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CERCOM
Circular Economy in Road COnstruction and Maintenance

Case study III – NRAs Strategic Approach to Transitioning to CE

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CEDR Call 2021: Transnational Road Research Programme

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Table of contents

Executive summary

This report is deliverable D4.3 of the Circular Economy in Road COnstruction and Maintenance (CERCOM) project, funded under the CEDR 2020 Transnational Research Programme on Resource Efficiency and Circular Economy. CERCOM aims to deliver tools and supporting resources to assist National Road Administrations (NRAs) transition to more resource efficient (RE) highway maintenance, consistent with the principles of circular economy (CE).

D4.3 presents the third of three case studies carried out in Work Package 4 and explores the practical implementation of RE and CE principles in the delivery of road infrastructure projects. The objective was to identify strategies adopted by NRAs to embed RE and CE thinking in their organisation and supply chain. The results are presented in two parts: section 2 presents an in-depth investigation of the approach adopted by the UK National Highways (NH) to make CE an integral part of road infrastructure management. Section 3 presents brief descriptions of five initiatives that are in early stages of development from 4 countries (UK, Netherlands, Ireland and Sweden) representing constituent aspects with potential to contribute to CE:

- Initiative 1: Resource exchange mechanism (UK) – (**In1**)
- Initiative 2: Circular road partner programme (NL) – (**In2**)
- Initiative 3: Sweating the pavement asset (IE) – (**In3**)
- Initiative 4: Living document / route map to energy reduction in tunnels (NL) – (**In4**)
- Initiative 5: Interactive decision support tool for climate action (SE) – (**In5**)

The case studies confirm the high level of interest and commitment, reported in the earlier review (CERCOM deliverable D2.1) that NRAs have in adopting a CE approach to road construction and maintenance. There is synergy between CE and carbon net zero, and with national governments committed to binding net zero targets, CE is recognised as fundamental to achieving these targets. There are increasing numbers of examples of the practical steps being taken to embed CE. Different approaches are being taken in the countries investigated, spanning all aspects of organisational maturity:

- CE ambition – defining CE and producing route maps and implementation plans aligned with organisational policy and strategy
- Embedding CE – involving internal and external stakeholders to achieve buy-in to CE aims, raising the profile of on-going trials, and, in general, ensuring greater awareness of the need for and benefits of CE and RE
- Monitoring performance / circularity (KPIs) – NRAs are still in the early stages of understanding and developing appropriate indicators to measure progress to circularity. However, the need for indicators for measuring and monitoring outcomes is recognised and there are examples including measures for constituent elements contributing to CE and RE (amounts of primary and secondary materials used, percentage of waste reduction, etc.).
- Standards – rethinking standards and working to better understand and mitigate barriers resulting from current standards for scheme design, construction and maintenance
- Supply chain – engaging a wider group of stakeholders, including the supply chain, from early in the design process and taking a collaborative approach to developing and delivering innovative solutions
- Business models – exploring mechanisms to move from a linear to CE by recognising the value of designing assets and materials for longer lives, emphasising reuse/recovery/recycling, potentially achieving this through transfer of ownership

- Circular procurement – embedding CE thinking into procurement through better communication between procurement and design/delivery teams, aligning supply chain and client incentives, whole life evaluations etc.

Communication and collaboration are key themes that emerge as essential to enable transition to CE. The significant supply chain expertise needs to be harnessed to deliver practical solutions. Engagement with the supply chain in pathfinder projects produced a large number of potential innovations; developing these into a library will allow them to be communicated to other projects.

In the Netherlands, negotiation prior to contract is a key part of the business model to move to 'Infrastructure as a Service', a new way of thinking that aligns supply chain incentives directly with those of the road authority and enables innovative approaches to be adopted (see In2, in section 3). Establishing a broad, expert, stakeholder group has been shown to be an effective way of introducing new approaches, building trust and sustaining progress over time (In 4).

Closing the materials loop, i.e. finding opportunities for reuse of material resources, while minimising the need for storage and transport requires collaboration between different projects and organisations, and ultimately, across different sectors. The Resource Exchange Mechanism being explored by National Highways is one approach to formalising this in the form of a digital tool than can build resilience in the move to using resources efficiently (see In1).

There will inevitably be a period of increased risk during the transition from established, rather conservative standards to new approaches that, for example, preserve existing pavements, use less material or use different / secondary materials. The Irish Analytical Pavement Design Model (see In3) is a useful approach to managing this risk. However, there is also a need to engage designers and engineers with the new methods so that they are taken up in practice. Communication of successes and on-going challenges can build confidence in new approaches and hasten adoption and learning.

Achieving CE in road construction and maintenance may well incur additional financial cost, at least in the short term. Deciding how to prioritise budgets will require complex value assessments. This area is still at an early stage and it is clear that much effort will be required to, for example, define materials not just in terms of their financial cost but their value. This requires agreement on the relative importance of different outcomes (functional performance / risk, cost, resource efficiency / circularity, environmental value, social value, etc.) and appropriate metrics to estimate the lifecycle impacts of different options. The value of a clear visualisation of available data, in a way that sets the relative importance of individual decisions in the context of the overall objective, is demonstrated by the Swedish climate action visualisation (In5).

In conclusion, NRAs have started the transition process to move from linear take-make-use-discard approach to use-reuse-recycle-recover. There are growing numbers of examples addressing different constituent elements that contribute to CE but there is still much to do before CE thinking constitutes business-as-usual.

1 Introduction

This report forms deliverable D4.3 of the Circular Economy in Road COnstruction and Maintenance (CERCOM) project, funded under the CEDR 2020 Transnational Research Programme on Resource Efficiency and Circular Economy. The CERCOM project aims to deliver tools and supporting resources to assist National Road Administrations (NRAs) to adopt a more resource efficient (RE) approach to highway maintenance. This is consistent with the principles of a circular economy (CE) where greater emphasis is placed on reusing, repairing, repurposing and recycling materials, preserving their value through multiple lifecycles. This change forms the basis of the European Commission plan for addressing climate change challenges and building a “greener, more digital and more resilient Europe”.

Circular economy gained a presence in policy statements made by NRAs in Europe in the early 2010s. However, there was limited progress in translating the concept to reality in any holistic sense in the early years. There are examples of the application by NRAs of individual aspects that could contribute to CE, such as improving resource consumption, incorporating reused and recycled materials into asphalt and designing out waste. However, by the late 2010s, while it was recognised that CE could deliver economic, environmental and social benefits and was key to achieving net zero carbon emissions, there was still no actual evidence of systemic development and integration of circular economy approaches into major road infrastructure projects.

D4.3 presents the third of three case studies that explores the practical implementation of RE and CE principles in the delivery of road infrastructure projects. The objective was to identify the strategies that can be adopted by NRAs to embed RE and CE thinking in their organisation and supply chain. Information has been gathered through interviews with organisations in the UK, Netherlands and Ireland, and reviews of published reports, surrounding documents and information provided during discussions.

The results are presented in two parts: section 2 presents an in-depth investigation of the approach adopted in the UK, by National Highways, to make CE principles an integral part of road infrastructure management. At the end of the section, the approach is summarised against the headings used in the framework for organisational maturity developed in CERCOM and reported in deliverable D2.1.

Section 3 presents a summary of five initiatives addressing particular aspects of CE. In each case, the owner and context (or goal) are stated, followed by a summary of what was done, how it was done, what was achieved, as well as what worked and why. The initiatives explored are:

- Initiative 1: Resource exchange mechanism (UK) – (**In1**)
- Initiative 2: Circular Road partner programme (NL) – (**In2**)
- Initiative 3: Sweating the pavement asset (IE) – (**In3**)
- Initiative 4: Living document / route map to energy reduction in tunnels (NL) – (**In4**)
- Initiative 5: Interactive decision support tool for climate action (SE) – (**In5**)

The information presented in this deliverable should be useful to NRAs formulating their own strategies for the adoption of CE principles.

2 National Highways approach to implementing circular economy

2.1 Background

The UK Government reiterated commitment to moving towards a more CE with the publication of the Circular Economy Package (CEP, 2020) which included the legislative framework for the transition, identifying steps for the reduction of waste and establishing an ambitious and credible long-term path for waste management and recycling. The stated aims include optimising the use of resources, increasing the use life of assets, and ensuring productive reuse at the end of life.

One of the first examples of taking a whole systems approach to the move to circularity in the planning and delivery of a major transport infrastructure in the UK was the publication of corporate commitment to CE principles in 2017 by High Speed 2 Ltd (HS2, a major UK rail project). The report sets out the definition, potential benefits (economic, environmental and social), key underlying principles and potential steps to move to circularity.

Definition: HS2 defined CE as an alternative to the traditional linear economy (make, use, dispose), keeping resources in use and at their highest value for as long as possible and decoupling economic growth and development from the consumption of finite resources. It also included rethinking ‘waste’ and aiming to achieve the best ‘whole-life for all processes.

The key underlying principles of CE were identified to be:

- Keeping resources in use for as long as possible
- Recovering and regenerating resources at the end of each use
- Keeping resources at their highest quality and value at all times

2.2 Developing strategy

2.2.1 Motivation

The first Road Investment Strategy (Department for Transport, 2015) represented a 5-year programme (2015 to 2020) to deliver £9 billion of road schemes alongside capital efficiency savings of £1.21 billion served to catalyse the National Highways (or Highways England as it was then) move to circularity as a means of achieving greater resource efficiency, better value for money, and improved longer-term financial gains (AECOM and Atkins, 2016). The key drivers for the move to CE were:

- A recognition of the competition for resources given the large scale of the 5-year programme underway
- Ensuring security of the availability of resources
- Constraints resulting from the need to improve efficiency in cost and use of resources
- Need for resilience to climate change and to deliver a low carbon infrastructure

National Highways first started investigating opportunity to move to CE in 2015 by commissioning the development of a corporate circular economy plan to help build a culture of resource efficiency and effectiveness across the organisation. A new way of managing the

infrastructure by 'decoupling economic activity from resource consumption and therefore also reducing the emissions associated with that resource use (MI-ROG, 2020) was seen as integral to transitioning to a low carbon world.

2.2.2 Definition of circular economy

In 2015, National Highways started by adopting the generic definition of CE (Ellen MacArthur Foundation, 2015), "one that is restorative by design, and aims to keep products, components, and materials at their highest utility and value, at all times". Following consultations with stakeholders, National Highways published its interpretation of CE definition that aligned with the organisation's policies and strategy for the management of the strategic road network:

- Minimising demand for primary resources extracted from the ground and maximising the reuse of resources already in use on the network and ultimately in the wider economy. Reutilising resources at end of life in as high a value application as is possible
- Being innovative; working with suppliers to find new ways to deliver a more resilient and adaptable network – seeking efficiency and value for money
- Working to achieve security of supply; working with others to improve the stability and predictability of demand for high-performance products and services. Enabling suppliers to invest in innovative approaches and secure long-term partnerships with wider supply networks, their staff, and wider communities
- Supporting the objectives of Biodiversity 2020 seeking to reverse biodiversity loss and, in the longer term, delivering biodiversity gains
- Consideration of the potential for a natural capital approach to capture the value of National Highways' land holding

2.2.3 Circular economy route map

The development of a 'CE route map' was the first step in the National Highways corporate approach to the transition to CE. Recognising the need for a collaborative approach with stakeholders to ensure buy-in to the transition process, the route map was developed through widespread consultation with internal and external stakeholders, including technical specialists and the supply chain. The route map focused on four key areas, set out in Table 1.

'Pathfinder projects' were a key element of the route map and the objective was to use live projects to develop and record the practical application of CE thinking at project level, learn lessons and build knowledge on how and what to do to make CE an integral part of the procurement and delivery of schemes on the Strategic Road Network. They would also serve to demonstrate the concept across the organisation, test options and identify barriers and opportunities, and facilitate the integration of circularity into infrastructure schemes. The first two pathfinder projects are (New Civil Engineer, 2020):

- The A14 Cambridge to Huntingdon improvement scheme, started in 2016, was National Highways' first CE pathfinder project, which involved collaboration with partners throughout the supply chain to implement a CE approach. However, the work on adopting a CE approach started only part of the way through project delivery at the detailed design phase.
- The optioneering and design phase of the A303 Amesbury to Berwick upgrade scheme, which started in 2017, was the second CE pathfinder project. It built on the lessons from the earlier pathfinder project and was the first project to focus on CE from the

preliminary design phase. (As of 2023, A303 is still in the planning phase with further work ongoing on the planning).

Table 1 Focus of National Highways' route map

Governance	Develop a CE Policy Integrate CE in 'Business as usual'
Procurement	Contractual requirements for CE Supply chain liaison • Exploration of capacity and motivations within the sector • Identify areas with materials constraints and create opportunities register for future schemes • Prioritise major schemes
Monitoring and Reporting	Tool development Effective monitoring of materials and resource efficiency Key Performance Indicators (KPIs) and reporting
Tools and Guidance	Incorporate route map, BSI standard, asset design, support, etc. Consider design life and future proofing Dynamic platform of regional CE responsibilities Material and design guidance to capture CE Amendments to standards / evolving legislation

2.2.4 Circular Economy and net zero

Total global CO_2 emissions from the transport sector as reported by IEA (2021) was 36.3 Gt (36.3 billion metric tonnes) in 2021 with transport's share of CO_2 emissions being 31%. For the roads sector, although the largest source of emissions are the vehicles using the road network, the construction (e.g. new build), operations (e.g. street lighting, tunnel lighting and ventilation) and maintenance of the highway network also represent large sources of carbon emissions, as shown in Figure 1 (PIARC, 2022).

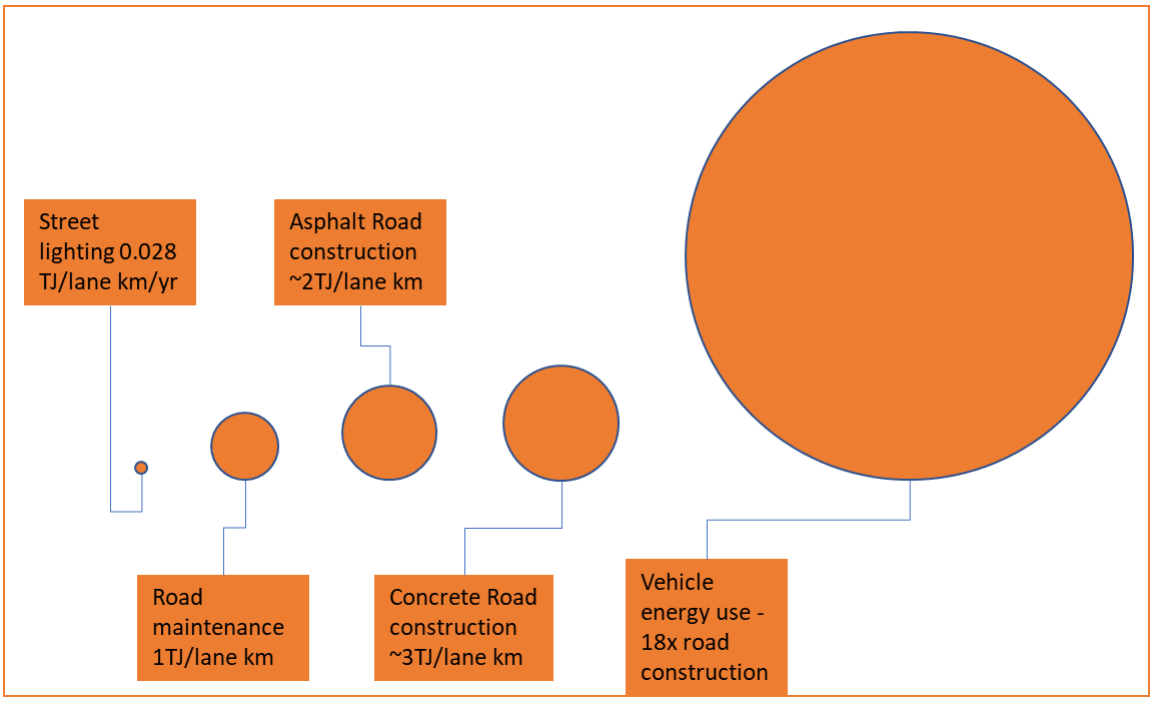

Figure 1 Relative energy use for different activities (PIARC, 2022)

Transition to CE and the commitment to net zero are complementary with the Action Plans for net zero and CE focussing on materials used in road construction and maintenance:

- Reduce the quantities of materials used by reducing amount of construction & maintenance
- Getting the designs right and extending the life of existing assets
- Being more efficient in the use of materials through better and more recycling and reuse

Transition to circular economy is further supported by the commitment to net zero emissions from construction and maintenance activities by 2040 (National Highways, 2022). As a large proportion of emissions are from construction and maintenance activities, it is clear that significant reductions in emissions relating to the materials used, (e.g., their manufacture, transport, longevity, reuse and recycle etc.) will play a major role in the decarbonisation. The envisaged hierarchy of activities for carbon reduction, i.e. building nothing (retaining existing assets longer), building less (reusing, recycling and recovering to maximise use), building clever (e.g. re-thinking design with alternative low C materials and streamlining delivery) and building efficiently (e.g. with new technology and designs and aiming for zero waste), mirror the activities to achieve circularity.

Carbon reduction targets for major projects are defined as part of as part of the PAS2080 carbon management system. Roadmaps for concrete (48% reduction in the carbon intensity of concrete by 2040 against 2020 baseline), steel (70% reduction in the carbon intensity of steel by 2040 against 2020 baseline) and asphalt (78% reduction in the carbon intensity of asphalt by 2040 against 2020 baseline), driven through procurement, innovation, standards, working in collaboration with stakeholders and client organisations, support the delivery of the defined targets for all major projects and renewals schemes.

- Lower Thames Crossing is the third pathfinder project (Greener Highways, 2022). The focus of this project is on the delivery a carbon-neutral infrastructure. As with the earlier

pathfinder projects, collaborating with a range of stakeholders to 'identify, test and scale-up innovative ways of building and maintaining low carbon infrastructure' is a key aspect of the approach. In March 2023, the UK Government affirmed commitment to the project but also announced a 2-year delay in construction).

- Within this scheme, CE principles have underpinned the design and development of material assets and waste commitments. This has been addressed through identifying ways to adopt waste management practices that are as far up the waste hierarchy as practicable and reduce impacts on the capacity of local / national facilities for managing waste.

2.3 Implementation of the circular economy approach

The high-level objectives of the pathfinder projects were to trial approaches that would:

- Minimise carbon emissions by reducing raw material consumption and waste generation
- Optimise the use of resources (materials, water and energy)
- Minimise demand for primary resources
- Maximise productive/useable lives of assets
- Maximise reuse of resources already in use on the network
- Reutilise materials in as high a value function as possible

2.3.1 Pathfinder project A14

This major infrastructure project that started in 2016 was the first project in which National Highways worked with its supply chain partners to investigate and implement a CE approach.

Explicit exploration of CE started only at the detailed design phase and followed the Ellen MacArthur Foundation ReSOLVE framework – **Re**generate, **S**hare, **O**ptimise, **L**oop, **V**irtualise and **E**xchange. Opportunities for circularity were identified through workshops with stakeholders including Environmental Advisors, National Highways supply chain manager and construction sub-contractors. Key steps adopted to introduce CE approach into scheme development included:

- Consideration of resource (materials, energy and water) requirements and how and where they would be sourced during the planning process
- 'Design for resource efficiency workshop' with all the technical leads of all the disciplines involved to identify and prioritise RE opportunities for the whole system. All opportunities identified were recorded and those with the potential for high impact and high feasibility for delivery were prioritised for further investigation
- Assessment criteria based on CEEQUAL assessment (now, BREEAM Infrastructure) tools of sustainability aspects were addressed during the development of scheme design
- An Integrated Delivery Team Earthworks Strategy to develop plans to deliver cost and materials efficiencies and thereby commercial and environmental benefits
- Continue to hold regular meetings to support communications, e.g. raise the visibility and identify transferable 'best practice' in the application of CE principles
- Identify and record potential opportunities and initiatives for CE. For example, the design for resource efficiency workshop identified several opportunities for RE through designing for reuse and recycling, off-site construction, resource optimisation and efficient procurement. For options to be available for consideration and possible

adoption at the project delivery stage, it is necessary that they are identified during the design stage
- Review competition for resources from and opportunities to work collaboratively with other infrastructure owners (e.g. Network Rail) and major construction projects to tap into whole system benefits through efficient sharing/exchange of resources, transport options etc.

Lessons learnt

- CE is a natural progression from good practice that already exists, such as using resources (materials, water, energy) efficiently, generating revenue through sales of unwanted resources, optimising waste generation and reducing disposal to landfill, improving sustainable practices and reducing greenhouse gas emissions. CE can deliver additional benefits through focusing on these aspects and taking a whole system approach covering all aspects (materials, technical, operational, environmental and people)
- Better communication about the opportunities to increase RE and the potential benefits are key to improved RE and CE
- Maintaining a list of the opportunities identified can provide a head start for future schemes. For example, over 60 opportunities were identified at the detailed design phase. While several were implemented on the A14, a majority of the opportunities were generic in nature. As they were not seen as adding value to this specific scheme, they were not adopted. However, these were retained as they could potentially be applicable to other future schemes.
- Opportunities with the greatest potential for reducing whole life costs, improving RE and contributing to CE in major infrastructure projects occur in the early stages, during the feasibility and preliminary design phases. Identifying and incorporating these opportunities can help to make significant progress to circularity

2.3.2 Pathfinder project A303

The optioneering and design for this major infrastructure project, A303 Amesbury to Berwick, started in 2017. It followed on and built upon the lessons from the A14 pathfinder project and was the first infrastructure project in the UK to focus on CE from the preliminary design phase.

The specific objectives in the context of CE were to:
- Integrate CE thinking into the preliminary design phase of the project
- Ensure that the approaches align with corporate CE implementation plan
- Raise awareness of and support the identification and documentation of RE and CE opportunities during the preliminary design phase of the scheme
- Collate and document CE opportunities and activities to help build a CE case study library
- Support transfer of best practice to later stages of the scheme as well as future projects, and the on-going evolution of organisational approach to transition to CE

Key steps adopted to further develop CE approach are summarised in Table 2:

Table 2 Steps to introduce CE approach

Communications	• Internal stakeholders - seminars/meetings introducing CE to scheme team members including designers, impact assessment team, technical leads describing the CE concept, examples from the A14 CE pathfinder project, guidance on consideration of CE during procurement, potential benefits, contracts for suppliers etc.
Identifying and recording RE & CE opportunities	• Initiatives previously identified in the A14 pathfinder project were reconsidered for relevance in this project. • Review of the A303 Amesbury to Berwick Down Solutions Log to identify alternative designs, consideration of options for RE approaches, whole life impacts, mitigation of adverse environmental impacts etc • Develop live list of potential opportunities for CE and RE
Workshops with delivery teams	• Review, explore and prioritise RE & CE opportunities, including those recorded in the A14 opportunities register • Reuse and recovery, off-site construction, resource optimisation, resource efficient procurement, for consideration in the future • The high-level options selection in the early design phase with plans to evaluate options in the detailed design phase are set out in the Environmental Statement (Highways England, 2018)
Engaging with a wider network	• Interested parties, such as Major Infrastructure Resource Optimisation Group and potential suppliers • Research to identify innovative solutions to add value to the scheme • Benefits Realisation and Procurement Teams to integrate CE requirements within the procurement process • Recording and reporting of activities, including what worked and why, with recommendations for next steps, to inform and align with National Highways' wider corporate CE objectives and activity
Performance monitoring (KPIs)	• Develop and review potential CE metrics and indicators to inform and enable monitoring and evaluation of circularity and RE performance
CE Delivery	• Identification of opportunities and mechanisms to integrate CE into the project delivery framework • Resource Exchange Mechanism (REM) was as a potential means of enabling circular economy by facilitating the exchange of surplus resources (products, components, materials) between schemes. The aim would be to encourage greater use/reuse by removing some of the existing barriers in terms of availability, accessibility, quality etc. and thereby support greater RE, life extension, maintain value and reduce embodied carbon.

Outcomes

Communications: Identifying the scheme as a 'pathfinder project' demonstrated commitment to CE and helped to raise the profile of the project both internally and externally. Discussions with internal stakeholders helped to make efficient use of project resources. Raising awareness and understanding of the CE amongst the Design and wider project delivery team enabled buy-in to CE approaches not only within the A303 scheme but also helped with generating new ideas and knowledge transfer to other infrastructure projects.

Ideas and innovations: Applying CE approach in the preliminary design phase itself helped not only in raising awareness but also identifying over 100 potential RE and CE opportunities and included options such as alternative construction materials, whole life impacts and mitigation of adverse environmental impacts. Selected opportunities were incorporated into the scheme while others were either recorded as ideas with potential for future road schemes or discarded.

Evidence for CEEQUAL assessment: Subsequent to the pathfinder projects, a paper on using CEEQUAL to support Circular Economy was developed (MI-ROG, 2021), it showed the links between the CE in these pathfinder projects and the CEEQUAL. Aligning the initial approach to identification of opportunities with the CEEQUAL assessment criteria (rather than the ReSOLVE framework as in the first pathfinder project, A14), helped to integrate CE activities with an already established element of scheme delivery. This added demonstrable 'value' as a source of evidence for the scheme's Preliminary Design stage CEEQUAL assessment.

Procurement: The procurement process has been designed with aspects that align with and support key CE themes and CE has been specifically included in the Procurement Balance Scorecard. However, there are no formal mechanisms to incentivise contractors to address CE specifically, other than for the adoption and optimisation of a whole life cost solutions (which support some aspects of the CE).

Performance monitoring (KPIs): There are processes in place to monitor aspects such as sustainable development and carbon, application of good road design[1] throughout the design lifecycle, benefits management and evaluation across all projects, programmes, and portfolios. However, there are currently 'no universally accepted approach to measuring organisational effectiveness in its transition to a more circular and sustainable mode of operation'.

One consideration has been the use of the numbers of opportunities identified and opportunities incorporated to be used as 'CE enabler' indicators. But as the opportunities vary in type, scope and benefits, they may only have limited value in assessing scheme.

National Highways has a formal means of ensuring continuous good carbon management that meets PAS2080 requirements. This involves the monitoring of whole life carbon at each project stage and producing a Carbon Management Report (CMR). CE, that minimises consumption of virgin materials and extends life of assets, is seen as a means to improve performance in relation to any targets set for the scheme.

Two potential indicators developed by the Ellen MacArthur Foundation (Ellen MacArthur Foundation and Granta Design, 2022), the Linear Flow Index (LFI) and Material Circularity

[1] Good road design is defined in standard GG 103, described in section 2.4.1

Indicator (MCI) are being looked into by the Benefits Realisation and Monitoring Team as potential indicators that could be included at a later stage of scheme delivery.

Resource Exchange Mechanism (REM): National Highways has explored the feasibility of a REM (National Highways, 2022b) by considering its development and how it aligns with their approach to carbon net zero and CE, and potential benefits that could be realised. This review also looked at existing Standards to identify potential barriers and opportunities.

The study confirmed the feasibility of developing a REM which could form part of the overall solution to enabling a CE in materials. The study identified the essential requirements of a REM as well as desirable options and showed benefits from significant carbon savings, less materials going to landfill, reduced dependence on primary source materials and reduction in adverse environmental impacts. One of the recommendations to maximise potential resource exchange is access to a network of physical facilities to support the storage, testing and processing of resources.

The next steps, e.g. software platform to be used to develop the REM are being looked at.

Conclusions

The A14 and A303 pathfinder projects have successfully demonstrated the feasibility of working collaboratively with stakeholders to identify mechanisms to integrate CE approaches both at the preliminary design and future construction phases.

Further work is required to develop KPIs specifically addressing CE and enabling the transition to circularity and the quantification of outcomes to be monitored and reported.

Desk based research on feasibility of a REM has confirmed the benefits of such a system and plans to move on to the development of the system are under consideration.

A third pathfinder project, Lower Thames Crossing, is currently underway. It has net zero as the main objective but incorporates the CE principles and lessons from the first two pathfinder projects as being essential to achieving net zero.

2.4 Development of standards

The development of standards has been highlighted as a key enabler to implementation of circular principles. The MI-ROG White Paper (MI-ROG, 2020) on CE approaches for reaching net zero proposes ideas on Standards that would encourage take up of CE:

- Ensuring standards and specifications facilitate the use of recycled and secondary materials and remanufactured products, and they are seen by business and consumers as comparable, or better than new products
- Having a system for using products certified to CE, e.g. Cradle to Cradle Products Innovation Institute (Standards for materials, products and systems based on their positive impact on people and the planet) and Natureplus Select products that can be repaired, refurbished, remanufactured or re-used at end of first life

National Highways standards are contained in the Design Manual for Roads and Bridges (DMRB). For all DMRB documents, the parts common to all four regions of the UK are contained at the front of the document, followed by national annexes containing further,

specific requirements for England, Northern Ireland, Scotland and Wales. Two standards explicitly relevant to CE are GG 103 for sustainable development (see Section 2.4.1) and LA 110 for waste management (Section 2.4.3).

DMRB documents are updated following a 5-year programme of cyclic review. However, given the pace of innovation needed, an established mechanism of 'Departures from Standards' can provide approval on a case-by-case basis to permit the adoption of novel approaches prior to standardisation. A recent review (National Highways, 2022b), as part of an investigation into establishing a formal REM identified areas that will require further development to promote circular use of materials:

- Existing standards focus on construction and maintenance; requirements for decommissioning and reuse need to be incorporated, as do requirements for appropriate storage of secondary materials to minimise deterioration and the need for further processing
- The variable quality of secondary resources means that they may not comply with the material testing requirements established for virgin materials; furthermore, the test protocols for virgin materials may not adequately reflect the nature of secondary materials. A means of managing the additional risk is required.

2.4.1 GG 103 – Introduction and general requirements for sustainable development and design

The GG103 document, version 0 (National Highways, Transport Scotland, Welsh Government and Department for Infrastructure, 2019) introduces the concept of sustainable development and notes the fundamental importance of decisions made at the design stage on achieving it. The goals of sustainable development (in section 4 of GG 103) are closely aligned with those of CE. Regarding materials specifically, the aspirational goal is to:

> ***"Be resource efficient and reflect a circular approach to the use of materials"*** *[4.2.8]*

The basis of GG 103 is to introduce a mechanism for managing the opportunities and risks, such that they are managed in an iterative process to ensure sustainable development is achieved; there is a requirement that:

> ***"A design solution shall take all reasonable steps to maximise contribution towards all goals of sustainable development"*** *[4.5]*

The English national annex elaborates further on the goals of sustainable development, principles of good design and monitoring strategies. The goal for RE is translated into the requirements [E/1.20 - E/1.21]:

- Design solutions shall seek to minimise the consumption of materials and the generation of waste
- Opportunities to reuse site-won materials or arisings from on-site demolition, where available, should be identified, assessed and incorporated into design

- Safe design solutions that enable deconstruction, demounting and decommissioning to facilitate future high value recycling, re-manufacture or re-use at end of first life, shall be identified and where feasible incorporated into design

Good road design (Appendix E/A) is noted to minimise waste and the need for new materials as well as allowing for future adaptation and technical requirements and deliver long-lasting value. Section E/3 deals with monitoring, evaluation and reporting. It requires evidence to be submitted at preliminary and detailed design stages to show how the goals of sustainable development have been applied, or clear justification where the goals are deemed not relevant to a project.

2.4.2 Example of application – M54 to M6 link road

As an example of the principles above, the environmental statements associated with the planning for the M54 to M6 link road (Highways England, 2020) listed mitigation measures that had been considered and would be taken forward to the detailed design phase for further consideration and potential implementation:

- Design for reuse and recovery: identifying, securing and using materials that already exist on site, or can be sourced from other projects
- Design for materials optimisation: simplifying layout and form to minimise material use, using standard design parameters, balancing cut and fill, maximising the use of renewable materials and materials with recycled content;
- Design for off-site construction: maximising the use of prefabricated structure and components, encouraging a process of assembly rather than construction
- Design for the future (deconstruction and flexibility): identify how materials can be designed to be more easily adapted over an asset lifetime and how deconstructability and demountability of elements can be maximised at end of first life
- Design for waste efficient procurement: identify and specify materials that can be acquired responsibly, in accordance with a recognised industry standard
- Engineering plan configurations and layouts that show how the most effective use of materials and arisings can be achieved

2.4.3 LA 110 – Material assets and waste

The LA 110 document, version 0 (Highways England, Transport Scotland, Welsh Government and Department for Infrastructure, 2019b) sets out the requirements for assessing and reporting the effects on material assets and waste, in line with Directive 2011/92/EU, as amended by Directive 2014/52/EU on the environmental effect of public and private projects, and Directive 2008/98/EC on waste. Its scope includes the consumption and use of material assets and the disposal and recovery of waste. However, effects associated with transport of materials are not included in the scope.

The standard requires a scoping assessment to be carried out to identify whether a project is likely to require significant quantities of materials (particularly primary materials), sterilise mineral sites / peat resources, or generate large quantities of waste. Where this is the case, data are collected to enable the significance to be determined on a 5-point scale from very large (e.g. <70% of material recovery / recycling of non-hazardous waste, or waste represents

1% of national landfill capacity) to neutral (e.g. >99% material recovery / recycling, or no effect on waste infrastructure in the region).

The environmental assessment is required to show how the project design has adopted the waste management hierarchy (preference for avoidance, above re-use, recycling, etc.) and to identify opportunities for environmental enhancement. There is also a requirement to report on material assets and waste for the construction phase and first year of operation.

The English national annex goes further, with regional targets for aggregate recycling [E/1] and a stated aim for projects to achieve at least 90% by weight material recovery of non-hazardous construction and demolition waste [E/2].

2.5 Indicators for circular economy

National Highways was one of 25 partners that collaborated on a project to drive innovation and productivity in major construction and infrastructure schemes (the TIES living lab). Although wider than just CE, the project has some outcomes relevant to CE. One element of the work was to define core metrics across nine performance areas, that would be sufficiently robust to be benchmarked and used to assess the impact of future projects.

The project identified challenges that are relevant for European NRAs: differences exist in the definition and scope (i.e. boundaries) of metrics, there is inconsistent use of metrics across the different lifecycle states of an asset, metrics may not be sufficiently detailed to identify areas for improvement. Achieving consistency in these areas will enable the supply chain to respond in an efficient manner. In the project, consensus was reached in four areas, see Table 3, which are summarised in information paper IP5A (Ties Living Lab, 2022).

Table 3 Areas of consensus regarding metrics for benchmarking

What to benchmark	Metrics that add value to infrastructure projects: cost; schedule; productivity; quality; carbon; CE; biodiversity and natural capital; climate resilience; social value
What metrics to use	Prioritise metrics on the basis of: relevance and scope compared with strategic objectives; diagnostic capability; level of detail; familiarity; coverage; unit of measurement
Ensuring data consistency	Use a consistent framework that covers metrics appropriate to: whole asset performance; each stage of delivery (preliminary design to end of life); specific types of works
Capturing the context of the data	Assign attributes to enable relevant comparisons: project description; basis of pricing; procurement method; prevailing physical conditions; asset-specific attributes, e.g.: functional type, principal design features, dimensions, quantities

Further recommendations from the project (Ties Living Lab, 2022b) were to agree and establish protocols for (i) collecting, cleansing, storing in a central repository, analysing and reporting data to derive metrics and (ii) to cover the organisation, governance and processes to assure the quality of the data and its analysis.

At present, National Highways makes use of the following metrics for CE and is considering the recommendations made during the TIES project:

- Materials used in construction
- Percentage of non-hazardous waste recycled
- Reduction in waste generation
- Percentage of waste diverted from landfill

In addition, all major projects are required, as part of the Standard for materials assets and waste (LA110), to review the Environment Management Plan and provide updated data on amounts of site arisings and waste generated at construction sites against forecast amounts based on initial assessments.

2.6 Aligning against CERCOM 'steps to transition' / pathfinder projects (A14/A303)

CE Ambition - Beginnings
National Highways started the process of adopting CE in 2015 following the publication of RIS2 (5-year Road Investment strategy). • CE approach and route map (2016) • Definition of CE reflecting National Highways policy and strategy for management of the strategic road network with extensive stakeholder involvement (2017) • Contribution to development of the then draft BS 8001, Framework for implementing the principles of the CE in organizations (2017). • Pathfinder projects to trial CE approaches, learn lessons, and establish transferrable process for future projects – Focus on improving RE, moving to zero waste and net zero (started 2016)
Embedding CE
The need for clear communication of what National Highways is trying to achieve has clearly been high on the agenda: • This has been demonstrated by involving internal and external stakeholders since the start of the transition to CE, starting with the development of a definition for CE that aligned with National Highways policies and strategies • Collaborative working with the supply chain and more broadly across the sector has been a common thread in the 2 pathfinder projects • Extensive communication through presentations, workshops and discussions have provided a route to collate a broad list of ideas, opportunities and innovations • The 'pathfinder project' initiative has raised the profile of commitment to CE both internally and externally, helping to raise awareness and understanding of the circular economy widely.
Performance / circularity monitoring (KPIs)
Targets and timeline for carbon emissions reduction are in place but CE related KPIs and circularity indicators are still under development. Two indicators proposed by the Ellen MacArthur Foundation, LFI and MCI are being investigated as potential indicators. However, as part of the development of National Highways environmental sustainability strategy GG 103 (Highways England, Transport Scotland, Welsh Government and Department for Infrastructure, 2019) has set out initial measurable parameters for resource

efficiency and reflecting a circular approach in the use of materials for road construction and maintenance activities:

- Design solutions shall seek to minimise the consumption of materials and the generation of waste
- Opportunities to reuse site-won materials or arisings from on-site demolition, where available, should be identified, assessed and incorporated into design
- Safe design solutions that enable deconstruction, demounting, and decommissioning to facilitate future high value recycling, re-manufacture or re-use at end of first life, shall be identified and where feasible incorporated into design

Supply chain carbon data (which is one aspect of circularity), collated via the National Highways Carbon tool are used to:

- Report against the RIS2 metrics on supply chain carbon / carbon intensity. Although these are not targeted metrics, they are submitted to the regulator
- Report via the Collaborative Performance Framework to score major projects performance – the carbon tool includes a number of recycle, re-use options waste management options as well as carbon footprints for procured materials, including some recycled / secondary materials. Ultimately if projects use less, for longer, they will have better carbon performance scores
- Projecting carbon impacts in Environmental Assessment – almost all projects use the carbon tool to estimate their construction carbon footprint baseline, future baseline and do something scenario. These projects have to mitigate for emissions from construction carbon, as an indication of being resource efficient and circular

In the A303 scheme, the assessment criteria identified and quantified included:

- the types and quantities of materials required for the project
- details of the sources of materials
- the cut and fill balance
- the types and quantities of forecast waste arisings from the project
- waste that requires storage on site prior to re-use, recycling or disposal
- materials and wastes to be pre-treated on site for re-use within the project
- waste requiring treatment and/or disposal offsite; and
- the impacts that may arise from the issues identified in relation to materials and waste

Standards

The role of standards as an enabler to CE principles is established and the standards GG 103 and LA 110 set out requirements for projects to explicitly report on RE and the management of waste, within a framework of sustainable development. Crucially, the role of good design is highlighted, with a requirement being to identify options for increasing CE early in the design process. There is evidence of these assessments being contained, albeit at high level, in the environmental statements being developed for current projects. Areas for further development are in materials standards, to reflect the need to preserve the value of site won materials and the challenge of accommodating variations in quality.

Supply Chain

A key lesson from the experience on the A14 scheme was the importance of establishing partnerships and collaborating early in the design phase with stakeholders, including supply chain partners, in particular the need to engage from the very start of project planning, e.g. at the preliminary design phase.

In both pathfinder projects, extensive stakeholder holder consultations, internal and external have been used to identify and develop opportunities, overcome barriers and get a mechanism for building a 'library of ideas' for use both in current and future projects

Business Models

This area is still very much in the early stages of 'work in progress' phase. For example, one significant change in the 'Business Model' thinking in National Highways is the demonstration from the pathfinder projects of the move from the traditional model of make-take-dispose to circularity with emphasis on reuse and recycle, reduced dependence on primary material and zero waste. The REM is a tool that can help to maximise the retention in the value of materials

In terms of procurement, there are as yet no incentives for contractors specifically for solutions enabling CE other than for solutions demonstrating the adoption and optimisation of whole life cost.

The acceptance of the need to transition to CE and net zero targets have stimulated discussions on potential new business models (MI-ROG, 2020):

- Leasing components as opposed to purchasing them
- Exploring new mechanisms to implement and finance CE business models, by incentivising environmental considerations and whole-life and natural capital approaches alongside the economic aspects of infrastructure
- Ensuring standards and specifications facilitate the use of recycled and secondary materials and remanufactured products, and they are seen by business and consumers as comparable, or better than new products

Circular Procurement

Some aspects of circular procurement, particularly those that support net zero targets are increasingly part of the procurement process. For example, in the A303 scheme, the Environmental Statement sets out plans to follow-up on the high-level option selection carried out the early stages of scheme.

During the construction and operation phases, there are further opportunities to prioritise waste prevention, and then preparing for re-use, recycling, recovery and lastly disposal to landfill and including environmental, social, and economic criteria. From a CE perspective, it would be useful if material resources and generation and management of waste played an influencing role in option assessment and selection during this phase.

A key element of both pathfinder projects that support circular procurement are the stakeholder workshops to identify and record all potential RE and CE opportunities, including those which may not be appropriate for the projects due to reasons such as economics, timing, logistics, commercial considerations, geography etc. The generation of a list of opportunities have the potential to inform and help structure the approach taken by future schemes and thereby facilitate adoption of CE approached more widely across the organisation.

A white paper (MI-ROG, 2016) on embedding circular economy principles into infrastructure operator procurement activities has identified procurement policies that could act as significant drivers in achieving the transition to CE:

- A consistent approach to procurement across major infrastructure projects; this could be taken further by adopting a holistic approach with organisations working together to develop a consistent approach to procurement across the UK's pipeline of major infrastructure projects

- Infrastructure owners and operators including procurement criteria focused on CE from the very outset of infrastructure schemes
- A whole life approach to the development of critical infrastructure, with assets and materials kept at their highest value for as long as possible
- Innovative procurement that evaluates the 'whole life value' of materials throughout commissioning, maintenance and disposal and not just the costs
- Greater engagement between procurement teams and project managers writing detailed specifications, as well as between operators and their suppliers from the outset of infrastructure schemes.

3 Circular economy initiatives by different organisations

The following initiatives provide examples of specific initiatives being undertaken by different organisations. In each case, the owner and context (or goal) are stated, followed by a summary of what was done, how it was done, what was achieved and the reasons why it was successful, which should be of use to NRAs in formulating their own strategies. Links to further information are also provided.

Initiative In1	**Resource exchange mechanism (UK)**
Owner	National Highways
Context /goal	The need for a tool / mechanism to enable greater use of surplus resources from schemes was identified during the National Highways pathfinder project A303. A REM can facilitate greater reuse of materials (which may otherwise be treated as waste) by matching availability and need between schemes. This will increase circularity of materials and can contribute to extending life of assets, maintaining materials value, and reducing consumption of virgin materials as well as supporting GHG reduction and net zero targets.
What was done?	• A feasibility study was commissioned to assess the approach and viability of implementing a REM, facilitating transfer of surplus resources between National Highways' schemes and other organisations at a regional scale. The study considered first life resources (bought-in materials that were surplus to scheme requirements) and second life resources (those generated from works).
How was it done?	• A review of approaches and tools to support resource exchange was carried out to identify the core functionalities of a REM that would be needed. • Stakeholder consultation was carried out to develop the specification for a REM (accessibility, functionality, data requirements, user interface)
What did it achieve?	• Identified barriers to and opportunities for resource exchange and how this would influence the requirements for a REM. These included

	managing risks and liabilities, particularly for second use materials, identifying / developing appropriate facilities for temporary storage of materials to be exchanged, improving communication and data sharing (within National Highways supply chain and the wider infrastructure sector), and amending standards and procurements processes to encourage material reuse. • Defined the requirements for a REM, including modes of access needed by appropriate stakeholders, functionality and data requirements. • Reviewed the standards relevant to resource management and reported on potential barriers and opportunities for resource exchange between schemes. For example, the requirement for third party certification of compliance with relevant standards could be a barrier to use of second life resources and records may be required of resources' previous use. • Showcased 3 examples where exchange of significant amounts of materials had occurred, or were planned (at an informal level), and highlighted the barriers and how these were overcome as well as opportunities and how these were realised. • Developed business case and Project Plan for development and implementation of a REM.
Why did it work?	• Made a high-level estimation of the carbon savings that could be achieved through re-use of materials as well as additional potential savings such as reduction in landfill tax. • Identified REM as one tool in the context of a wider solution to increase resource exchange. Also identified important opportunities and barriers that will need to be addressed to improve resource efficiency and provided recommendations to address these. • Provided National Highways with information to support the business case to progress to the next steps, of developing the REM.
Further information	Major Infrastructure – Resource Optimisation Group (MI-ROG). The case for a resource exchange mechanism. White paper no.3 (2019) http://www.aecom.com/content/wp-content/uploads/2019/10/MI-ROG-White-Paper_3-The-Case-for-a-REM_Oct2019.pdf

Initiative In2	**The Circular Road partner programme (NL)**	
Owners	Municipality of Amsterdam Southeast Municipality of Amersfoort Municipality of Utrecht Province of North Brabant Province of North Holland Province of Overijssel	TU Delft ABN AMRO Dutch Water Board Bank Dura Vermeer Sweco Netherlands
Context /goal	Exploring the role of business model innovation in delivering circular solutions. Specifically, whether the "infra-as-a-service" (IaaS) business model, in which the contractor becomes the economic owner and operator	

	of an asset for the contract duration can motivate investment in circular innovations during all lifecycle phases, i.e., design, lifespan and reuse.
What was done?	• Seven pilot projects have been carried out to test the IaaS model, located in three provincial authorities and three municipalities. Their scope includes, e.g., reconstruction projects, lighting and road management. The programme launched in 2020 and Phase 2 is being established at the time of writing. • For each project, a negotiation occurred between the client and contractor with the objective of agreeing the performance requirements for the contract and how they will be measured. • There were no pre-defined requirements for circularity (or anything else). The client was free to be either more or less prescriptive in their requirements, depending on each project, and their starting point could be challenged by the contractor during the negotiation, to obtain better solutions. • Research was carried out by TU Delft to explore whether the approach incentivises the contractor to adopt more circular practices.
What did it achieve?	• Three of the pilot projects have advanced to a position where an IaaS contract could be signed and implemented. The most suitable projects for this approach were found to be where the asset is smaller and well-defined. In these cases, contracting through IaaS model can free the client to focus on core business. • In more complex cases, the pilots have exposed barriers on legal, social and technical levels that need further investigation. These will be further explored in Phase 2. • Demonstrated circularity metrics that are suitable as a contractual basis of performance assessment. These were based on the CB'23 indicators (link to further information provided below). However, consistent methods for evaluation and audit of data are essential and this remains a challenge. • Innovative approaches were identified to deliver each project with improved outcomes, for example, significantly reduced material or energy demands compared with conventional requirements. • Contractors developed relationships with new partners to deliver the requirements, leading to new ecosystems and enhancing potential for innovation.
Why did it work?	• The pilot projects are genuine projects which can be implemented using an IaaS approach if it appears suitable at the end of the pilot phase. • With IaaS, the contractor owns the asset for the duration of the contract, so is motivated to preserve its value as well as achieve the other performance criteria, including asset condition at the end of the contract period, agreed with the client. • Joint acceptance of the challenge leads to innovative solutions being put forward and being tested, with resultant learning. • Makes use of the expertise and ability to innovate that exists in business but not necessarily in government; empowers contractor to think of innovative solutions rather than meet fixed criteria predefined by the client.

Further information	https://decirculaireweg.nl/the-circular-road-en/ The CB'23 platform and indicator set for circularity were described in CERCOM deliverable D2.1 https://cercom.project.cedr.eu/resources/

Initiative In3	**Sweating the pavement asset (IE)**
Owner	Transport Infrastructure Ireland
Context /goal	A range of initiatives, consistent with CE principles, aiming to maximise the use of pavement resources and contribute to the goal of reducing global warming potential by 50% from 2008 levels
What was done?	• Using 9Rs as a rationale to challenge whether projects should go ahead, whether they can be delivered using less asphalt, whether carriageways can last longer using rejuvenation, etc. • Developed the Irish Analytical Pavement Design Method (IADPM) and incorporated it into the pavement design standard (DN-PAV-03021-06) so that designs are customised to the performance characteristics of locally available materials and encompass innovative materials and construction methods. • Introduced performance measures in the specification for bituminous pavement materials (within Tables 2 and 3 of CC-SPW-0090). • Increased the %RAP allowed up to the 30% maximum for most existing plants and trials are being carried out for higher percentages. • Developing green procurement practice, including lifecycle analysis of impacts, and mandatory requirements for EPDs to be produced for hot mix asphalt, from 2023. Developing CE/carbon reduction criteria to be incorporated into selected schemes in the 2023 maintenance programme. • Developing pavement models and asset management practice to consider the impact of road user fuel consumption (via the impact of rough roads) as well as the carbon associated with maintenance activities, in maintenance decisions.
What did it achieve?	• Introduced whole life carbon accounting into decision making. This enables the dominant carbon contributors to be identified, across the whole life of the road. Future maintenance strategies will balance carbon required for maintenance with that for increased road user fuel consumption on rough roads. • Reduced pavement design thickness, use only the resource needed for the application by basing the design on local conditions and performance data. Pilot application of the IAPDM showed an average 10% reduction in the carriageway surface layer. • Standards have moved from recipe to performance specification, and facilitate high-quality, low temperature materials with increasing recycled content. A case study on the R180 showed a 41% reduction of embodied carbon for a cold mix asphalt with 80% RAP compared with traditional hot mix.

	• Suppliers to a recently tendered framework contract for the high-speed motorway network are offering lower temperature asphalt materials.
Why did it work?	• Focusses on TII's major contributions to global warming potential, which are maintenance activities not carried out directly by TII. • Updated standards drive change from the supply chain. • Challenges traditional, rather conservative pavement designs. • Web-based software (IADPM) is available to all registered users. • However, noted that warm mix asphalts are not yet widely taken up, despite being available to designers. The barrier is not technical and requires action / education to promote low carbon options.
Further information	DN-PAV-03021 (August 2022) https://www.tiipublications.ie/library/DN-PAV-03021-06.pdf 900 series specifications, CC-SPW-00900 (July 2022) https://www.tiipublications.ie/library/CC-SPW-00900-10.pdf TII Climate Action Roadmap https://www.tii.ie/sustainability/2022_12_07_Climate-Action-Roadmap_Final_Signed_Access_chcked.pdf

Initiative In4	**Living document / route map to reduced waste in tunnels (NL)**
Owner	COB stakeholder group *COB is a network organisation that collects, develops and discloses information about use of underground space*
Context /goal	Working towards a circular tunnel sector. Specifically, enabling the reuse of electrical and mechanical engineering components, which are currently discarded, and progress further to achieve energy-neutral tunnel operations. Set aspirational goal to be the most energy-efficient tunnel in the world.
What was done?	• In 2015, established an expert group with wide participation from industry • Started discussions on how to reduce energy consumption • Reached a consensus over the measures that could be adopted and set these out in a living document, which is made publicly available and been revised progressively over time • More recently, have started investigating measures to enable the reuse of materials in the tunnels sector
What did it achieve?	• The COB group has been in operation for 28 years and membership has grown to 120 organisations • Living document for energy reduction has been amended through 5 versions and is a go-to source of information / ideas for the industry • Contractors are citing their involvement in the COB group and the ideas from the living document in tender proposals

	• Energy efficiency measures have been adopted, initially by small organisations. Use of LED lighting has resulted in energy savings of between 10 to 20% • Increasingly innovative approaches are being developed and tested • Some of the early measures adopted have become common practice and been incorporated in standards • Further research is on-going to realise higher energy savings and updating current lighting guidelines that originate from the time of gas-discharge lamps. • The lessons learnt from and experience gained in creating the Living Document for energy reduction provides the start point for creating a Living Document for CE; current goal is to have the first version by the end of 2023
Why did it work?	• By starting the discussion and sharing knowledge, solutions start to be developed. The energy living document is a source of inspiration / ideas to the industry • Took small steps – initially identifying the 'low-hanging fruit' (in this case LED lighting) that could be achieved within the current regulations • Technical subject-matter experts with a sustainability focus were present in the group and were able to challenge objections, based on accurate knowledge of the options, costs, and regulations • A large number of people, >100, representing the whole of this niche topic area in the Netherlands, worked on each version of the living document • Trust was established within the group, in spite of competing commercial interests • Bypassed confidentiality issues by rating cost and value of potential solutions on a 1-5 scale rather than in currency terms • Piloting solutions provided a route for implementation that did not require changes in standards / regulation at the outset • Determined champions did not give up in the face of initial set backs
Further information	https://www.cob.nl/wat-doet-het-cob/groeiboek/maatregelencatalogus-voor-energiereductie-in-tunnels

Initiative In5	**An interactive decision support tool for climate action (SE)**
Owner	ClimateView *CimateView is a climate action technology company that combines scientific modelling, machine learning and interface design to help cities understand and act on the complex climate challenge*
Context /goal	Carbon reduction on a national, city, or sector scale is a complex challenge that requires multiple solutions. Huge quantities of data exist and there was a need to present these in a simple but informative way to decision makers, helping them to plan a transition to net zero.

	This example is relevant as a similar challenge exists for NRAs seeking the best approach to CE principles and being able to communicate the complex topic it to wide range of stakeholders.
What was done?	• Developed a compelling data visualisation that links the huge quantity of data available on national carbon emissions with the targets and road maps that have been established and with details of known and potential solutions. • An online tool, "Panorama", was launched, enabling users to navigate the data at different levels of detail, including: o National emissions by sector ↳ Transportation emissions by source ↳ Private, freight & other emissions by type of solution ↳ Further detail on individual solutions ↳ Similarly for other sectors: industry, agriculture, energy, etc. • The tool is underpinned by mini models that represent the effects of shifts from high-carbon to low-carbon activity. Hence, at each level, the historic, current, and projected future emissions can be viewed, and this is provided together with descriptive text and links to relevant policies and commitments. • In further development, cost and co-benefit data have been added recently to enable economic impacts to be included in the case for funding.
What did it achieve?	• Provided a simple and compelling way of indicating the impact of potential solutions and monitoring progress on carbon emissions against plan, that is easily communicated with stakeholders. • The approach has been adopted by the Swedish national government and a further 50 cities in Sweden, Spain, Germany, USA and UK, helping them to plan and manage the transition to net zero.
	
Why did it work?	• The tool displays an integrated picture, combining the projected effects of many separate initiatives to give a comprehensive, socioeconomic perspective to decision makers

Further information	Information about ClimateView: https://www.climateview.global/about Panorama tool implemented in Sweden: https://app.climateview.global/public/board/48023530-bb99-4a82-a00e-c9e7aad71f5d Related news article: https://www.theguardian.com/technology/2023/feb/08/they-get-the-big-picture-the-swedish-tech-startup-helping-cities-go-green?CMP=Share_iOSApp_Other

4 Summary and way forward

This report provides practical examples that NRAs can adopt in their transition to CE, in all aspects of developing organisational maturity:

- CE ambition – defining CE and producing of route maps and implementation plans aligned with organisational policy and strategy
- Embedding CE – involving internal and external stakeholders to achieve buy-in to CE aims, raising the profile of on-going trials and, in general, ensuring greater awareness of the need for and benefits of CE and RE
- Monitoring performance / circularity (KPIs) – NRAs are still in the early stages of understanding and developing appropriate indicators of progress to circularity. However, the need for indicators for measuring and monitoring outcomes is recognised and there are examples including measures for constituent elements contributing to CE and RE (amounts of primary and secondary materials used, percentage of waste reduction, etc).
- Standards – rethinking standards and working to better understand and mitigate barriers resulting from current standards for scheme design, construction and maintenance
- Supply chain – engaging a wider group of stakeholders, including the supply chain, from early in the design process and taking a collaborative approach to developing and delivering innovative solutions
- Business models – exploring mechanisms to move from linear to circular by recognising the value of designing assets and materials for longer lives, emphasising reuse/recovery/recycling, potentially achieving this through transfer of ownership
- Circular procurement – embedding CE thinking into procurement through better communication between procurement and design/delivery teams, aligning supply chain and client incentives, whole life evaluations etc.,

Communication and collaboration are key themes that emerge as essential. Significant expertise exists in the supply chain and this needs to be harnessed to deliver practical solutions. Engaging with the supply chain in National Highways pathfinder projects produced a large number of potential innovations; developing these into a library will allow them to be communicated to other projects.

In the Netherlands, negotiation prior to contract is a key part of the business model to move from asset ownership to ‘Infrastructure as a Service’, a new way of thinking that aligns the incentives for the supply chain directly with those of the road authority and enables innovative approaches to be adopted (see In2, in section 3). Establishing a broad, expert, stakeholder group has also been seen to be an effective way of introducing new approaches, building trust and sustaining progress over time (In 4).

Closing the materials loop, i.e. finding opportunities for reuse of material resources through multiple lifecycles, while minimising the need for storage and transport, will demand collaboration between different projects, possibly different organisations and, ultimately, across different sectors. The Resource Exchange Mechanism being explored by National Highways is one approach to formalising this in the form of a digital tool that can build resilience in the move to using resources efficiently (see In1).

There will inevitably be a period of increased risk during the transition from established, rather conservative standards to new approaches that, for example, preserve existing pavements, use less material or use different / secondary materials. The Irish Analytical Pavement Design Model (see In3) is a useful approach to managing this risk. However, there is also a need to engage designers and engineers with the new methods. For example, lower temperature asphalts are permitted under new standards introduced by TII but are not widely used to date. This is attributed to the degree of comfort offered by traditional hot mix materials. In contrast, warm mix asphalt has become the default requirement for Strategic Roads in England and is becoming the first option offered by suppliers to other clients. Communication of these successes and on-going challenges can build confidence in new approaches and hasten adoption and learning.

Achieving CE in road construction and maintenance may well incur additional financial cost, at least in the short term. Deciding how to prioritise budgets will require complex value assessments to be made. This area is still at an early stage and it is clear that much effort will be required to, for example, define materials not just in terms of their financial cost but their value – to the NRA, the supply chain (including manufacturers, providers, buyers) and also to the environment and the community. Deliverable 3.1 of the CERCOM project set out a framework for weighting different outcomes (risk associated with functional performance, cost, RE / circularity, environmental value, social value) to identify the preferred maintenance option from a range of options. Whether using this approach or an alternative, an agreement will be needed on the relative importance of different outcomes. It also requires appropriate metrics to be agreed, and produced, to estimate the lifecycle impacts for each option.

It is clear, both from these case studies and from Work Package 4 (deliverables D4.1 and D4.2), that much work remains to be done in this area. However, the value of a clear visualisation of available data, in a way that sets the importance (or relative lack of importance) of individual decisions in the context of the overall objective is clear from the way that the Swedish climate action visualisation (In5) has been widely taken up.

5 Conclusions

The case studies described in this report confirm the high level of interest and commitment, reported in the earlier review (CERCOM deliverable D2.1) that NRAs have in adopting a CE approach to road construction and maintenance. There is synergy between CE and carbon net zero, and with national governments committed to binding net zero targets, CE is recognised as fundamental to achieving these targets.

The case studies also show that there are increasing numbers of examples of the practical steps being taken to embed CE. The approaches taken differ in the countries investigated:

- UK: National Highways are taking a systematic approach to identifying CE opportunities in selected major projects with a view to transferring the knowledge and implementing the approaches in new and upcoming projects;

- Netherlands: The approach adopted in a new initiative, led by TU Delft, is to explore a new business model, 'Infrastructure as a Service' to determine if this can incentivise the supply chain to deliver more circular outcomes; a second example, work being done by COB (Knowledge Centre for Underground Construction) is on developing a holistic approach to moving to circularity in the construction and renovation of tunnels. A key focus is the reuse of electrical and mechanical components that are currently mainly treated as waste, leading to significant loss of the residual value of the materials;
- Ireland: Transport Infrastructure Ireland has taken a range of positive steps to improve the RE of pavements, including through developing new standards and design models to deliver the required performance but with reduced pavement thickness, maximising use of existing materials through increasing percentage of RAP
- Sweden: The approach adopted in the interactive decision support on-line tool to help cities go green has demonstrated the importance of communicating complex data, targets etc in a readily understandable format. Breaking the entire green transition into its constituent parts and presenting as a single integrated picture (made up of building blocks that represent mini models showing the effects of various high to low carbon environmental levers) and making it available to a range of stakeholders has successfully transformed the approach adopted in a number of European cities. In conclusion,

NRAs have started the transition process to move from linear take-make-use-discard approach to use-reuse-recycle-recover. There are growing numbers of examples addressing different constituent elements that contribute to CE but there is still much to do before CE thinking constitutes business-as-usual.

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