Net zero highways:
our zero carbon roadmap for concrete, steel and asphalt

A628 at Woodhead Reservoir in the Peak District

Foreword

In 2021 we set out our plan for Net Zero Highways which includes a commitment to net zero emissions from construction and maintenance activity by 2040. Achieving this target will require significant reductions in emissions relating to the materials we use, how we use them, how they are manufactured, how we transport them, how long they last and how we reuse and recycle them.

The material roadmaps for concrete, steel and asphalt show for the first time how the sector can significantly decarbonise based on our best knowledge and show how they can contribute to achieving net zero in construction and maintenance by 2040.

They have been developed by National Highways in conjunction with the supply chain and trade bodies so that there is a clear consensus for the way forward. They will be reviewed and evolved on a regular basis so that they always consider state of the art thinking. They have been developed for the sector with the sector.

Malcolm Dare
Executive Director Commercial & Procurement

Mike Wilson
Chief Highways Engineer

Inspecting the Orwell Bridge in Suffolk

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Decarbonising concrete, steel and asphalt is key to our net zero plan

We published our net zero highways plan in 2021 where we committed to realising net zero emissions from our construction and maintenance activities by 2040. Decarbonising our most carbon intensive materials is going to be vital to us delivering on this commitment.

What do we mean by Net Zero?

Net zero means we must reduce our maintenance and construction emissions by at least 90% compared to our 2020 baseline by 2040. The remaining 10% or less can be neutralised using permanent removal offsets to reach net zero, but only once we have achieved our reduction targets.

These ambitions require us to go beyond decarbonising the materials and will drive us to change how we operate across our business.

Material decarbonisation, building less, efficiently using materials, getting things right first time, making our assets last longer and driving change through whole life carbon decision-making are just some of the things we will do to reach net zero.

The significance of concrete, steel and asphalt

Our biggest source of carbon emissions in construction and maintenance is the production of materials (concrete, steel and asphalt), their transport, and the construction activities associated with their use.

Realising our net zero commitments means we will need to significantly reduce these emissions and work with our supply chain to achieve this.

Our role is to drive the change we need

A large part of our business is procuring concrete, steel and asphalt materials. This strengthens our position and enables us to influence change by working with the industry to realise our ambitions.

The roadmaps have been developed with industry, which will benefit us in working collaboratively to achieve our ambitious targets.

We are expecting our supply chain to take demonstrable action to decarbonise the manufacture of concrete, steel and asphalt. As this ambition will shape how we operate into the future this will become a necessity for working with us as we move forward.

Why we need this roadmap

These roadmaps establish the ambitious decarbonisation activities we see as being required to deliver our net zero targets, and the areas where we need to work with the industry to realise them.

The way we work will be guided by these roadmaps and our Net Zero Plan, helping to shape how we procure and deliver our schemes and how we maintain and manage concrete, steel and asphalt-based assets.

These roadmaps are the starting point and we will be updating them regularly as technology develops and data improves in the years ahead.

Recycling waste concrete to produce recycled concrete aggregate

About the roadmaps

Our carbon emissions are mostly generated by the production of concrete, steel and asphalt and their associated transport and construction activities.

These roadmaps describe how we can reduce emissions through:

- Decarbonising the raw materials
- Decarbonising the manufacture of the materials
- Decarbonising transport and construction emissions

The process aligns with the A1 to A5 modules defined by EN15804: Sustainability of Construction Works.

BS EN 15804 modules

- **A1.** Raw material extraction and processing
- **A2.** Transport to manufacturer
- **A3.** Manufacturing

Product stage

- **A4.** Transport to site
- **A5.** Installation

Construction process stage

We have engaged with the industry to understand what actions have been publicly committed to, or are technically feasible to, decarbonise the materials.

We have looked at the impact of implementing carbon efficiencies into the asset design, such as using alternative materials and optimising material use.

Although we need to achieve a minimum 90% reduction in our overall construction and maintenance emissions by 2040, this is not going to be delivered through a 90% reduction in emissions from material manufacturing.

There is also a need to reduce the quantities of materials we are using through building less, getting it right first time and extending the life of our existing assets. However, the roadmaps do not forecast changes in material quantity and type at this stage.

Next Steps

- Establish a Materials Decarbonisation Plan that defines the process for delivering the activities and actions set out in these roadmaps.
- Additional modelling to quantify the impacts of material reduction, re-use and recycling.
- Additional modelling to evaluate whole life, focusing on asset management and maintenance.
- Further research into emerging technologies to understand their potential impact and applicability for use on the strategic road network.
- Generate improved data on material usage that can be used to re-baseline these roadmaps in future.

Quarrying rock to produce aggregates at Cliffe Hill Quarry

Net zero roadmap for **concrete**

Concrete is widely used in our maintenance, ancillary structures, bridges and foundations, and is one of our most commonly used materials. Cement and concrete is our largest source of carbon emissions compared to asphalt and steel.

We use different concrete types and strength grades to meet different performance needs; mixes for ancillary structures and maintenance activities differ from those grades of concrete used for structural applications.

On average every tonne of concrete installed emits 88 kg CO_2e. Analysis of our usage estimates that we produced 217,200 tCO_2e in 2020.

The decarbonisation trajectory for concrete

Modelling the activities in this roadmap shows that a 48% reduction in the carbon intensity of concrete against our 2020 baseline is achievable by 2040. Decarbonising actions like building less and extending concrete life will also reduce overall emissions. These will be captured in future updates to this roadmap.

Reducing emissions from concrete production between now and 2030

Before 2030, the priority is reducing the negative impact of lower availability of ground granulated blast-furnace slag (GGBS) due to changes in the steel industry. Limestone cements and ternary blends will help to reduce the use of GGBS, and at the same time not increase our total emissions.

Specification of lower carbon concrete mixes in our contracts will help to drive the changes we are expecting. Our Project Control Framework (PCF) and 3D Passport scheme delivery processes will also require carbon reporting at every delivery stage.

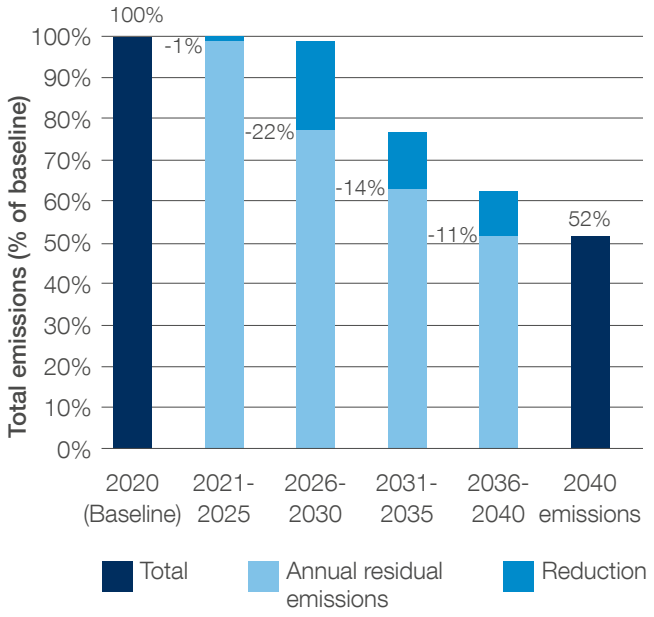
Sourcing concrete from suppliers that are using state of the art mix design technologies will help to reduce the cement content of concrete mixes we use. Innovative technologies such as pile void formers will reduce the concrete usage and will reduce the thickness of blinding. We will partly replace the current concrete mixes we use in our activities (i.e. “ST” to “GEN” mixes) and adopt 56 day strength compliance where appropriate for mixes with high volume cement replacement. It is estimated that having 56 day strength compliance will help to reduce cement content by up to 5% in these mixes.

Emerging technologies driving further reductions from 2030 - 2040

Emissions associated with cement clinker production is the biggest contributor to our concrete residual emissions in 2040.

After 2030 it is expected that cement plants will use decarbonised raw materials, improve thermal efficiency, and install carbon capture and storage units. This will reduce the embodied carbon of cement clinker. In addition, we will still continue our efforts to reduce the cement content in our concrete mixes.

The decarbonisation of the transportation sector and the construction plant used on our sites will gain pace, and alternative fuels (e.g. hydrogen) are expected to drive down transport and construction emissions.



Current concrete decarbonisation trajectory

Trialling rapid early strength concrete in Norfolk

WE ARE GOING FURTHER THAN DECARBONISING CONCRETE MATERIALS

Realising net zero means going beyond material decarbonisation and actively integrating net zero thinking across all of the complementary activities and decision-making processes that take place in the organisation. Some of the most important of these are summarised below:

Refining our asset management strategy

We will adopt management strategies that improve the service life of our assets. This will extend the service life of our concrete elements and reduce the requirement for new construction.

Driving best practice in design and construction

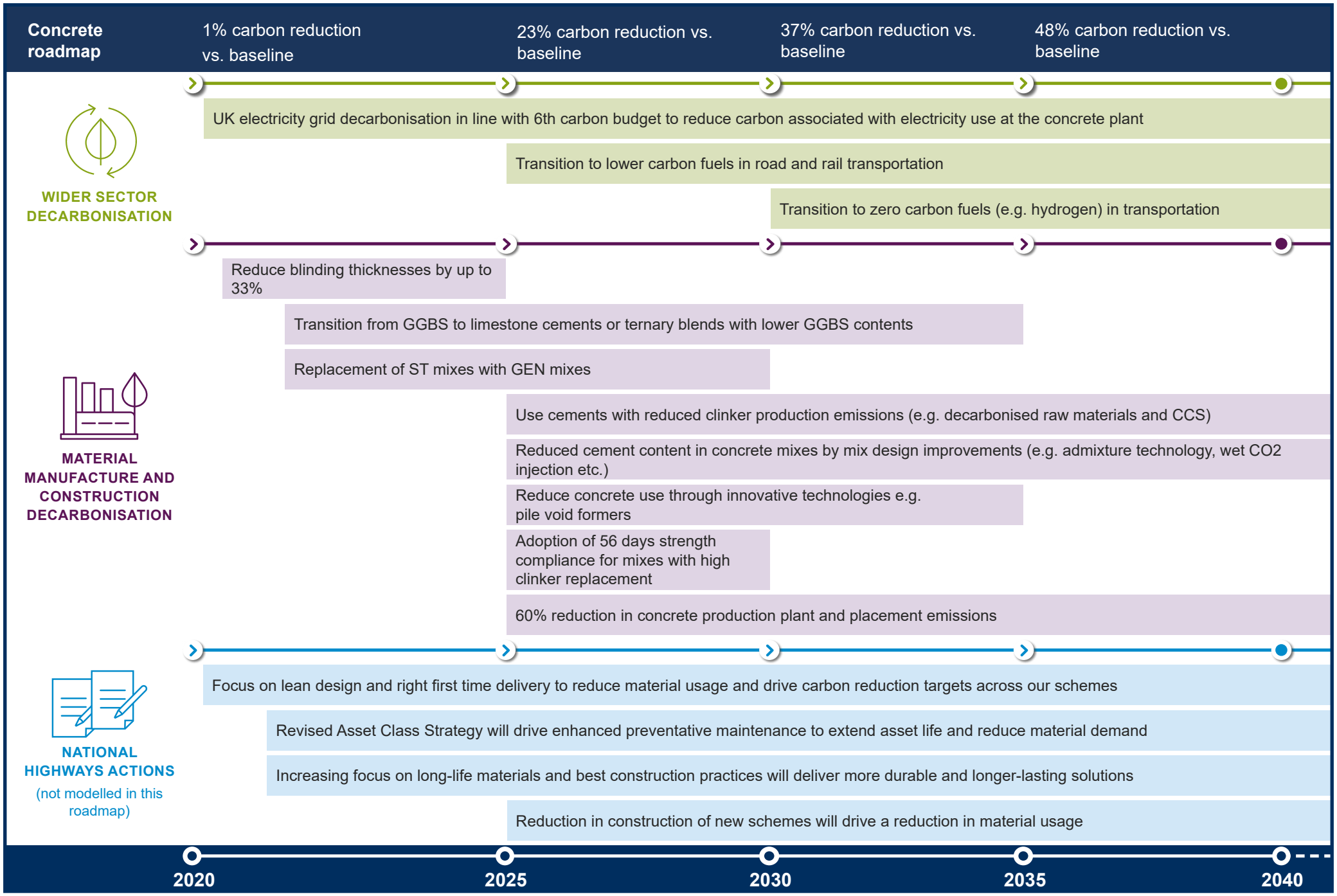
By adopting best design and construction practices, we will reduce the requirement of concrete and the capital carbon associated with it. Designs that reduce concrete use, improve the service life and facilitate the re-use or recycling of the components with be promoted. We will also focus on ‘right first time delivery’.

Improved data collection and analysis

Improved reporting of our concrete usage, emissions and condition of our concrete assets will enable us to more accurately model reductions in concrete usage, plan maintenance and re-use, and consider whole life carbon.

Building less new road infrastructure

‘Building less’ is a component of our Net Zero Plan, and this will reduce our demand for cement and concrete, further driving down our carbon emissions associated with materials.


Concrete roadmap
1% carbon reduction vs. baseline
23% carbon reduction vs. baseline
37% carbon reduction vs. baseline
48% carbon reduction vs. baseline
WIDER SECTOR DECARBONISATION
UK electricity grid decarbonisation in line with 6th carbon budget to reduce carbon associated with electricity use at the concrete plant
Transition to lower carbon fuels in road and rail transportation
Transition to zero carbon fuels (e.g. hydrogen) in transportation
MATERIAL MANUFACTURE AND CONSTRUCTION DECARBONISATION
Reduce blinding thicknesses by up to 33%
Transition from GGBS to limestone cements or ternary blends with lower GGBS contents
Replacement of ST mixes with GEN mixes
Use cements with reduced clinker production emissions (e.g. decarbonised raw materials and CCS)
Reduced cement content in concrete mixes by mix design improvements (e.g. admixture technology, wet CO2 injection etc.)
Reduce concrete use through innovative technologies e.g. pile void formers
Adoption of 56 days strength compliance for mixes with high clinker replacement
60% reduction in concrete production plant and placement emissions
NATIONAL HIGHWAYS ACTIONS
(not modelled in this roadmap)
Focus on lean design and right first time delivery to reduce material usage and drive carbon reduction targets across our schemes
Revised Asset Class Strategy will drive enhanced preventative maintenance to extend asset life and reduce material demand
Increasing focus on long-life materials and best construction practices will deliver more durable and longer-lasting solutions
Reduction in construction of new schemes will drive a reduction in material usage
2020
2025
2030
2035
2040

Net zero roadmap for **steel**

Steel is widely used across the strategic road network and is our highest source of carbon emissions per tonne of material used.

We use different steel types to meet different performance needs. These include steel plates, sections (such as steel beams and columns), and rebar (steel bars used in reinforced concrete). These types of steel are used to construct highway assets like gantries, safety barriers and bridges.

On average every tonne of steel used emits 2,220 $kgCO_2e$, and analysis of our usage estimates that we produced 78,500 tCO_2e in 2020.

The decarbonisation trajectory for steel

Modelling the activities in this roadmap shows that a 70% reduction in the carbon intensity of steel against our 2020 baseline is achievable by 2040. Decarbonising actions like building fewer steel structures and extending steel life will also reduce overall emissions and will be captured in future updates to this roadmap.

Reducing emissions from steel production between now and 2030

Before 2030 the priority is maximising the impact of emerging and available technology to reduce emissions, primarily from steel production (i.e. module A1).

The optimisation of existing manufacturing routes to reduce waste and speed up production will be the first step manufacturers will implement to mitigate carbon emissions.

We will be working with our designers to reduce the amount of steel we use, where possible. This will include optimising design and challenging standards to reduce unnecessary over-specification, where it is safe to do so.

Transitions to lower carbon fuels are already underway across our supply chain and this will further support our reduction targets. This includes decarbonisation of construction plant by 2030.

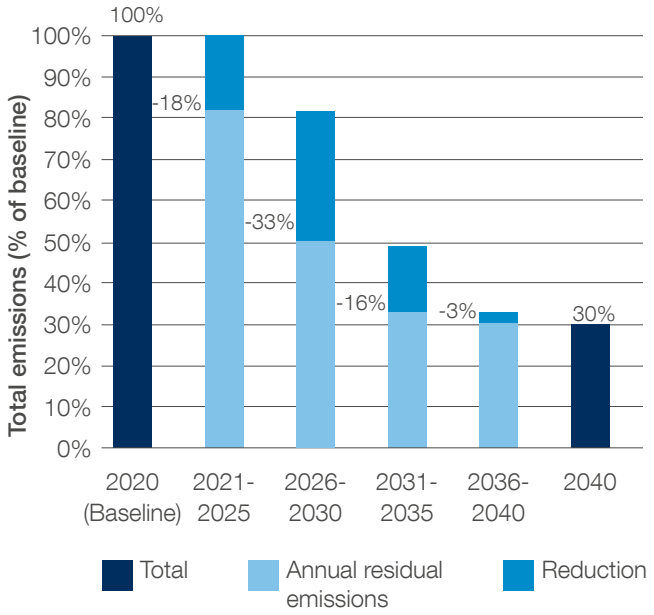
Emerging technologies driving further reductions from 2030 - 2040

Steel production can lead to waste materials and can be the cause of unnecessary carbon emissions. We anticipate manufacturers to be looking at process and material efficiency to reduce these emissions.

Research into emerging technologies such as hydrogen fuel development, hybrid solutions with electric arc furnaces (EAF) and direct reduced iron (DRI), and carbon capture and storage will help manufacturers reduce their carbon emissions at the necessary rate.

Decarbonisation of the UK's electricity grid will help to further reduce carbon emissions in manufacturing plants.

Decarbonisation of the transportation sector will gain pace and alternative fuels (e.g. hydrogen) are expected to drive down transport emissions.



Current steel decarbonisation trajectory


British Steel, Scunthorpe

WE ARE GOING FURTHER THAN DECARBONISING STEEL MATERIALS

Realising net zero means going beyond material decarbonisation and actively integrating net zero thinking across all of the complementary activities and decision-making processes that take place in the organisation. Some of the most important of these are summarised below:

Considering whole life carbon of our steel assets

This roadmap has already modelled some of the ways to reduce the amount of steel we use. Reducing this even further will be necessary to reach net zero. Benefits will be realised from increasing the resilience of our structures, improving maintenance practices and re-purposing elements at the end of their service lives. This will reduce the frequency we need to replace structures or other steel assets and reduce whole life carbon emissions.

We will be undertaking more research to assess the benefits of improved adaptability and resilience allowing less material in future, compared to the benefits of using less material now.

Driving change through procurement

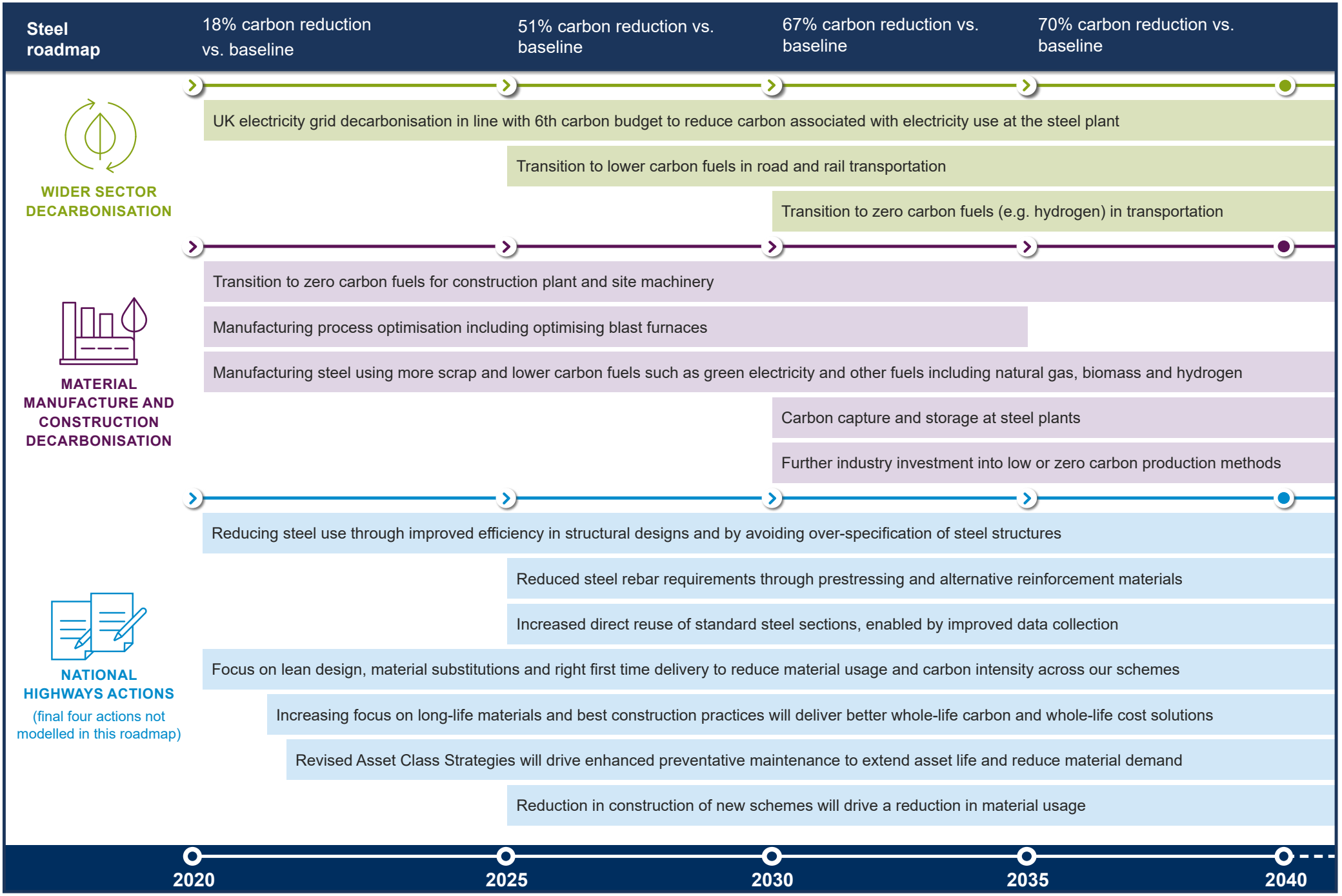
National Highways' main lever for reducing steel emissions is through strong procurement commitments. We are updating our procurement processes to drive the use of lower carbon materials on our network and will look at industry-wide coalitions to create surety in the market for the need for investment in low emissions steel manufacturing.

Improved data collection and analysis

Improved reporting of steel usage, emissions and condition of steel assets will be required to more accurately model potential reductions in steel usage, plan maintenance and re-use, and consider whole life carbon.

Building less new road infrastructure

'Building less' is a component of our Net Zero Plan, and this will reduce our demand for steel, further driving down our carbon emissions associated with materials.


Steel roadmap
18% carbon reduction vs. baseline
51% carbon reduction vs. baseline
67% carbon reduction vs. baseline
70% carbon reduction vs. baseline
WIDER SECTOR DECARBONISATION
UK electricity grid decarbonisation in line with 6th carbon budget to reduce carbon associated with electricity use at the steel plant
Transition to lower carbon fuels in road and rail transportation
Transition to zero carbon fuels (e.g. hydrogen) in transportation
MATERIAL MANUFACTURE AND CONSTRUCTION DECARBONISATION
Transition to zero carbon fuels for construction plant and site machinery
Manufacturing process optimisation including optimising blast furnaces
Manufacturing steel using more scrap and lower carbon fuels such as green electricity and other fuels including natural gas, biomass and hydrogen
Carbon capture and storage at steel plants
Further industry investment into low or zero carbon production methods
NATIONAL HIGHWAYS ACTIONS
(final four actions not modelled in this roadmap)
Reducing steel use through improved efficiency in structural designs and by avoiding over-specification of steel structures
Reduced steel rebar requirements through prestressing and alternative reinforcement materials
Increased direct reuse of standard steel sections, enabled by improved data collection
Focus on lean design, material substitutions and right first time delivery to reduce material usage and carbon intensity across our schemes
Increasing focus on long-life materials and best construction practices will deliver better whole-life carbon and whole-life cost solutions
Revised Asset Class Strategies will drive enhanced preventative maintenance to extend asset life and reduce material demand
Reduction in construction of new schemes will drive a reduction in material usage
2020
2025
2030
2035
2040

Net zero roadmap for **asphalt**

Over 96% of the strategic road network is surfaced with asphalt, making it one of our most widely used materials and one of our largest sources of carbon emissions.

We use different types of asphalt to meet different performance needs, including thin surface course systems (TSCS) for our surface courses and asphalt concrete (AC) for our lower asphalt layers. We also use a small amount of hot rolled asphalt for re-surfacing bridge decks and in other limited applications.

Every tonne of asphalt that we lay emits an average of 70 kg CO_2e and analysis of our usage estimates that we produced 77,300 tCO_2e in 2020.

The decarbonisation trajectory for asphalt

Modelling the activities in this roadmap shows that a 78% reduction in the carbon intensity of asphalt against our 2020 baseline is achievable by 2040. Decarbonising actions like building less and extending asphalt life will also reduce overall emissions and will be captured in future updates to this roadmap

Reducing emissions from asphalt production between now and 2030

Before 2030 our focus is on maximising the impact of emerging and available technology to reduce emissions from asphalt production (i.e. module A3).

Warm mix asphalt is already becoming the default option and by 2030 it will account for >80% of the asphalt we use. The asphalt we extract from our maintenance activities will be recycled into new asphalt mixes in increasing quantities and we will work with our supply chain partners to realise this on our schemes.

Transitions to lower carbon fuels are already underway across our supply chain and they will further support the reduction targets we must achieve by 2030.

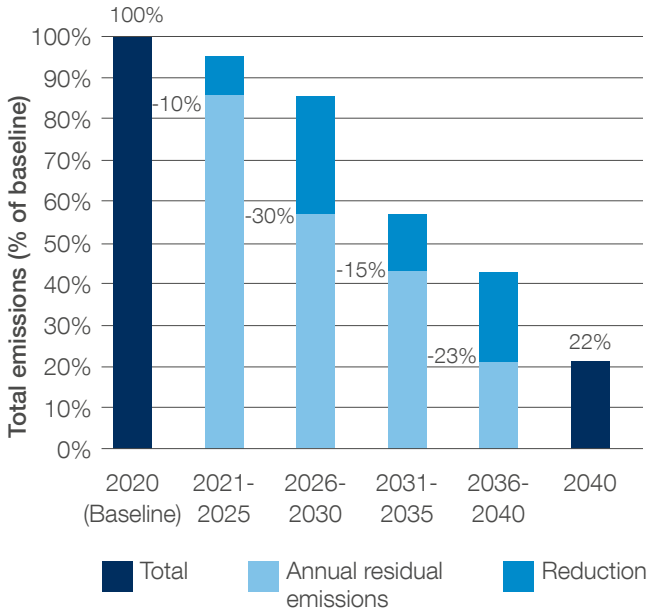
Increasing emphasis will be placed on reducing the carbon intensity of asphalt in the procurement of materials on all of our contracts. This process has started and aligns with our 2025 target for every project we commission to have an ambitious and transparent carbon reduction target applied to it.

Emerging technologies driving further reductions from 2030 - 2040

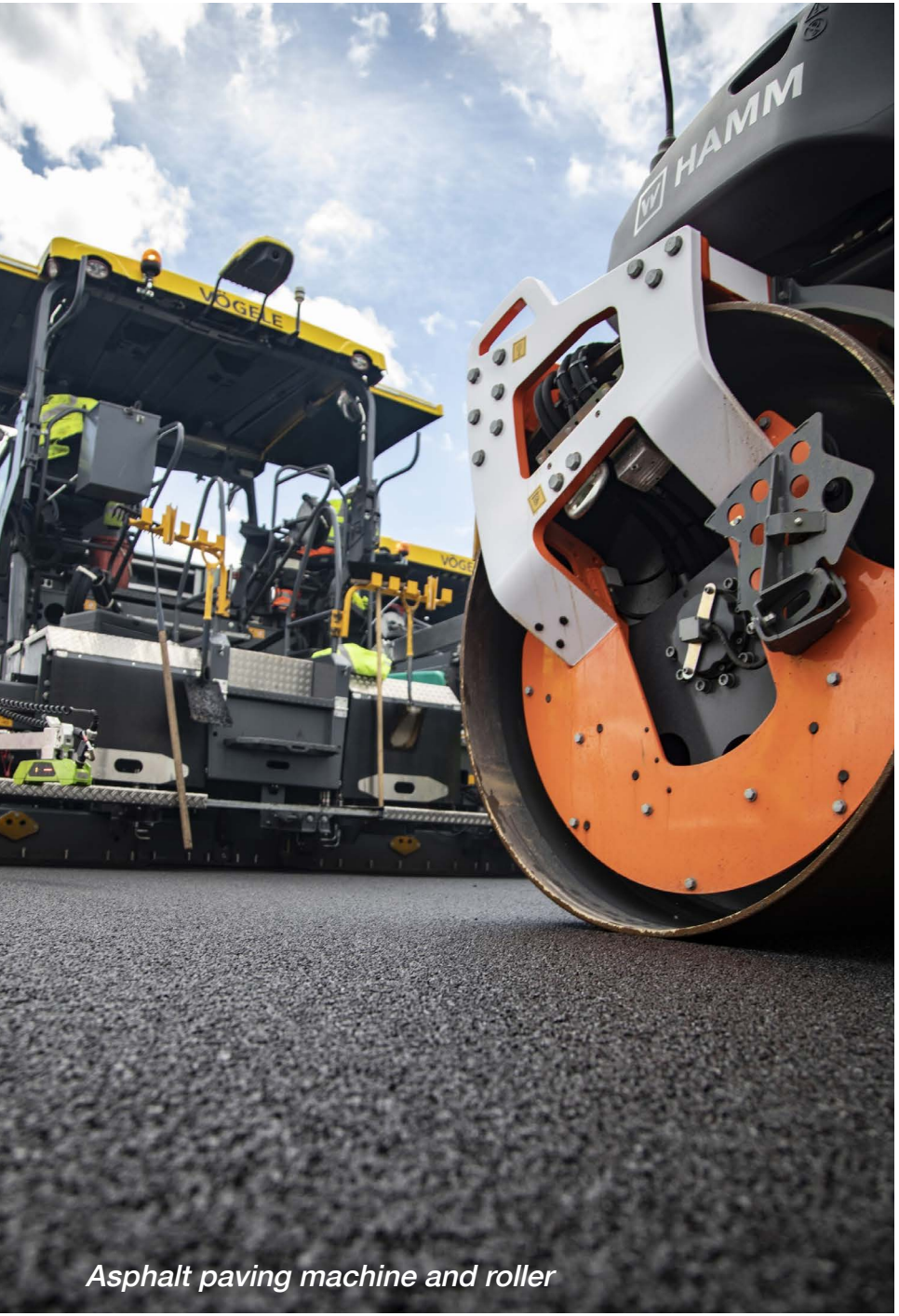
Emissions from bitumen production are the biggest contributor to the residual carbon in 2040. This is because crude oil extraction and global transport are anticipated to decarbonise slowly given the geographical and geopolitical influences.

Bio-component binders will mitigate some of the emissions associated with bitumen production and some products are available now. These will become increasingly prevalent and work has started to enable their use on the network.

Decarbonisation of the transportation sector and construction plant will gain pace as alternative fuels (e.g. hydrogen) drive down transport and construction emissions further. They are also expected to reduce heating and drying emissions at the asphalt plant generating additional carbon reductions for asphalt production.



Current asphalt decarbonisation trajectory



Asphalt paving machine and roller

WE ARE GOING FURTHER THAN DECARBONISING THE ASPHALT MATERIALS

Realising net zero means going beyond material decarbonisation and actively integrating net zero thinking across all of the complementary activities and decision-making processes that take place in the organisation. Some of the most important of these are summarised below:

Embedding whole life carbon reduction into pavement asset management

The Asset Class Strategy for Pavements defines the approach for maintaining pavement assets. The new strategy has been developed and it defines a new approach to extending asset life. A combination of preventative maintenance and using more durable, longer-life materials is an important enabler in realising a reduction in asphalt use. It also reduces the disruption to customers associated with resurfacing works.

More durable asphalt materials will deliver longer service life

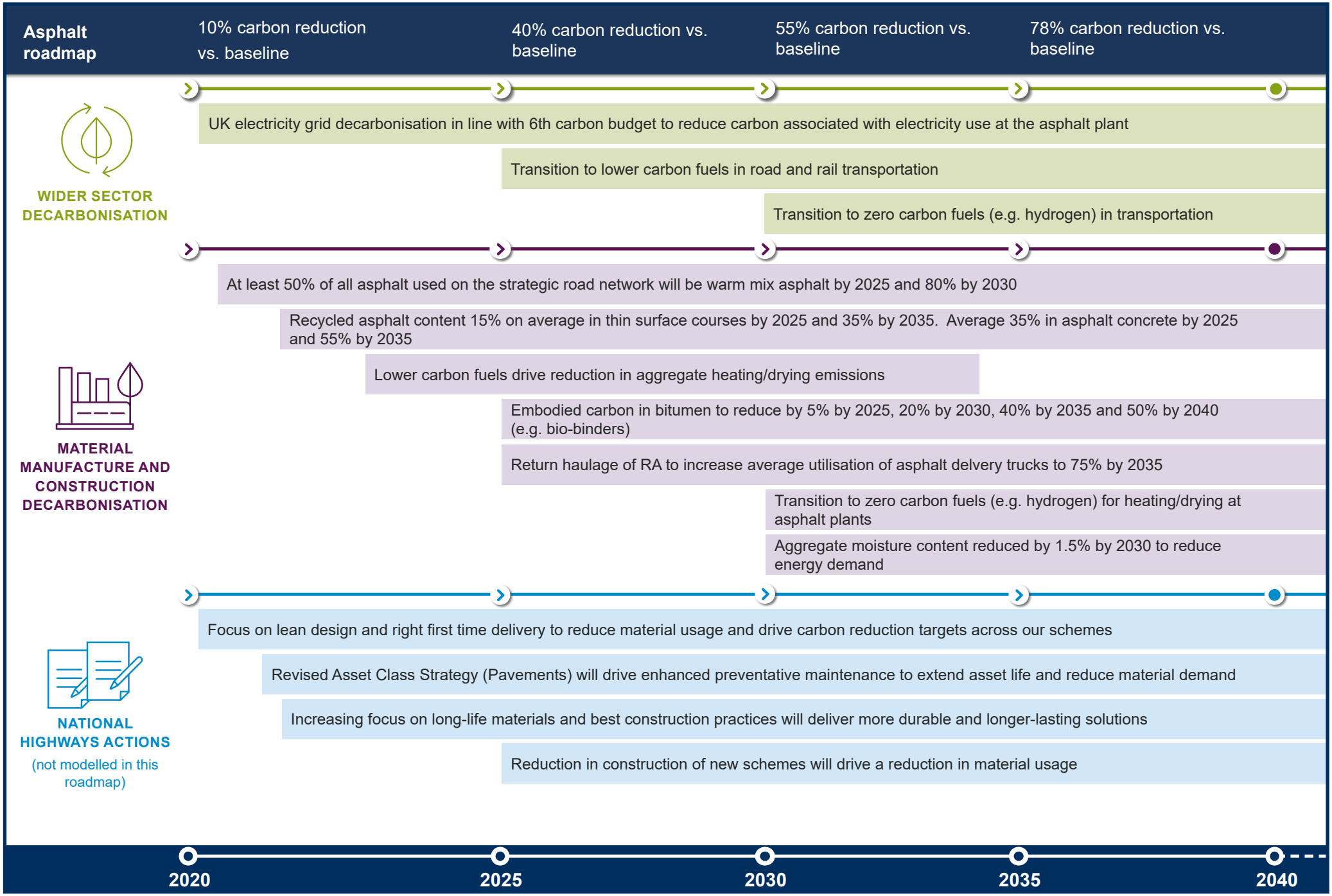
Increased material durability can extend the lifespan of asphalt surfaces and reduce re-surfacing frequency and material use. Material selection and mix design is critical to maximising asphalt service life. Long-life asphalt surfaces can deliver whole life financial cost and carbon reductions even if their initial construction cost is higher.

Best practice pavement construction will reduce maintenance and operational carbon

Adopting best construction practices will extend the service life of asphalt pavements and reduce operational carbon associated with their use. We will be advocating construction processes that reduce joints (e.g. echelon paving), maintain asphalt delivery consistency and quality (e.g. material transfer vehicles) and enhance surface regularity to improve ride quality.

Building less new road infrastructure will directly reduce demand for asphalt

'Building less' is a component of our Net Zero Plan and this will reduce our demand for asphalt, further driving down our carbon emissions associated with these materials. This must be balanced against the need to deliver a modern and efficient road network that meets the needs of the nation. Building less also reduces disruption for our customers given fewer maintenance interventions will be required to maintain roads in the future.


Asphalt roadmap
10% carbon reduction vs. baseline
40% carbon reduction vs. baseline
55% carbon reduction vs. baseline
78% carbon reduction vs. baseline
WIDER SECTOR DECARBONISATION
UK electricity grid decarbonisation in line with 6th carbon budget to reduce carbon associated with electricity use at the asphalt plant
Transition to lower carbon fuels in road and rail transportation
Transition to zero carbon fuels (e.g. hydrogen) in transportation
MATERIAL MANUFACTURE AND CONSTRUCTION DECARBONISATION
At least 50% of all asphalt used on the strategic road network will be warm mix asphalt by 2025 and 80% by 2030
Recycled asphalt content 15% on average in thin surface courses by 2025 and 35% by 2035. Average 35% in asphalt concrete by 2025 and 55% by 2035
Lower carbon fuels drive reduction in aggregate heating/drying emissions
Embodied carbon in bitumen to reduce by 5% by 2025, 20% by 2030, 40% by 2035 and 50% by 2040 (e.g. bio-binders)
Return haulage of RA to increase average utilisation of asphalt delvery trucks to 75% by 2035
Transition to zero carbon fuels (e.g. hydrogen) for heating/drying at asphalt plants
Aggregate moisture content reduced by 1.5% by 2030 to reduce energy demand
NATIONAL HIGHWAYS ACTIONS
(not modelled in this roadmap)
Focus on lean design and right first time delivery to reduce material usage and drive carbon reduction targets across our schemes
Revised Asset Class Strategy (Pavements) will drive enhanced preventative maintenance to extend asset life and reduce material demand
Increasing focus on long-life materials and best construction practices will deliver more durable and longer-lasting solutions
Reduction in construction of new schemes will drive a reduction in material usage
2020
2025
2030
2035
2040

Our actions for accelerating the Net Zero transition

National Highways has a significant role to play in driving the decarbonisation activities modelled in these roadmaps. Many decarbonisation activities in these roadmaps are outside of our direct control, but we will engage and work with suppliers to indirectly influence their implementation. A decarbonisation plan for concrete, steel and asphalt will be developed and will define an integrated approach to realising decarbonisation across all our directorates. This will build on the analysis completed so far and establish our internal approach to delivering the changes identified in the roadmaps.

Procurement

The mechanism for driving change is through our contracts and how we procure and deliver to achieve our net zero carbon emissions. Our message is clear to our supply chain as to the obligations required to help deliver and achieve set targets. We require our Tier 1 and 2 suppliers to be PAS2080 accredited by the end of 2025 and changes are being made to reflect our carbon reduction requirements within our procurement contracts that will support project delivery.

Innovation

Achieving our net zero targets will require transformation of our organisation and supply chain. We are launching the Carbon Construction Innovation Programme to support the coordinated investment in carbon reduction technologies and innovations. Through this programme, we will engage with our supply chain to identify products and innovations that provide meaningful carbon reductions. This will provide a route to trialling opportunities in a safe way on our roads.

Government influence and client body cooperation

Coordinated delivery of our net zero ambitions requires a unified approach from the client organisations that purchase concrete, steel and asphalt. We will lead cooperation between our client body partners to secure alignment between what we are expecting of our supply chains. We will also actively participate in discussions with government to drive the wider sectoral transitions we need to fully realise and exceed our current decarbonisation trajectories (e.g. carbon capture and storage technology and green hydrogen).

Standards

Standards are one of the ways we can mainstream and accelerate the use of alternative materials and design approaches. We are updating our DMRB and MCHW standards to incorporate net zero. We will review the end-to-end process for updating standards and implement a programme of work to accelerate the inclusion of new materials and approaches into standards whilst maintaining our focus on ensuring safety. This will look at how we can work with our supply chain to share learnings from testing and trials across the industry, as well as the role of accelerated testing methodologies.

Major Projects & Renewals

Following the launch of our new PAS 2080 compliant Carbon Management System in December 2022, all of our major projects and enhancement schemes will be required to deliver carbon reductions relative to a 2020 baseline. These targets will drive carbon reductions through the application of the carbon reduction hierarchy, by incentivising “build nothing” and “build less” solutions and getting it right first time. These targets will also require delivery teams to identify and implement lower carbon materials and construction methods.

Roadmap updates

Our roadmaps will define the strategic direction of these activities. We will update our modelling in 2023 to quantify the impacts of material re-use, recycling and design efficiencies. We will also revise based on updates to data on material quantities and use, reflect new technologies as they emerge, and to capture significant changes to emissions factors for materials.

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This image: wildflowers at A30/A391 junction
Cover image: view of the Humber Bridge from the A63

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