Compliant	EU Stage IV	4.03	0.37	EU Stage IIIB	29.94	0.37
4	6) Fit-out, testing and cc	Cleaning equipment	100	10	Hybrid	EU Stage V		n/a	Compliant	EU Stage V	5.12	0.49	EU Stage IIIB	11.29	2.36

Figure 16.
Toolkit view

Recognition and awards

This project has attracted a good deal of positive feedback and attention from the industry and also wider across the air quality and net zero communities. The Tustin Estate project was highlighted as demonstrating best practice in the Chief Medical Officer's Report 2022[9] (page 161).

The Chief Medical Officer's report set out how the approach taken by the Tustin Estate project to embed the emission reduction requirements into the tender along with the follow up work to support developers and report outcomes is leading the way for the industry.

The Bouygues team are rightly proud of the efforts made to reduce emissions and the success achieved to date. They have won an internal Bouygues environmental award for the actions taken.

The Bouygues team have also presented the positive outcomes of their project on Clean Air Day. Celebrating the successes and showing how as an industry leader in this area they have been able to apply best practice and reduce emissions at the Tustin Estate.

The work carried out by the Bouygues team has been instrumental to the success of the work. The Arup team would like to formally recognise that and thank them for the input to the development of the construction emissions tool, as well as for their time when gathering results and outputs from their work.

Bouygues have provided a quote which demonstrates the value they have gained from the work at this site and how they can apply this approach in other areas.

The Arup team have presented information about the project widely as added value during the course of the project, again with excellent feedback being received. A list of the presentations and engagement added over the course of the project is summarised by the following page.

"Bouygues would like to thank the project team for their support. Developing the construction emissions tool is hugely valuable for us as a business when helping to review and reduce our project emissions. We can see real value for the construction emissions tool and the approach which has been taken to set a reduction target through the tender requirements."

Environmental Lead,
Bouygues UK

CMO annual report

The work on our project was highlighted in the CMO's annual report as an effective method for reducing emissions following best practice.

Clean Air Day 2022

1 hour talk to a worldwide audience, several questions were coming from people joining from Africa noting the issues they have with controlling emissions from generator use.

Arup Geotech Lunch and Learn

1 hour talk which highlighted the need for early engagement and benefits of environmental procurement questions for sub-contractors.

NHS CPD Session

Half an hour talk with questions to the NHS national planning team. Noted points about their interest in using the approach to control other emissions associated with their portfolio.

Arup Buildings team presentation

1 hour talk discussing the implication of use of the toolkit during planning.

Southwark Joint Health Places and Health and Housing Network

20 minute talk summarising the work carried out during the project.

City of London

1 hour presentation to the City of London air quality team about the tool and its application within their roles.

Clean Air Day 2023

Topic burst on construction activities and action to reduce emissions.

Routes to Clean Air Conference

1 hour talk at the national air quality conference. Provided industry wide awareness and sparked a great debate.

Danish Municipality of Copenhagen

20 minute talk about the work carried out and the international applicability of the toolkit.

Next steps and conclusions

There is clearly a huge range of possible routes the industry can take with the use of the toolkit and the lessons learned from the project. A number of actions and activities are covered already within the CLEC report[10].

Next steps

It is understood that that the London Boroughs of Lambeth and Southwark intend to employ construction compliance officers to help support emissions reduction from the sector within their boroughs. Therefore actions/ opportunities have been set out for a number of areas and some specifically linked to those future roles.

Policy/ influence

The project has demonstrated the value of exemplar site approach and the emission savings which are possible. The Chief Medical Officer report highlighted the benefits of this project and approach and the Defra Clean Air Strategy clearly advocates for the implementation of control via environmental procurement. Which leads to the following opportunities:

The toolkit approach is scalable and will provide the construction industry with the tools and information they need to support emissions reduction targets

- Continue working with the GLA to demonstrate benefits and influence city wide policy or more stringent targets. A first step could be to embed the toolkit into the NRMM policy/register.
- Work with local boroughs to provide best practice guidance and local policy to require environmental procurement and emission reduction targets above the existing GLA minimum
- Work with non-London cities or local authorities to implement similar targets and test options out of London.
- Councils can work with developers to ensure forward planning is considered so that best practice methods can be followed. This work can be shared with councils to demonstrate the value and show how it could become local policy.
- Work with Defra and DESNZ to support future policy and influence innovation funding. The case study to demonstrate their guidance in the clean air strategy can work but needs some additional considerations to become widely adopted and effective. Create shared best practice opportunities with Defra and DEZNZ to possibly leverage further matched funding for wider adoption or testing alongside carbon reduction plans in other cities.
- Share the example widely and internationally to influence best practice elsewhere. For example with conference presentations and adding to existing best practice guidance documents for the sector.
- Bring the project example into wider industry best practice guidance. For example as a case study within other documents such as those from the construction leadership council or GLA guidance.

Data and evidence

The data from the tool could be highly valuable if collated either at the city level or even at a local borough wide level. Creating a mandatory database approach such as the NRMM GLA register and linking the toolkit to that process will provide significant value from the data. This can be used to inform future investment and targeted policy action.

- Identify cities where a database approach could work.
- Consider if this approach should be built into the GLA NRMM website. Further discussions are needed with the GLA to review how it could be added and to demonstrate the value.
- Use the data to develop future insights to share with the industry ensuring a level playing field for developers and equipment manufactures (e.g. emission trends for different plant types).
- Update the tool based on the wide range of opportunities as shown in Figure 16.
- Test the toolkit with other industries such as filming and events.
- Work with smaller sites to understand their perspectives and challenges.

Communications

As with any project the success comes when initiatives are widely implemented. The engagement could always be added to and there are future opportunities for this work.

- Host an industry wide conference to close out the project and launch the toolkit formally.
- Review options for hosting the toolkit with GLA or Construction Leadership Council.
- Identify a series of future events to present at to maintain momentum.
- Review opportunities for winning awards from the work.
- Ensure the correct teams understand how to complete the toolkit and explain how it is valuable to their role.
- Link the work with wider action to reduce carbon. Ensure the dual aspects are clear.
- Create a template report which can be created from the toolkit which will give a summary of the outcomes per project. Thus standardising outcomes and maintaining best practice and transparency.

Compliance officer actions

A compliance officer will have the time and resources to implement a series of the above actions. In particular they could take on the following tasks:

- Check equipment list matches site equipment being used.
- Check the hours of use are reasonable based on experience and information from other construction sites.
- Develop a wider database of information for use, starting with the Tustin Estate site.
- Model the emissions savings to demonstrate the benefit in terms of potential pollutant concentrations.
- Review further opportunities for reductions and other environmental benefits around noise and carbon savings.
- Interview the Tustin Estate team to gather further feedback regarding challenges and opportunities.
- Develop a case study for publishing updates on the council or Impact on Urban Health website once the project is completed.

Conclusions

The project has clearly demonstrated the benefits of testing emission reduction actions at exemplar sites. A range of lessons learned during the course of the project have been able influence the design of best practice guidance. The toolkit has provided the industry with a method of quantifying their savings and supports them by showing how equipment options and management will help reduce on-site emissions.

Ultimately the project is about health improvements from reductions of air pollutants. This project has demonstrated the reductions are achievable and will lead to improvement in health outcomes for populations near to construction sites.

There is clearly more work to be done in this area and this project is only a start but the lessons learned and number of opportunities are clear.

Arup would like to thank Impact on Urban Health for the flexibility and engagement during the project without which this would not have been possible.

Endnotes

1 https://urbanhealth.org.uk/partnerships/current-partnerships/partnering-to-reduce-air-pollution-from-the-construction-sector

2 https://urbanhealth.org.uk/partnerships/current-partnerships/exemplar-air-quality-construction-sites

3 https://urbanhealth.org.uk/wp-content/uploads/2022/09/IOUH-CLEC-Report_v08_FINAL.pdf

4 https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/nrmm

5 Evidence packs were provided to Tustin Estate, Ledbury Road and Cornwall Road.

6 Diesel-electric hybrids.

7 https://www.constructionleadershipcouncil.co.uk/

8 https://www.constructionleadershipcouncil.co.uk/

9 Chief Medical Officer's Annual Report 2022 Air Pollution

10 https://urbanhealth.org.uk/partnerships/current-partnerships/partnering-to-reduce-air-pollution-from-the-construction-sector

ARUP

Contact:
James Bellinger
Associate Director | Climate and Sustainability Services
CEnv, CSci

t: +44 207 755 4185
e: james.bellinger@arup.com

8 Fitzroy Street, London,
W1T 4BJ, United Kingdom

arup.com