



HM Treasury

# Infrastructure Carbon Review

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November 2013





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# Foreword

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To successfully compete in the global race, the UK is driving forward the delivery of new strategic infrastructure alongside the maintenance, modernisation and renewal of existing assets. We must achieve this while contributing to national reductions in carbon emissions.

The Government has no doubt that cutting carbon is fundamentally important to long term global economic, social and environmental sustainability. As previous Government reports have set out, there is also a compelling business case for doing so.

We face an increasingly resource-constrained future. Now is the time to prepare to develop technical, management and cultural innovations that will strengthen the UK economy and sharpen our competitive edge in international markets.

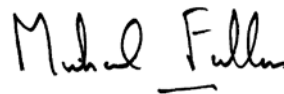
This report makes clear that **reducing carbon reduces costs**. It is part and parcel of saving materials, reducing energy demand and delivering operational efficiencies.

Pursuing a **low carbon agenda stimulates innovation**, making businesses more competitive not only in their home markets but on the international stage too.

This report is targeted at infrastructure industry leaders who hold the power to effect real change and builds on the Infrastructure Cost Review of December 2010. It contains practical advice and examples that the Government is keen to see applied across the industry. Whether you are already engaged in the carbon reduction challenge or encountering it for the first time, this document will spark new thinking, stimulate discussion and trigger action on this most important of issues.



Lord Deighton  
Commercial Secretary to the Treasury



Michael Fallon  
Minister of State for Business and Energy





# Executive summary

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## Purpose

The aim of this report is to release the value of lower carbon solutions and to make carbon reduction part of the DNA of infrastructure in the UK. It also begins to address the low-carbon aspirations set out in the Government's Construction Industry Strategy.<sup>1</sup>

This report is aimed at the leaders of organisations involved in designing, constructing, operating and maintaining economic infrastructure assets across all the sectors defined in the Government's Strategy for National Infrastructure: **Communications, Energy, Transport, Waste, Water**

It is about...	It is not about...
Carbon reduction	Other aspects of the wider sustainability agenda
Cost saving and resource/energy efficiency	Investing in renewables and decarbonising the grid
Carbon associated with construction, operation and maintenance	Carbon associated with power generation
Carbon that is under the control of the infrastructure sector – capital and operational carbon	Carbon that is not under the control of the infrastructure sector – end-user carbon
Climate change mitigation	Climate change adaptation

**Chapter 1** sets the context about carbon in UK infrastructure, **Chapter 2** presents practical steps to reduce carbon in your organisation and supply chain and **Chapter 3** recommends actions for wider change across the infrastructure sector.

Reducing capital and operational carbon makes good business sense:

- **It reduces costs;**
- It unlocks innovation and drives better solutions;
- It drives resource efficiency;
- It provides competitive advantage and export potential; and
- It contributes to climate change mitigation

Leading clients and their supply chains have already achieved reductions in capital carbon of up to 39 per cent, and 34 per cent in operational carbon. These reductions in carbon have been achieved in association with average reductions in Capex of 22 per cent.

If emerging best practice is driven across the infrastructure sector over the coming years, analysis suggests that up to 4 MtCO<sub>2</sub>e/year of capital carbon and 20 MtCO<sub>2</sub>e/year of operational carbon could be saved by 2050. This represents a net benefit to the UK economy in that year of up to £1.46 billion/year.<sup>2</sup>

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<sup>1</sup> <https://www.gov.uk/government/publications/construction-2025-strategy>

<sup>2</sup> MtCO<sub>2</sub>e – Million metric tons of carbon dioxide equivalent. This measure can aggregate different green house gases into a single measure.

## How to reduce carbon in your organisation and supply chain

**Effective leadership:** Provide highest level sponsorship of carbon reduction and set out a vision of how your organisation should address it; provide clear and consistent policy.

**Communication and culture:** Make carbon reduction part of your organisation's DNA. Articulate carbon reduction as a core organisational value; change behaviours, share best practice and develop carbon skills.

**Metrics and governance:** Make your carbon visible and set targets to reduce it against a clear baseline. Report transparently on progress; build carbon into decision making.

**Innovation and standards:** Unleash new thinking by challenging your supply chain to reduce carbon. Define outcomes and allow creative freedom in meeting them. Enable standards and specifications to be challenged.

**Commercial solutions:** Embed carbon reduction into your procurement process. Make carbon reduction a prerequisite for winning work. Integrate your supply chain and align it with your carbon objectives. Share carbon-related risk and reward equitably and incentivise outperformance of your targets. Create the environment in which innovation can thrive.

*"We have gained real value from lower carbon solutions. The greatest benefit comes from joining up the value chain, with the client taking the lead in defining clear 'low carbon' targets and being responsive to the opportunities that are offered. That's what leads to positive sustainable outcomes."*

Chris Newsome, Director of Asset Management, Anglian Water

## Effecting wider change

The overarching recommendation of this report is that Government and industry clients should work together to make carbon reduction a requirement on all their infrastructure projects and programmes by 2016. Clients clearly have a central leadership role, but the real value will come from joining up the value chain and unleashing innovation.

The keys to releasing the value of lower carbon are:

**Leadership** – to create the environment and the imperative for change

**Innovation** – to be the engine of change, largely within the supply chain

**Procurement** – to provide the mechanisms that enable the supply chain to respond

## Foundations for this report

This report is built on:

100+ cross-sector senior stakeholder interviews

200+ published documents included in the literature review

300+ organisations contacted through surveys supported by the Institution of Civil Engineers

**Low Carbon Routemap** – data analysis built on the work of the Green Construction Board’s Low Carbon Routemap for the Built Environment and DECC’s 2050 Pathways calculator. <sup>3</sup>

#### **Terms used in the Infrastructure Carbon Review**

**Carbon** is used throughout this report as shorthand for the carbon dioxide equivalent of all greenhouse gases. It is quantified as ‘tonnes of carbon dioxide equivalent’ (tCO<sub>2</sub>e).

**Capital carbon**, or ‘CapCarb’, refers to emissions associated with the creation of an asset. Capital carbon is being adopted within the infrastructure sector because it accords with the concept of capital cost. (Going forward, the related term “embodied carbon” will continue to be used at a product-level, whereas capital carbon will have greater relevance at an asset-level).

**Operational carbon**, or ‘OpCarb’, describes emissions associated with the operation and maintenance of an asset. It is analogous to operational cost and is quantified in tCO<sub>2</sub>e/year.

**Whole life carbon**, combines both capital and operational carbon and is analogous to whole life cost.

**End-user carbon**, or ‘UseCarb’ describes emissions from the end-users of infrastructure assets. Although not directly controlled by infrastructure asset owners, UseCarb can be influenced.

**Mitigation** involves taking action to reduce the probability and limit the extent of climate change.

**Adaptation** involves taking action to cope with the effects and reduce the impact of climate change when it does occur.

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<sup>3</sup> For more detail on the data analysis, please refer to the accompanying Green Construction Board Technical Report at <http://www.greenconstructionboard.org/>



# 1

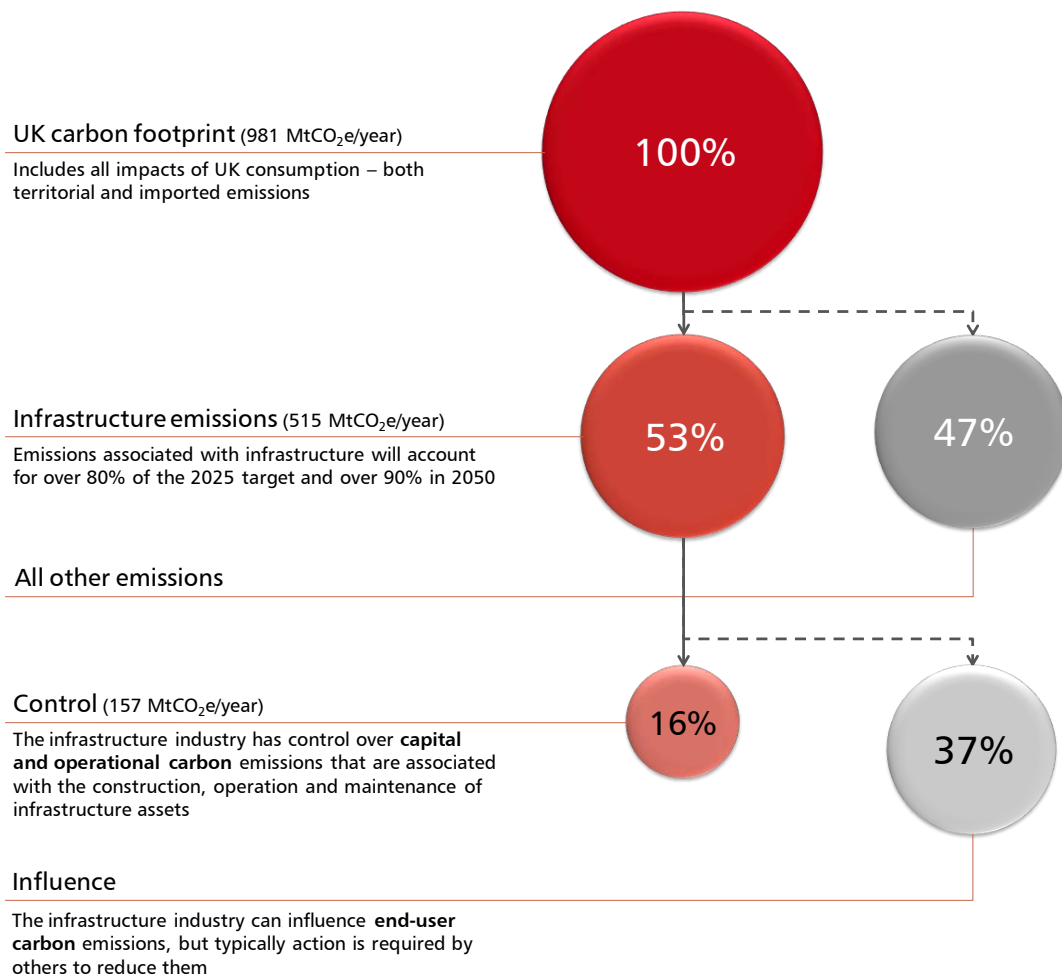
## Carbon in UK infrastructure

### Infrastructure's contribution to carbon emissions and the case for tackling them

#### The influence of the infrastructure sector

1.1 The UK has a legally-binding commitment to achieve an 80 per cent reduction in its carbon emissions by 2050. The Government has also committed to halving UK emissions during the 2023 to 2027 carbon budget period, relative to 1990. Although there are no sector-specific targets, the infrastructure sector does have control over almost one sixth of total emissions and therefore has a key role to play in contributing to the national reduction.

Chart 1.A: Current carbon emissions associated with infrastructure

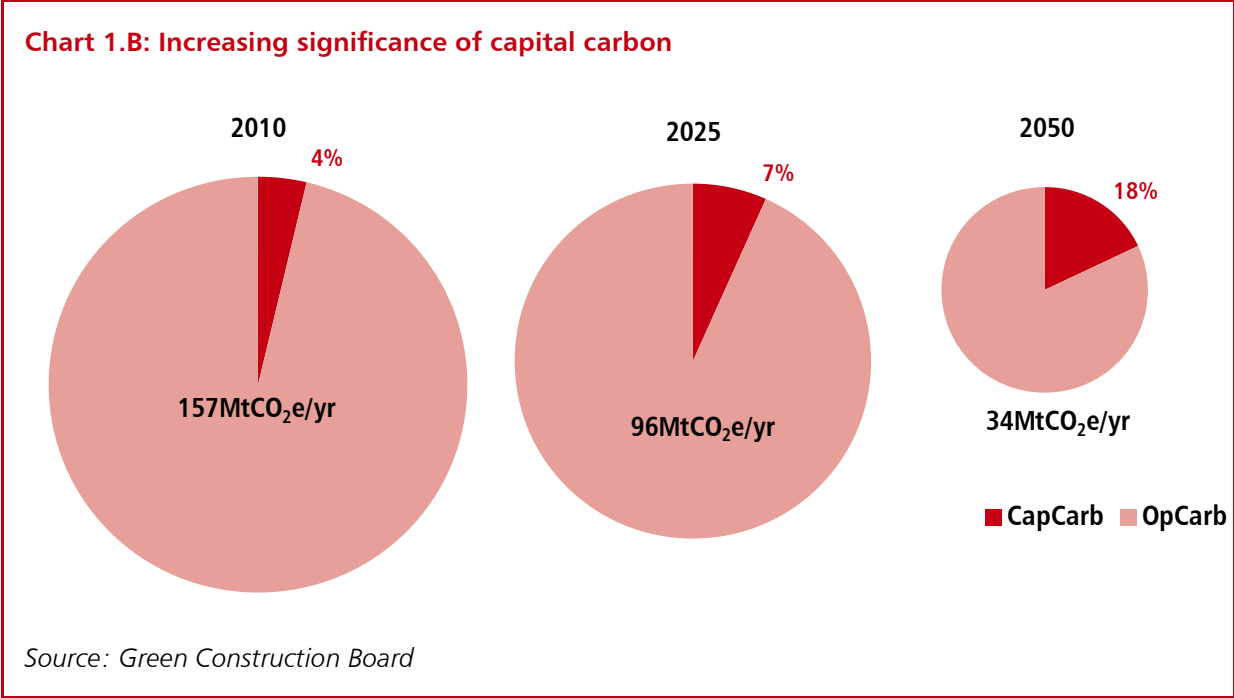


Source: Green Construction Board

1.2 The impact of infrastructure is projected to increase from 53 per cent of UK emissions in 2010 to over 80 per cent of the carbon reduction target in 2025, and rising again to 90 per cent

in 2050. This leaves very little room for all other areas of the UK economy, so if low carbon best practice is not rolled out across the sector, the UK's emissions targets will not be met. Urgent action is clearly required.

**1.3** Extensive measures are already being taken by the Department of Energy and Climate Change to decarbonise the UK's electricity supply which, coupled with greater electrification, should make significant strides to reduce capital and operating carbon. However that is a long-term process and the infrastructure sector can make immediate carbon and cost savings by reducing the emissions under its control.



**1.4** The relative significance of capital carbon will increase as the grid is decarbonised and operational emissions reduce. At the same time, the substantial planned increase in infrastructure investment will tend to increase capital carbon emissions in spite of future construction efficiencies, therefore even greater action is required by the sector to drive down capital carbon.

*“Infrastructure is created to meet the requirements of the end users. The real question about sustainable infrastructure is: how are we going to meet users’ needs in the long-term when everything points towards a resource-constrained future?”*

Peter Hansford, Chief Construction Adviser, UK Government

**Opportunities for carbon reduction**

**Cut capital carbon**

**1.5** Carbon is a good proxy for resource efficiency. Extraction and processing of resources and their subsequent use in construction consumes significant energy, which is currently strongly related to carbon. Cutting the volume of materials consumed and using resources more efficiently will reduce cost as well as carbon.

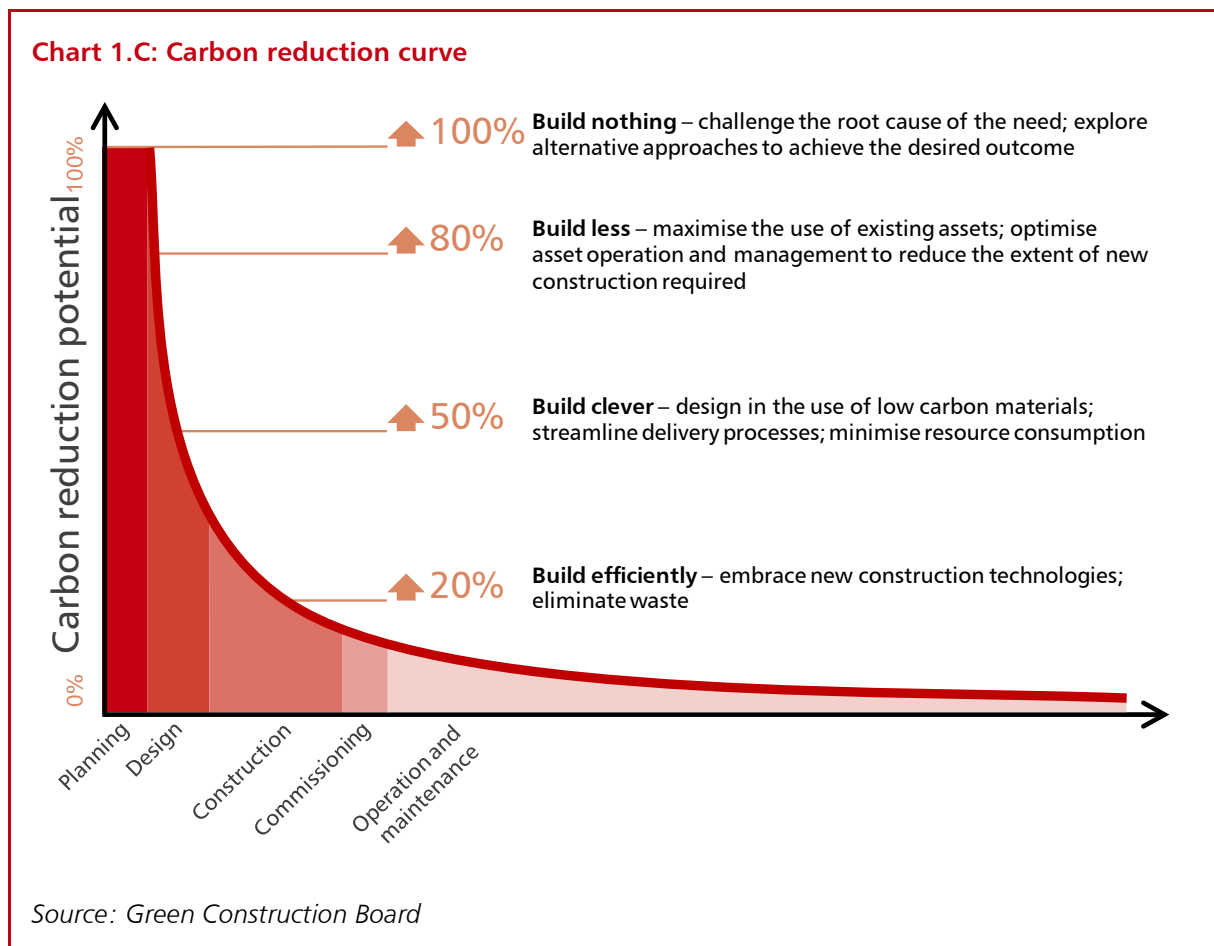
## Cut operational carbon

1.6 Operational carbon is directly related to energy use, and hence cost. Designers and suppliers have significant influence over this up-front, through the development and design of schemes. Likewise, operation and maintenance play vital ongoing roles in energy, carbon and cost savings. Infrastructure owners are also able to exercise direct control over the source of their electricity, and potentially choose to generate renewable energy themselves.

## Reduction potential

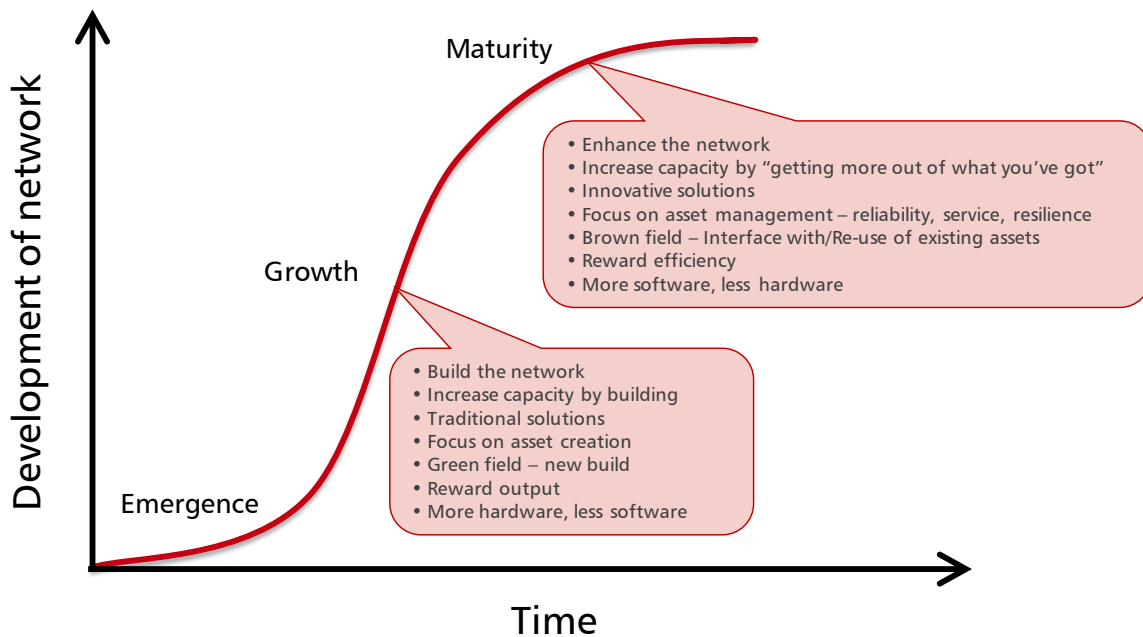
1.7 At a project level, the Highways Agency has examples of capital carbon savings of 40 per cent and reductions of up to 26 per cent were achieved on Olympics infrastructure. At a programme level, Anglian Water has managed to reduce capital carbon by 39 per cent and operational carbon by 34 per cent against its 2009 baseline. If emerging best practice were driven across UK infrastructure over the coming years, analysis suggests that up to 4 MtCO<sub>2</sub>e/year of capital carbon and 20 MtCO<sub>2</sub>e/year of operational carbon could be saved by 2050.

## Tackle carbon early



1.8 You can reduce carbon at any point in the delivery process, but the opportunities are greater the earlier you start. Adopting the concepts of Chart 1.C above may require clients, consultants, contractors and suppliers to rethink some of their business models, many of which are fundamentally based on creating assets. However, helping clients to avoid construction, with its attendant cost and emissions, opens up new business opportunities.

**Chart 1.D: Infrastructure maturity curve**



Source: Green Construction Board

**1.9** Reducing carbon is not just about building new assets in a more intelligent way – it’s about demanding better performance from what we already have. Most of the UK’s infrastructure networks are already mature. Although new infrastructure is needed to meet new social and economic needs, getting more out of existing assets will play a significant part in increasing capacity and meeting customer demand. Many of the carbon reduction opportunities available will be associated with upgrading, adapting and modernising infrastructure currently in operation.

**1.10** Constructing, operating and maintaining infrastructure is all about meeting the needs of customers. And the way customers use infrastructure accounts for a massive 70 per cent of infrastructure-related emissions, so there’s huge scope for reducing infrastructure carbon by changing customer behaviour. That is a topic deserving of its own report, but it lies outside the scope of this one.

### Export opportunity

**1.11** The UK has a leadership position across many low carbon technologies and industries that arise from its dynamic business environment and its approach to innovation and collaboration. It can provide smarter sustainable, more resilient solutions that can be applied and replicated across the world.

*“UK companies are pioneers in low carbon solutions and the export potential is very clear. Organisations that get ahead of the curve will benefit in the longer term.”*

Steve O’Leary, Director, Infrastructure and Low Carbon in Sectors Group, UKTI

**1.12** In UK Trade and Investment’s ‘High Value Opportunities Programme’ that focuses on helping UK companies win business from 100 of the largest non-defence projects in the world, UK companies are already starting to win business, helped by their strong low carbon credentials, across a wide range of sectors and countries including Taiwan’s ECO Cities project or



airport development in Hong Kong. The UK's ability to provide holistic low carbon solutions to complex projects is an increasingly important part of the UK offer to overseas customers.

## Lessons from three low carbon leaders

### Anglian Water

*"Reducing carbon reduces cost, which stands to reason: you use less resource and less energy. That's not all. Our drive to reduce carbon has been a game-changer for innovation, leading to solutions that perform better all round."*

Dale Evans, @one Alliance Director, Anglian Water

**1.13** Water is the only sector to date that has generated programme-level data on carbon and cost reductions. Anglian Water has been demonstrating the link between carbon and cost for eight years and is a leader in that regard. The company's data demonstrate a clear correlation between reduced carbon and reduced cost, and Anglian Water is convinced there is a causal link.

**1.14** When conventional cost reduction techniques have been exhausted, the drive to reduce carbon has spurred innovations that have delivered additional cost savings.

#### **Box 1.A: Anglian Water case study - Covenham to Boston water transfer scheme.**

MMB, the design and construction joint venture between consultant Mott MacDonald and contractor JN Bentley, achieved a 12,000t (57 per cent) reduction in capital carbon and associated £13 million cost saving by building less and building clever on this 60km pipeline from Covenham reservoir and water treatment works to Boston, Lincolnshire. Detailed network modelling led to a solution in which 40 per cent of the 15M/d flow could be transferred through existing assets, reducing the size of pipeline required and eliminating an intermediate pumping station. Further gains were made through extensive use of standard products and supply chain efficiencies from early contractor involvement.

*Source: Anglian Water*

**1.15** In 2009 water industry regulator Ofwat required all water companies to produce a capital and operational carbon footprint of their proposed 2010-15 (AMP5) investment programme. Anglian Water used this as a baseline against which to drive carbon reduction.

**1.16** Anglian Water's @One Alliance estimates that the additional capital cost savings that result specifically from carbon reduction initiatives are of the order of 4 to 6 per cent across the full investment programme, and that does not include the knock-on benefits that come from the carbon challenge driving wider innovation.

### Highways Agency

*"Carbon reduction is all about innovation – you only get different results by doing things differently – it's that simple."*

Doug Sinclair, Major Projects Portfolio Office Director, Highways Agency

**1.17** The Highways Agency is systematically chasing down costs by embracing innovations proposed by its supply chain.

**1.18** The Highways Agency has faced significant financial challenges over the last few years yet at the same time has delivered greater capacity on the UK's roads. It has embraced innovation on capital investment and maintenance projects as a way of delivering them faster, reducing social and environmental impacts and cutting resource use. Design and construction of highway structures is governed by numerous codes and standards. Realising the benefits of innovation has required the Agency to work with its suppliers to scrutinise and adapt its standards.

#### **Box 1.B: Highways Agency case studies**

**M25 Widening** – 5 per cent cost saving delivered through 115,000 t carbon reduction on £1 billion highway upgrade

Connect Plus, a joint venture between Skanska, Balfour Beatty, Atkins and Egis Projects, realised a 115,000t reduction in capital carbon and cut the outturn cost by £53 million through building clever and building efficiently during the widening of a 63km length of the M25 motorway. Extensive use of the proprietary King Sheet Pile profile, with long piles interspersed with shorter intermediate piles, reduced associated capital carbon by over 80 per cent. Further savings were achieved through use of recycled aggregates and reducing pavement thicknesses. The resulting solution was quicker to install, reducing project risk and improving safety with fewer hours spent working next to a live carriageway.

**A21 Stocks Green Bypass embankment stabilisation** - Innovative earthworks solution saves 30 per cent cost and 40 per cent carbon

Design and build joint venture Mott MacDonald-Balfour Beatty used electro-osmosis in combination with soil nailing and improved drainage to stabilise a failing dual carriageway embankment in Kent. In contrast to conventional stabilisation techniques the solution required no removal, replacement or reprofiling of the embankment slope and was achieved by installing 195 perforated steel tubes into the ground. Half were angled downwards, acting as nails, and half upwards, acting as drains. An electrical current was passed through the nails, driving pore water from the soil matrix into the drains. No lane closures were required and embankment vegetation was largely undisturbed. Carbon emissions were 70 per cent lower than using a traditional granular fill and 40 per cent lower than a standard soil nail solution. Stocks Green was the first use of electro-osmosis on a UK highway.

## **Olympic Delivery Authority**

*“We set out to stage a low carbon Games and built that into procurement. The result was venues and infrastructure that set standards for resource-use and cost efficiency – standards that future host cities are striving to emulate and beat.”*

Sir John Armit, Head of the Olympic Delivery Authority, London 2012

**1.19** For the London 2012 Olympics, clear and challenging sustainability targets were set pre-procurement. These were reinforced in tender documents and contracts that allowed for innovation, resulting in a 20 per cent carbon reduction between concept design and construction.

**1.20** The low carbon agenda underpinning the 2012 London Olympics was led from the top. Senior managers believed in it, owned it and kept it live:

- Time was taken at the start to plan rather than rushing into the build phase. Project scope, budget and funding were pinned down early. The supply chain was then challenged to drive sustainability while beating the budget and delivery objectives.
- The right people with the right practical skills were recruited early on. The project culture enabled and encouraged challenge between all parties, resulting in identification and support for innovative solutions. Resources and knowledge were shared between projects.
- Sustainability was embedded through every part of the delivery chain. Contracts were assessed on a best whole life value basis. Challenging targets were set for sustainable materials and resource efficiency, including carbon, water and waste. A reliable and independent assurance body was employed to safeguard transparency and check credibility.

#### **Box 1.C: London 2012 case study - Olympic Park – structures, bridges and highways**

Capital carbon was cut by a quarter across the Olympic park infrastructure projects between the initial and construction design stages. Consultant Arup with contractor Balfour Beatty achieved this through building less and building clever, making widespread use of lightweight structures and temporary solutions with shorter life expectancies that used less material. The number and size of bridges were reduced through accurate modelling of crowd flows; and geotechnical testing allowed piles to be optimised, reducing the number of vibro-concrete columns by 25 per cent and the length of continuous flight augur piles by 10 per cent. Alignment of the new park highway was designed to incorporate existing sections of road, reducing requirements for concrete, reinforcing steel and asphalt. Temporary 'Games-only' portions of the road were made leaner with a design life of just four years.

## **Challenges to carbon reduction**

*“Resistance to change can be as much to do with individual psychology as organisational and sector issues. Even when people have ‘got it’ they also have to ‘own it’”*

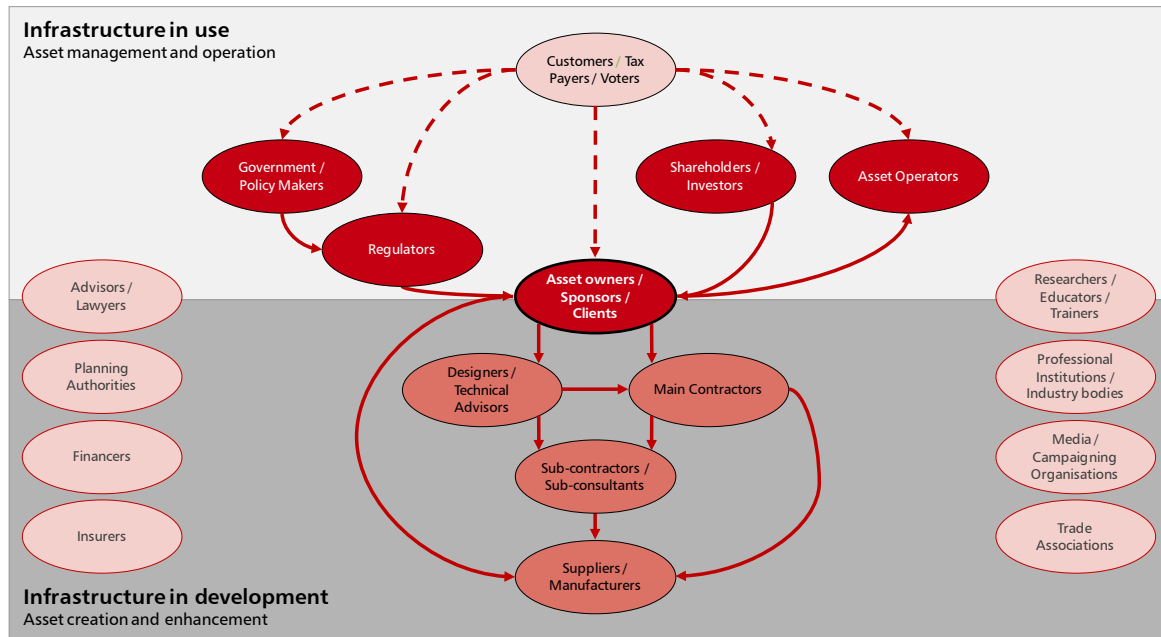
Terry Hill, Member of Construction Leadership Council; Chair of Arup Group Trusts

**1.21** The consultation for this report revealed a wide range of perceived or actual barriers to the pursuit of low carbon infrastructure. They fall into three broad categories: structural | cultural | practical

### **Structural challenges**

**1.22** The diagram below illustrates interrelationships between the broad range of stakeholders involved in managing and creating infrastructure assets – the value chain. All parts of the value chain are partially reliant on others to enable low carbon solutions, but at present there are blockages in the network. Clients play the pivotal role in removing those blockers – and stand to benefit most from doing so. Nevertheless, each of the key stakeholder groups has a part to play.

**Chart 1.E: Infrastructure sector stakeholder network and value chain**



Source: Green Construction Board

### 1.23 What the stakeholder groups say...

**Suppliers and manufacturers:** We are producing many great low-carbon innovations. **BUT** we need designers to specify and contractors to buy them. Clients often don't even hear about our carbon and cost saving ideas because higher tiers in the supply chain effectively block them.

**Designers and technical advisors:** We drive down carbon in design and we can reduce it significantly more by getting involved earlier in the development process, when strategic decisions are made. **BUT** the point at which carbon and cost can most dramatically be reduced has often been missed by the time we're involved. Even if we are engaged early on, carbon reduction has to be in our scope – if it's not, we could be criticised for doing it.

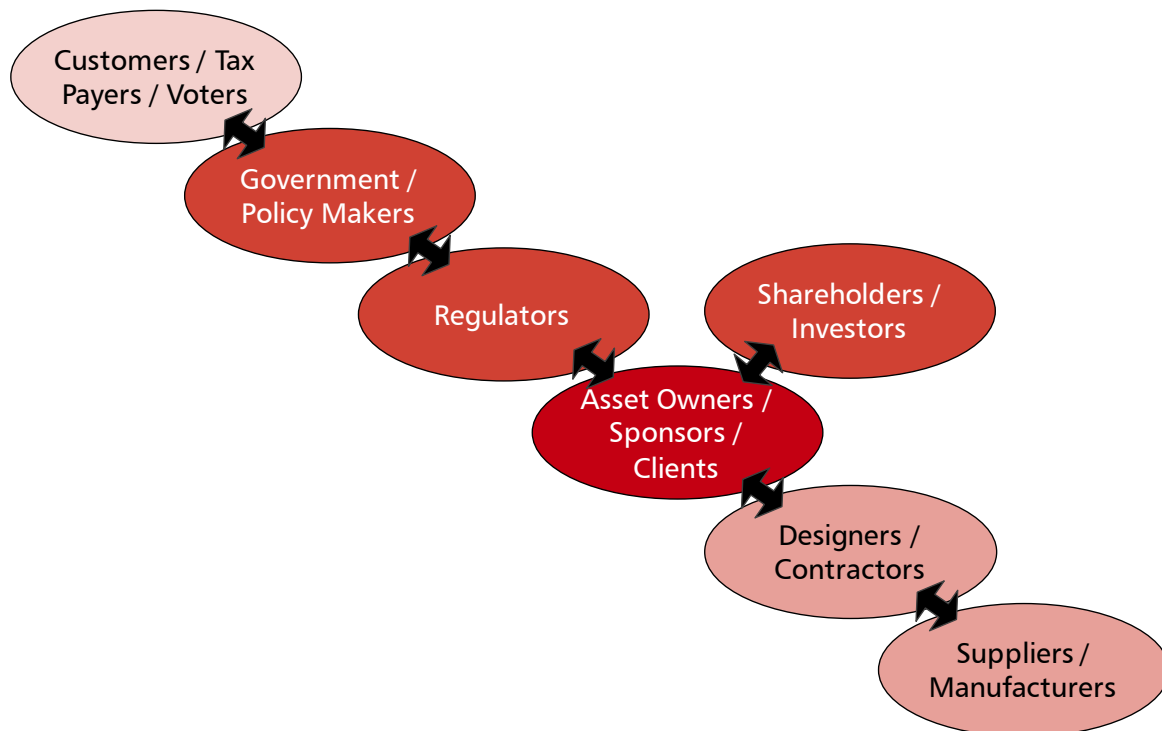
**Contractors:** Experience shows that we can successfully drive down carbon and cost when we're asked to. **BUT** it is rarely a contractual requirement. Clients need to demand reductions and provide appropriate incentives and rewards to change 'business as usual'.

**Clients:** We want to demonstrate best practice in reducing carbon and recognise that there are associated operational efficiencies. **BUT** the regulatory environment does not support action in this area. For many of us, our ownership and financial models inhibit the long-term thinking that is needed for whole life cost and carbon planning.

**Regulators:** Carbon reduction makes a lot of sense. **BUT** we can't direct client organisations to drive low carbon solutions because it is not part of our mandate from government.

**Government and policy makers:** If carbon reduction makes so much sense, why don't they just get on and do it anyway?

**Chart 1.F: Simplified value chain**



Source: Green Construction Board

**1.24** Addressing the structural blockers is key to realising the value of lower carbon solutions across infrastructure. Each stakeholder group has an opportunity to gain some value by autonomously reducing capital and operating carbon. However, maximum value can only be released by joining up the value chain.

## Cultural challenges

**1.25** There are also a number of cultural and behavioural challenges...

**Leaders' values:** If leaders do not believe that there is value in reducing carbon, nothing happens.

**Short-termism:** Accountants and shareholders don't always buy into the whole life cost/carbon argument. Procurement on a project-by-project basis exacerbates short-term thinking.

**Negative perception:** Some clients and customers fear that lower carbon solutions will result in reduced levels of service or increased costs.

**Resistance to change:** Some people just aren't comfortable with the new.

## Practical challenges

**1.26** ...and numerous practical and process challenges.

**Policy:** Currently lacks clarity and consistency regarding carbon reduction.

**Values:** Carbon reduction is not embedded in the culture and mind-set of most infrastructure organisations.

**Skills:** From graduate level upward, people working in the infrastructure sector lack carbon awareness, don't have the right skills and can't access appropriate training.

**Tools:** The assortment of carbon models, tools and standards is confusing.

**Governance:** Carbon is not built into the governance of the sector's delivery processes.

**Codes:** Standards and specifications are overly prescriptive and hard to change, blocking innovation.

**Procurement:** Low carbon performance is not a standard requirement; public procurement processes often stifle the supply chain integration and collaboration that are vital for value-added new thinking and efficiencies.

**Incentivisation:** Risk and reward for delivery and operational efficiencies are currently unbalanced.

**Insurance:** Professional indemnity insurance arrangements drive risk aversion.

**1.27** However, all these challenges are surmountable. The next chapter explains how.

# 2

## Recommendations for your organisation

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### Enabling carbon reduction within your organisation and supply chain

**2.1** Derived from over 100 senior interviews, the key enablers for implementing carbon reduction are summarised below and are set out in greater depth over the coming pages. Echoing the Infrastructure Cost Review, **Leadership, Innovation and Procurement** were found to be the most significant.

#### Effective leadership

**Vision** – Provide the highest-level sponsorship, vision and commitment

**Values** – Embed carbon reduction as a core organisational value – make it part of the DNA

**Policy** – Deliver clear and consistent policies on carbon reduction

#### Communication and culture

**Behaviour** – Be clear what carbon behaviours are wanted and reward them

**Communication** – Share carbon knowledge effectively within your organisation, your supply chain and the wider industry

**Skills** – Develop carbon skills at all levels through education and training

#### Metrics and governance

**Baselines** – Know where you're starting from; establish a baseline against which to measure performance

**Targets** – Set stretching carbon targets and strive to beat them

**Tools** – Put appropriate carbon modelling tools into the hands of those that need them

**Visibility** – Shine a light on carbon performance

**Governance** – Build clear and effective carbon control into the delivery process

#### Innovation and standards

**Innovation** – Unleash new thinking across the supply chain

**Standards** – Enable existing standards and specifications to be challenged; set new standards for carbon best practice

#### Commercial solutions

**Procurement** – Bake carbon into commercial and contractual solutions; create a commercial environment in which innovation can thrive

**Reward** – Align supply chain objectives with reducing carbon; support positive carbon behaviours through long-term incentives; equitably share risk and reward

**Integration** – Remove blockers in the value chain

**2.2** Every organisation is at a different place on the carbon reduction journey. The carbon maturity matrix in Annex A lets you locate your current position and define what your next steps should be.

*“At the beginning of a change like this, it’s more about values and belief, but when you call it right the metrics soon catch up and support you.”*

Adam Green, Managing Director, Carillion Construction Services

## Effective leadership – driving change

### Vision

**2.3 Provide the highest level sponsorship:** Experience of industry-changing agendas indicates the fundamental importance of belief, buy-in and sponsorship at the very top of every organisation. Your Board needs to set out a clear vision and strategy for carbon reduction, communicating them through the tiers of managers to all staff in a compelling way. Client organisations must provide the strongest lead, but leadership is required right across the value chain.

### Values

**2.4 Embed carbon reduction as a core value:** What you believe about carbon determines what you do about carbon. Like health and safety and business ethics, it is clear that reducing carbon brings financial and reputational benefits as well as being the ‘right thing to do’. A broad spectrum of factors influences the values held by individuals and organisations and each will find its own point of balance between the moral and commercial.

### Policy

**2.5 Provide clear and consistent policies on carbon reduction:** With vision and values mapped out, clear and consistent policies provide a practical framework to guide strategic decision making and actions that will deliver carbon reduction. Clear and consistent policies are crucial for getting carbon on to the main agenda and engaging the supply chain. They show your long term commitment, enabling your supply chain to align and respond.

#### **Box 2.A: To legislate or not?**

A small but significant group of those consulted said that legislation or taxation is necessary to drive carbon reduction in the construction, operation and maintenance of infrastructure assets. However, the prevailing view was that Government should use its influence as UK infrastructure’s most powerful client to drive the agenda, as it has done with Building Information Modelling (BIM).

## Communication and culture – disseminating change

### Behaviour

**2.6 Be clear what behaviours you want and reward them:** Reducing carbon is as much about changing behaviours as about changing processes. Be clear what behaviours are wanted within your organisation and from your supply chain partners. Recognise and reward desired



behaviours. Enlist low carbon 'enthusiasts' within your organisation as champions to drive the agenda. When early adopters are empowered and rewarded, others notice and follow.

**2.7** Behavioural change is required at sector scale, as well as at an organisational level. Designers and contractors need to become comfortable in delivering solutions that are not predicated on construction – for example by diversifying into asset management to extract more value from existing assets through improving efficiency and increasing capacity.

## Communication

**2.8 Share carbon knowledge effectively:** Create the 'tone at the top, the mood in the middle and the buzz at the bottom' to support the values and generate buy-in and change. In large organisations effective communication is needed to achieve internal alignment and consistency before approaching the supply chain. Internal communication should include bottom-up groundswell as well as top-down cascades.

**2.9** Though there may be sensitivities to address about intellectual property and competitive advantage, there is real value to be gained from sharing best practice with your supply chain and peers.

**2.10** Identify key messages for different stakeholders. Climate change and moral obligation works for some, resource efficiency and saving money for others.

- Keep the message simple – too much detail can be a turn-off;
- Choose the right medium for the message;
- Lead by example;
- Provide a narrative – people are more receptive to a story, not just an argument;
- Make carbon real to people by helping them to visualise and quantify it;
- Provide evidence – showing data is far more powerful than telling;
- Develop and encourage cross-sector knowledge sharing and learning;
- Communicate and celebrate successes;
- Drive improvement by obtaining and communicating feedback;
- Use branding to develop a visual identity for carbon reduction; and
- Maintain momentum – once the message is out there, keep it going.

## Skills

**2.11 Develop carbon skills at all levels:** From classroom to board room and across all tiers of the supply chain, increased general awareness about carbon is needed. There is also the requirement for specific skills, from design-level carbon modelling to development of carbon tools themselves. The sector needs to demand these from schools and colleges, initiating appropriate education of those entering or already in the sector. In addition the infrastructure sector itself needs to innovate and invest in carbon training.

### Box 2.B: Currency of carbon

Developing a 'currency of carbon' is important for giving people a feel for what carbon is and what it is worth.

**16 tCO<sub>2</sub>e/year** – annual carbon footprint of a typical UK citizen

That's the same as **10t** mild steel or **110t** reinforced concrete

It's equivalent to **four return flights** from London to Sydney

**Worth £67** at current European Union carbon trading price (£4.2/t)

**Worth £512** by 2020, based on a UK trading price of £32/t and rising at £4/t annually

## Metrics and governance – measuring/managing change

### Baselines

**2.12 Know where you're starting from:** The starting point for all carbon reduction is to know where the carbon is. By understanding where the carbon is in a proposed solution you can take action to reduce it. In the absence of sector standards for measuring carbon and setting a baseline it is down to each organisation to determine an appropriate approach. Client organisations must take the lead and work out their own strategy for setting baselines. Advice from low carbon leaders is to get started with an imperfect approach and improve it over time rather than wait for something perfect and risk never getting started at all.

### Targets

**2.13 Set stretching carbon targets:** Driving change and improving performance requires targets. Targets have sometimes resulted in perverse incentives and unintended consequences. So it is imperative that low carbon targets are intelligently designed to deliver the desired capital and operational outcomes. Intelligently designed targets are enormously valuable for driving change and improving performance across both capital and operational phases. Whether you adopt 'sensible', achievable targets or seemingly impossible 'big, hairy, audacious goals', you need to stretch colleagues and supply chain partners to achieve change. As with baselines, clients must lead by establishing targets that will meet their needs.

### Box 2.C: Tonnes or £s?

The majority of those consulted recommended that carbon reduction should be considered in terms of mass rather than money. It prevents time and effort being wasted arguing about conversion rates rather than reducing carbon and it removes the risk of carbon reduction being hijacked by financial gaming. Also, viewing carbon in tonnes provides a new lens that can reveal innovative solutions when the old lens of cost reduction is exhausted.

### Tools

**2.14 Put appropriate tools in the hands of those who need them:** Carbon modelling tools are needed across the project delivery chain, from client organisations through to suppliers. There are currently many unique tools developed by companies and specialists. Work is needed to develop standard tools and make them widely available. But, as with carbon measurement, it is better to start with imperfect tools and improve them than wait.

## Visibility

**2.15 Highlight carbon performance:** Performance visibility brings the metrics that matter into sharp focus. Making carbon performance visible encourages the right behaviours and enables individuals or teams to be held to account. It enables good performance to be recognised and rewarded. It also allows peer pressure to get to work.

- **Projects and programmes:** Visibility is important at key stage gates in the delivery process, informing the decision-making process.
- **Organisations:** It is increasingly important for organisations to understand and communicate their own carbon performance, encompassing the impact of their operations, products or services.

## Governance

**2.16 Build carbon into delivery processes:** Carbon should be used to inform decision making throughout the delivery process. Carbon needs to be measured and challenged at each key stage as part of the official governance. Prevalent practice addresses carbon during the later stages of project delivery, but there is benefit in driving down the carbon at every stage. By the time detailed design and construction are under way, opportunities for radically reducing carbon have already been missed. The greatest potential for carbon savings is in the early, strategic planning and conceptual stages of project development.

**2.17** Learning and feedback should also be built into the delivery process, informing subsequent projects and driving continuous improvement across programmes of work.

## Innovation and standards – conceiving change

### Innovation

**2.18 Encourage new thinking across the supply chain:** Innovation is absolutely essential to achieve carbon and cost reductions – and evidence shows that pursuing lower carbon drives technical, process and cultural innovation, giving those organisations that achieve it a sharper competitive edge and an export potential. Innovation spans blue sky thinking backed by research, to the application of well-proven processes or technologies in new contexts. Realising the benefits of innovation requires a combination of sustained support and effective risk management.

- **Set clear goals:** Focus innovation on specific business challenges: getting more out of existing assets through improved operation and control; life extension and performance improvements through better maintenance or in-service upgrades; development of low-carbon standard designs, specifications and products; off-site manufacture; reuse of materials and components;
- **Define outcomes, not inputs:** Set clear objectives and articulate them precisely – then allow creative freedom in reaching them. Don't suffocate innovation by dictating over-prescriptive specifications; and
- **Be risk aware but not risk averse:** Pilot new ideas to make sure they work. Establish contractual and insurance arrangements that don't unreasonably expose any one party to risk, and incentivise innovation by rewarding results.

*“Some stuff is going to go wrong. You need a small experimental space where you can make mistakes.”*

Charles Ainger, visiting professor, University of Cambridge

**2.19** Challenge your supply chain – that’s where the majority of innovation occurs and they already have great ideas waiting to be heard. Ask your supply chain partners, service providers and product suppliers to come up with solutions that reduce carbon and cost. Engage in dialogue to test thinking, drive performance, achieve the best fit for your business – and find opportunities that exceed expectations. Don’t just challenge your own supply chain. Get each member of the chain to challenge their partners and suppliers too.

## Standards

**2.20 Enable existing standards to be challenged:** Innovation will inevitably challenge standards, so your organisation needs an effective means of reviewing them, balancing the risk and the value of each proposed change. This process needs to involve and empower your supply chain as well as those within your organisation. Work with the supply chain to make the resolution process fast and effective.

**2.21** Go for standard assets rather than asset standards. Seek to standardise assets owned and operated by your organisation, but manage the potential tension between standardisation and innovation – favour innovative standardisation.

**2.22** Define outcomes rather than inputs. Move from product specifications towards performance or outcome specifications. This requires a clear articulation of what is really wanted rather than an over-prescriptive specification that can constrain value. Of course, some specifications do need to be highly-prescriptive, but it is about getting the balance right. Standards should be enabling rather than constraining.

**2.23** Stay focused on cost and carbon. Make sure that any new standards or specifications designed to improve performance and reduce risk also add commercial value for your business.

*“Standards are about helping people understand what good looks like.”*

Dr Scott Steedman, Director of Standards, British Standards Institution

### Box 2.D: National standard for carbon reduction

Infrastructure needs to develop a standard for carbon reduction to create clarity and drive consistency in carbon modelling, baselining, setting targets, measuring, and reporting.

## Commercial solutions – procuring change

### Procurement

**2.24** Embed carbon into commercial and contractual solutions: There’s no standard approach for writing carbon reduction into procurement at present, so you need to work out a strategy for your organisation, using all the pointers above. Essentially, clients get what they ask for, so ask for and expect savings. Two messages need to jump out at potential bidders:

- ‘You won’t win work unless you demonstrate a commitment to reducing carbon.’

- ‘Show how you are going to reduce carbon on this project **and** how it’ll save us money.’

**2.25** Capital and operational carbon reductions need to be included in your procurement processes and your evaluation criteria. As experience and confidence grows, a natural development should be to evaluate tenders based on whole life carbon and whole life cost.

**2.26** Create a commercial environment in which innovation can thrive because innovation is the real source of lower carbon solutions. Asking for carbon reductions with concurrent cost reductions creates the imperative for the supply chain to innovate, but more is needed for innovation to flourish: a fair share of risk and reward; longer-term programmes of work; clearer view of the project pipeline; greater integration and collaboration; and appropriate standards and specifications.

*“The key opportunity to promote low carbon solutions was to give all tiers of the supply chain the freedom to innovate.”*

Davendra Dabasia, Project Director, Mace Project Management Partner, London Legacy Development Corporation

## Reward

**2.27 Align supply chain objectives with reducing carbon:** Develop commercial models that incentivise whole life carbon and cost reductions. The client has the most to gain while the supply chain has the most to offer – and potentially the greatest risk to bear. Share risk and reward equitably.

## Integration

**2.28 Remove blockers in the value chain:** Integrate your supply chain and incentivise collaboration to address the challenges of reducing carbon. Drive this by creating a ‘principals’ group’ bringing together leaders from across the supply chain. Share and publicise strong ideas to ensure they become widely known and encourage them to be used time and again.

**2.29** There was a consensus amongst those interviewed that the most valuable innovation occurs within the supply chain. Integrating the supply chain enables greater innovation.

*“Align your supply chain to your corporate agenda. Then challenge and incentivise them to solve your problems.”*

Nirmal Kotecha, Director of Capital Programme and Procurement, UK Power Networks



# 3

## Recommendations for cross sector action

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### Effecting wider change

#### Recommendations

**3.1** Fundamentally, organisations responsible for infrastructure must demand lower carbon.

**3.2** Therefore, the overarching recommendation of this Infrastructure Carbon Review is that where it can reduce costs to the taxpayer and consumer, Government and industry clients should work together to incorporate carbon reduction objectives within all their infrastructure projects and programmes by 2016.

**3.3** Providing this **leadership** will include building carbon reduction into **procurement** requirements, defining clear low carbon targets and being responsive to the **innovation** that is offered by the supply chain.

**3.4** This overarching recommendation is all about creating the environment and the imperative for change. Clients clearly have a key leadership role in this, but the real value will come from joining up the value chain and unleashing innovation. Challenging the supply chain to deliver lower carbon solutions that also cost less has the potential to do just this.

**3.5** The Government's Chief Construction Adviser will champion carbon reduction via the Construction Leadership Council, and the Infrastructure UK (IUK) Client Working Group will take ownership of the carbon reduction agenda in relation to client leadership.

**3.6** While the previous chapter sets out the key enablers of change within an organisation and its supply chain, the following recommendations describe wider actions that are required to effect change across the sector.

#### Effective leadership

**Action 1** Personal leadership: A Board member from all major infrastructure organisations, both clients and suppliers, should be given express responsibility to drive the carbon reduction agenda. The Green Construction Board should keep track of which organisations have such a Board member.

**Action 2** Carbon maturity matrix: Each major client organisation should use the carbon maturity matrix to identify areas for development and implement an action plan for driving that improvement. The concepts of the carbon maturity matrix will be incorporated into IUK's Infrastructure Routemap.

#### Communication and culture

**Action 3** Carbon skills: Schools, colleges and universities should develop education and training resources to improve carbon skills at all levels. Industry should liaise with academia to ensure the right skill sets are developed. They should also improve in-house training so that carbon becomes a matter of basic knowledge for most people and a core competency for

some. The Green Construction Board will consider setting up a task group specifically to champion improvement in carbon skills.

## Metrics and governance

- Action 4** Sector carbon reporting: The Government's carbon reduction plan and annual progress report – the Carbon Budget – should be extended to include the performance of the infrastructure sub-sectors in reducing carbon. Government will consider the best mechanism to report on carbon reduction using the economic infrastructure sub-sectors as defined in the Strategy for National Infrastructure, namely communications, energy, transport, waste and water.
- Action 5** Measurement and modelling: Government will work with industry to consider the benefits of a national specification for tools for carbon modelling/estimating in infrastructure, recognising that such tools already exist for buildings (and such tools should be compatible with Building Information Modelling – BIM). Industry and Government should fully endorse and use the methodology in BS EN 15804: 2012 on the Environmental Product Declarations of construction products to ensure a consistent method of calculating and declaring the capital carbon of construction products and materials. The Green Construction Board should champion this.
- Action 6** PAS 1192 decision points: Industry should build appropriate requirements for carbon reduction governance into the decision points in the information delivery cycle defined by PAS 1192.

## Innovation and standards

- Action 7** Innovation and best practice sharing: The Green Construction Board should develop the measures to enable the infrastructure supply chain to share innovation and best practice across the sector. The Green Construction Board should establish a high-profile presence for infrastructure at Ecobuild with greater input from infrastructure organisations. The Green Construction Board should investigate and develop an open platform for showcasing best practice and innovation online.
- Action 8** Low carbon PAS: BSI should consider the development of a publically available specification (PAS) on carbon reduction in infrastructure, based on emerging best practice. The Green Construction Board should provide key inputs into the development process.
- Action 9** Industry awards: The Green Construction Board should continue to work with the organisers of major industry awards to ensure that outstanding examples of concurrent carbon and cost reduction, based on innovation, are properly recognised.

## Commercial solutions

- Action 10** Green Book: The Government will consider how whole-life carbon appraisal should be conducted as part of any feasibility study, and the case for additional guidance in the Green Book or Five Case Model.<sup>1</sup>

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<sup>1</sup> <https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government>



## Implementation and next steps

**3.7** There was broad consensus among the 100+ individuals and organisations consulted for this report that reducing carbon is the 'right thing to do'. There was also a strong sense that the infrastructure supply chain will respond positively to client leadership and that carbon reduction with cost reduction can be achieved, chiefly through innovation.

**3.8** The recommendations set out here need to be considered and developed into implementation plans. In particular, the sector's leaders need to commit to initiating and driving the required change.

**3.9** In order to facilitate industry commitment to this report and build on the ambitions set out in Construction 2025, the IUK Client Working Group and the Green Construction Board will jointly host a 'Carbon in Infrastructure' leadership event for the relatively small number of leaders who will make the biggest difference within the sector. Together, they will provide peer-to-peer challenge and support; they will create a shared understanding across the sector and commit to a course of action that will drive carbon and cost reductions throughout their supply chains.<sup>2</sup>

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<sup>2</sup> The Infrastructure Client Working Group, chaired by Simon Kirby from Network Rail, was established under the guidance of the Institution of Civil engineers in support of the Cost Review programme



# A

## Carbon maturity matrix

Carbon Maturity Matrix	Level 1 – Foundations	Level 2 – Embed and Practice	Level 3 – Lead
<b>Effective leadership</b>			
<ul style="list-style-type: none"> <li>• <b>Vision</b> – Provide the highest-level sponsorship, vision and commitment</li> <li>• <b>Values</b> – Embed carbon reduction as a core organisational value – make it part of the DNA</li> <li>• <b>Policy</b> – Deliver clear and consistent policies on carbon reduction</li> </ul>	<p>The organisation has a strategy containing a <b>vision</b> that implicitly or explicitly directs it towards a low carbon future. Organisational <b>strategy and policy</b> have been developed which focus on carbon reduction within the organisation.</p>	<p><b>Strategy and policy</b> are enhanced to include clear goals and logic for how carbon reduction can be achieved. Leadership teams align <b>organisational values</b> with carbon reduction goals. Carbon is integrated into decision making at all levels but there is not the track record of connecting decisions to promote a holistic approach.</p>	<p>Carbon reduction forms part of the corporate <b>vision</b>. <b>Strategy and policy</b> focus efforts on reducing supply chain and end-user carbon as well as direct organisational impacts. There are clear lines between organisational strategy, performance and carbon reduction. Carbon reduction is recognised as a <b>core value</b> which influences decision making at all levels, as well as the delivery model employed by the organisation.</p>
<b>Culture and communication</b>			
<ul style="list-style-type: none"> <li>• <b>Behaviour</b> – Be clear what carbon behaviours are wanted and reward them</li> <li>• <b>Communication</b> – Share carbon knowledge effectively within your organisation, your supply chain and the wider industry</li> <li>• <b>Skills</b> – Develop carbon skills at all levels through education and training</li> </ul>	<p>The organisation <b>communicates</b> a vision for sustainability, including carbon reduction goals, internally. It has started to develop a <b>culture</b> where carbon informs decision making but this is not systematic. The requirement for developing <b>skills and knowledge</b> at all levels has been acknowledged.</p>	<p>Clear, simple and consistent <b>communication</b> is used to raise awareness of carbon within the organisation. <b>Skills and knowledge</b> gaps have been identified and training programmes initiated. A new <b>culture</b> is developing and there has been a shift in leader <b>behaviour</b> which can be seen through ‘leading by example’.</p>	<p>Carbon reduction goals are <b>communicated</b> to the supply chain and end-users as well as internally. <b>Skills and knowledge</b> gaps are continuously addressed with comprehensive awareness and training programmes at all levels. New <b>behaviours</b> are encouraged across the organisation and its supply chain by linking carbon reduction to performance measurements.</p>

Carbon Maturity Matrix	Level 1 – Foundations	Level 2 – Embed and Practice	Level 3 – Lead
<b>Metrics and governance</b>			
<ul style="list-style-type: none"> <li>• <b>Baselines</b> – Know where you're starting from; establish a baseline against which to measure performance</li> <li>• <b>Targets</b> – Set stretching carbon targets and strive to beat them</li> <li>• <b>Tools</b> – Put appropriate carbon modelling tools into the hands of those that need them</li> <li>• <b>Visibility</b> – Shine a light on carbon performance</li> <li>• <b>Governance</b> – Build clear and effective carbon control into the delivery</li> </ul>	<p>Organisational carbon <b>reporting</b> is in place which meets the requirements of relevant regulators or reporting standards. A <b>baseline</b> has been established against which performance can be measured. Reduction <b>targets</b> have been set which are aligned with policy and strategy goals.</p>	<p><b>Tools and processes</b> have been put in place in order to facilitate the calculation and reduction of carbon emissions. <b>Governance</b> is used to ensure carbon management is integrated into the delivery process and becomes a key consideration in decision making.</p>	<p>The organisation works with supply chain partners to <b>report</b> on carbon reduction at a programme level. Carbon metrics are made <b>visible</b> across the value chain to raise awareness and drive performance. <b>Governance</b> is used to drive carbon awareness and reduction in the value chain.</p>
<b>Innovation and standards</b>			
<ul style="list-style-type: none"> <li>• <b>Innovation</b> – Unleash innovation across the supply chain</li> <li>• <b>Standards</b> – Enable existing standards and specifications to be challenged; set new standards for carbon best practice</li> </ul>	<p>Organisational leaders recognise that the carbon agenda provides a means of looking at organisational issues through a different 'lens' and therefore often inspires <b>innovation</b>. It is recognised that existing <b>standards, specifications</b> and associated practices may block innovation and development of low-carbon solutions.</p>	<p>A process is in place to challenge and change <b>standards and specifications</b>. <b>Innovation</b> is encouraged, not just in terms of technology but also in terms of culture, skills, business systems and commercial solutions. Leaders across the value chain are working together to understand how innovation can be unleashed to deliver better solutions.</p>	<p>A dedicated <b>innovation</b> programme is co-ordinated across the value chain. The value chain is regularly brought together to identify and implement low carbon solutions. <b>Standards, specifications</b> and associated practices are addressed to remove practical blockers; there is a move away from traditional specifications towards performance and outcome specifications which include carbon.</p>
<b>Commercial solutions</b>			
<ul style="list-style-type: none"> <li>• <b>Procurement</b> – Bake carbon into commercial and contractual solutions</li> <li>• <b>Reward</b> – Align supply chain objectives with reducing carbon; support positive carbon behaviours through long-term incentives; equitably share risk and reward</li> <li>• <b>Integration</b> – Remove blockers in the value chain</li> </ul>	<p><b>Contracts</b> include carbon requirements alongside general sustainability criteria but these are not integrated into the selection process. Client organisations are exploring <b>commercial models</b> that reward whole life cost and carbon savings and encourage innovation.</p>	<p>Carbon performance is integral to the award of <b>contracts</b> and is considered systematically alongside other performance criteria such as cost and quality. Commercial solutions that enable partnering, collaboration and <b>supply chain integration</b> are being sought in order to develop, promote and deliver low carbon solutions.</p>	<p>Commercial models are being implemented that <b>share the risk and reward</b> of developing, promoting and deploying low carbon solutions. Organisations' <b>ownership models</b> align with and facilitate lowest whole life cost/carbon decision making.</p>

Our thanks to Mark Browning and Paul Stephenson from CH2M HILL, UK for their assistance in the development of the carbon maturity matrix

# B

## List of contributors

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### Infrastructure Working Group

Chris Newsome	Anglian Water (Chair)
Adam Green	Carillion
Alan Couzens	HM Treasury
Bill Hocking	Skanska
Dale Evans	Anglian Water
David Bevan	Galliford Try
David Riley	Anglian Water
Doug Sinclair	Highways Agency
James Harris	Mott MacDonald
John Tebbitt	Construction Products Association
Mike Peasland	Balfour Beatty
Niall Mills	First State
Nirmal Kotecha	UK Power Networks
Paul Bentley	JN Bentley
Roan Willmore	Network Rail
Seamus Keogh	The Clancy Group
Tim Chapman	Arup
Tony Mulcahy	BIS

### Steering Group

David Riley	Anglian Water (Chair)
Alan Couzens	HM Treasury
Andrew Link	Construction Industry Council
Austin Flather	JN Bentley
Chris Whitehead	Balfour Beatty
Jennifer Clark	Skanska
Quentin Leiper	Carillion
Tim Chapman	Arup

### Author Team

Mark Enzer	Mott MacDonald (Lead Author)
Maria Manidaki	Mott MacDonald
Jamie Radford	Mott MacDonald
Terry Ellis	Mott MacDonald

## Consultees

### Government/Policy Makers

Committee on Climate Change

Department for Business, Innovation and Skills

Department for Transport

Her Majesty's Treasury

UK Trade and Investment

### Regulators

The Office of Communications (Ofcom)

The Office of Gas and Electricity Markets (Ofgem)

The Water Services Regulation Authority (Ofwat)

### Asset Owners/Sponsors/Clients

Anglian Water

British Waterways/Canals Trust

Crossrail

Environment Agency

Électricité de France (EDF)

FCC Environment

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Highways Agency

London Underground

National Grid

Network Rail

Northumbrian Water

Scottish and Southern Energy

Thames Water

Transport Scotland

UK Power Networks

Yorkshire Water

### Main Contractors/Sub-contractors

Balfour Beatty

Carillion

Galliford Try

JN Bentley

NG Bailey

Keller

Kier

Laing O'Rourke

Skanska

Tarmac/Lafarge – Cement and Asphalt

The Clancy Group

### Designers/Technical Advisors

Arup

CH2M Hill

IBM

Jeremy Benn Associates (JBA)

Mace/London Legacy Development Corp

Mott MacDonald

Sustain Ltd

The Carbon Trust

Adrian Gault

Eric Ling

Peter Hansford

Tony Mulcahy

Steve Gooding

Alan Couzens

Anthony Arkle

Steve Unger

Adam Cooper

Mark Worsfold

Chris Newsome

Dale Evans

Richard Mercer

John Mead

Andy Powell

Anuj Saush

Richard Belfield

Phil Wilbraham

Colin Beales

Dean Kerwick-Chrisp

Doug Sinclair

Simon Newton

Paul Godwin

Ian Galloway

Roan Willmore

Heidi Mottram

Craig Neill

Lawrence Gosden

Stephen Thompson

Nirmal Kotecha

Helen Phillips

Chris Whitehead

Mike Peasland

Adam Green

David Bevan

Paul Bentley

Cal Bailey

Jim DeWaele

Eleanor V. S. Mason

Jem Bezodis

Ron Gulliver

Philip Cartwright

Bill Hocking

Martin Kenny

Seamus Keogh

Terry Hill

Tim Chapman

Mark Browning

Paul Stephenson

Chris Cooper

Jeremy Benn

Davendra Dabasia

James Harris

Keith Howells

Craig Jones

Dominic Burbridge

### Suppliers/Manufacturers

Marshalls

Siemens

Tarmac/Lafarge – Concrete Division

Graham Holden

Julie Alexander

Jeremy Greenwood

### Professional Institutions/Industry Bodies/Trade Associations

Association for Consultancy and

Engineering (ACE)

Association of Directors of Environment, Economy, Planning & Transport (ADEPT)

British Aggregates Association

British Precast Concrete Federation

Building Research Establishment (BRE)

Buildoffsite

British Standards Institution (BSI)

Civil Engineering Contractors Association

Civil Engineering Environmental Quality

Assessment and Award Scheme (CEEQUAL)

Confederation of British Industry (CBI)

Construction Products Association (CPA)

Consumer Council for Water

Constructing Excellence

Energy UK

Green Building Council

Institute of Environmental Management

and Assessment (IEMA)

Institution of Civil Engineers

Renewable UK

Royal Institution of Chartered Surveyors

UK Contractors Group (UKCG)

Waste and Resources Action Programme (WRAP)

### Researchers/Educators/Trainers

Construction Industry Research and

Information Association (CIRIA)

Energy and Utility Skills (EU Skills)

Heriot-Watt University

Stockholm Environment Institute

University of Bath

University of Cambridge

University College London

University of Leeds

### Shareholders/Investors

First State

### Advisors/Lawyers

Acumen 7

Pinsent Masons

PricewaterhouseCoopers (PwC)

### Campaigning Organisations

Green Alliance

Prince of Wales's UK Corporate Leaders

Group On Climate Change

Peter Campbell

Matthew Lugg

Robert Durward

Martin Clarke

Chris Broadbent

Richard Ogden

Scott Steedman

Alasdair Reisner

Roger Venables

Nicola Walker

John Tebbitt

Lia Moutselou

Don Ward

Clare Dudeney

Paul King

Martin Baxter

Nick Baveystock

Andrew Crudgington

Rhys Thomas

Zoltan Zavody

Martin Russell-

Croucher

Simon Nathan

Richard Buckingham

Bill Healy

Jack Carnell

Paul Jowitt

Corrado Topi

Elena Colli

Roberto Rinaldi

Tony Urbani

Geoff Hammond

Peter Guthrie

Charles Ainger

Brian Collins

Denise Bower

John Barrett

Philip Purnell

Niall Mills

Will Oulton

Simon Murray

Graham Robinson

Jon Hart

Paul Davies

Julian Morgan

Eliot Whittington



## **HM Treasury contacts**

This document can be downloaded from  
[www.gov.uk](http://www.gov.uk)

If you require this information in another  
language, format or have general enquiries  
about HM Treasury and its work, contact:

Correspondence Team  
HM Treasury  
1 Horse Guards Road  
London  
SW1A 2HQ

Tel: 020 7270 5000

E-mail: [public.enquiries@hm-treasury.gov.uk](mailto:public.enquiries@hm-treasury.gov.uk)

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