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Carbon dioxide management in a major UK infrastructure project: High Speed Two

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High Speed Two, a planned high-speed railway in the UK, could play a key role in reducing national greenhouse gas emissions. The project has adopted whole-life carbon dioxide emissions reduction as a core project value and is using the PAS 2080 specification to implement carbon dioxide management. Effective leadership and governance, metrics, innovation and standards, and commercial solutions underpin the approach. This paper outlines the carbon dioxide management work undertaken to date, describes the proposed next steps to enhance the approach and summarises the lessons learned for other infrastructure projects.

1. Introduction

High Speed Two (HS2) is a planned high-speed railway in the UK. The first phase will connect London and Birmingham and the second phase will extend it to Manchester and Leeds (Figure 1). As the biggest project in Europe it will include the delivery of new rail infrastructure, stations and depots as well as rolling stock.

High Speed Two (HS2) Ltd is the client organisation responsible for developing and promoting the UK's new high-speed rail network. It is funded by the Department for Transport (HS2 Ltd,



Figure 1. Plan of the proposed HS2 high-speed railway network

2016a). In collaboration with the Department for Transport, the client has defined seven strategic goals which define the success of the project and are about the benefits it will bring to the country (HS2 Ltd, 2018a). These are

- be a catalyst for economic growth
- create a step-change for rail capacity and connectivity
- be good neighbours and protect the natural environment
- foster skills and create new employment opportunities
- set new standards for health, safety and security for the construction and operation of the railway
- deliver value for money to the UK taxpayer
- set new standards for customer experience.

The strategic goals are supported by a number of strategic objectives (HS2 Ltd, 2017a); one of which is, 'to design, construct and operate HS2 to reduce carbon [dioxide] and promote sustainably sourced resources'. 'Carbon dioxide' is used throughout this paper to mean the carbon dioxide equivalent of all greenhouse gases emitted by the project.

Infrastructure is associated with over half of the UK's total carbon dioxide emissions (HM Treasury, 2013). Around 30% of these emissions are directly attributed to the construction, operation and maintenance of infrastructure assets, such that they can be directly controlled by the infrastructure sector. The other 70% is due to the users of infrastructure, over which the infrastructure sector has influence rather than direct control.

Reducing infrastructure carbon dioxide emissions is key to achieving national carbon dioxide emission reductions (HMG, 2019) and is fundamental to addressing the global challenge of climate change. Additionally, as recognised in the *Infrastructure Carbon Review* (HM Treasury, 2013), there is also a compelling business case for reducing infrastructure emissions. Reducing emissions can reduce costs, unlock innovation and drive better solutions, drive resource efficiency and deliver better-performing infrastructure.

The new railway has the potential to play a key role in supporting transport sector (HMG, 2016; Johnson, 2018) and construction industry (HMG, 2013) carbon dioxide emissions-reduction objectives, which are an essential part of the government's plans for reducing national carbon dioxide emissions (HMG, 2017).

Construction and operation of the new railway will result in carbon dioxide emissions, but it will also deliver emissions benefits (HS2 Ltd, 2013a, 2017b); for example, through the transfer of passenger and freight journeys from road and air to rail. Nonetheless, the client plans to build the most sustainable high-speed railway in the world (HS2 Ltd, 2017a). It is committed to minimising the carbon dioxide footprint of the project and delivering low-emissions long-distance journeys supported by low-emissions energy (HS2 Ltd, 2017c).

This paper outlines the client's approach to carbon dioxide management and identifies lessons learned for other infrastructure projects.

2. Carbon dioxide management at HS2

The opportunity to reduce carbon dioxide emissions has been identified as a potential benefit of a national high-speed rail network for Britain and formed part of the justification for the investment in HS2 (DfT, 2012). Accordingly, the client has adopted carbon dioxide reduction – through its strategic objective to 'design, construct and operate HS2 to reduce carbon [dioxide]' – as a core project value. Robust and effective carbon dioxide management is therefore a key determinant of the project's success.

The carbon dioxide management approach seeks to define and implement measures that achieve reductions in whole-life emissions. The general principles and key components identified in Publicly Available Specification (PAS) 2080:2016: Carbon management in infrastructure (BSI, 2016a) have been adopted as a framework through which to implement the approach (Figure 2).

The client acknowledges it has a key leadership role in providing the vision, environment and imperative to motivate the

behaviours and actions required to deliver lower carbon dioxide solutions. To establish a leadership position, it has implemented the following.

- Secured chief-executive-officer-level sponsorship and commitment to carbon dioxide reduction (GCB, 2014; HS2 Ltd 2017c).
- Developed an understanding of the carbon dioxide performance of the new railway by undertaking assessments of the emissions implications of the project in route appraisals (HS2 Ltd, 2011, 2013b, 2016b) and impact assessments (HS2 Ltd, 2013a, 2017b).
- Adopted a carbon dioxide minimisation policy (HS2 Ltd, 2017d), which sets out a hierarchy of aims to minimise the carbon dioxide footprint of the project. The policy applies to all phases and life-cycle stages of the programme, has been adopted as a project requirement and is being cascaded across the supply chain.
- Adopted carbon dioxide reduction as a programme strategic objective which underpins its strategic goal to, 'create an environmentally sustainable solution and be a good neighbour to local communities'. The strategic goals have been clearly communicated (HS2 Ltd, 2018b) to help potential suppliers understand the client's values and to enable the supply chain to prepare to help realise the benefits of the project (Figure 3).
- Cascaded ambitious whole-life emission-reduction targets into relevant contracts. The targets are designed to empower the supply chain to challenge 'business as usual' approaches, motivate the necessary behaviours to deliver lower-emissions solutions and ultimately deliver reductions consistent with national and international climate change objectives.



Figure 2. Key components of a carbon dioxide management system (recreated from PAS 2080:2016 (BSI, 2016a))



Figure 3. HS2 London Euston terminus – carbon dioxide reduction is part of the project's goal to be a good neighbour to local communities

Collaborated with other infrastructure client organisations to address common carbon dioxide reduction challenges. For example, the client held a low-emissions-concrete event in partnership with National Grid, Heathrow and the Supply Chain Sustainability School to bring clients, designers, constructors and concrete suppliers together to hear client ambitions for using low carbon dioxide concrete, share experience and knowledge of using it and understand how the construction industry can increase its uptake. The client is also a member of the Major Infrastructure–Resources Optimisation Group, a forum for the UK's infrastructure operators to collaborate across the circular economy theme and to meet the challenge of delivering major infrastructure in a constrained economy.

As a responsible business, and to embed the carbon dioxide reduction agenda further, the client has set a target to reduce emissions from its office estate (e.g. from consuming energy for lighting and heating) and domestic business travel (e.g. UK road and rail journeys) by at least 10% by 2021 (from a 2017/18 baseline). A longer-term target to reduce emissions from the office estate and domestic business travel by at least 50% by 2027 has also been adopted (HS2 Ltd, 2018c). Performance is reported to the Department for Transport on a quarterly basis and, since 2014, performance has been reported publicly on an annual basis in the client's annual report and accounts (HS2 Ltd, 2018d).

In addition, as a further demonstration of leadership and to communicate clearly its intent and desired outcome for carbon dioxide reduction, the client has adopted challenging whole-life emission-reduction targets for phase one of the project. It is a requirement in contracts for civil, station and railway system design and construction contracts in this phase to achieve at least a 50% whole-life carbon dioxide reduction. The target was established in collaboration with other infrastructure client organisations through the Infrastructure Client Group.

Performance against the whole-life reduction target is measured against contract-specific baselines. The study period for the

baselines is 120 years to reflect the new railway's assumed design life. They are quantified and reported following a structure consistent with the principles and life-cycle boundaries set out in BS EN 15978:2011 (BSI, 2011) and BS EN 15804:2012 (BSI, 2012).

A whole-life target for the rolling stock design and manufacture has also been established. The target sets a maximum limit on the emissions associated with the construction and operation of the HS2 rolling stock as follows

- preferred: the life-cycle global warming impact shall be no more than 0.00233 kgCO, per passenger-kilometre
- maximum: the life-cycle global warming impact shall be no more than 0.00275 kgCO₂ per passenger-kilometre.

To support consistent, transparent and robust quantification and ensure carbon dioxide reduction performance is monitored and reported with sufficient frequency to inform decision making and drive continual improvement, the client has developed technical standards detailing the programme's quantification, monitoring and reporting requirements.

The technical standards mandate compliance with best-practice standards and guidance. For rail infrastructure, stations and depots, key references include: PAS 2080 (BSI, 2016a), BS EN 15978 (BSI, 2011), BS EN 15804 (BSI, 2012), BS EN ISO 14040 (BSI, 2006a), BS EN ISO 14044 (BSI, 2006b) (Figure 4). For rolling stock, it includes BS EN ISO 14025 (BSI, 2010) and the Product Category Rules for Rolling Stock (The International EPD System, 2018). The technical standards also require contractors to report performance to the client on a regular basis.

To facilitate the efficient delivery of the programme's requirements, carbon dioxide reporting has been aligned with the client's information management requirements and procedures. It has also procured a life-cycle assessment tool which is being cascaded into the project supply chain with associated user guidance and access to online training.

As a corporate key performance indicator (HS2 Ltd, 2018a), progress against carbon dioxide reduction targets is actively monitored and performance is reported to relevant governance panels at appropriate intervals. This includes reporting reduction performance to the client board and the Department for Transport on a quarterly basis.

The client has adopted several standards that complement the suite of carbon dioxide requirements and further support delivery of the programme's emission-reduction objectives. For example, it has implemented the following.

- Established, embedded and communicated circular economy principles and coordinated the realisation of circular economy opportunities (Charlson and Dunwoody, 2019).
- Set a project requirement for all stations (Figure 5) and depots to achieve 'nearly zero energy' status. The aim is to design and construct buildings that have a very high energy performance, with the nearly zero or very low amount of energy required to operate the building covered to a very significant extent by energy from low carbon dioxide sources – including energy from low-emissions sources produced on-site or nearby.
- Stipulated design features to minimise the energy demand and consumption of the rolling stock.



Figure 4. HS2 green tunnel portals – the client has specified standards covering all aspects of rail infrastructure, including emissions

The client has also established an innovation programme and engaged with industry initiatives to develop and deliver a number of new industry standards and tools to support the programme's



Figure 5. HS2 Curzon Street station in Birmingham – all stations have to achieve 'nearly zero energy' status

carbon dioxide reduction objectives. Examples include the following.

- PAS 2080:2016 Carbon management in infrastructure (BSI, 2016a) as members of the PAS 2080 steering group and technical advisory panel, the client provided input to the development of the world's first specification for carbon dioxide management in infrastructure. The client is aligning its carbon dioxide management system with the requirements and principles of PAS 2080 and has mandated PAS 2080 verification for relevant contractors (e.g. phase one civil contractors). Contractors are also encouraged, by means of a key performance indicator, to procure products and/or services from PAS 2080 verified suppliers.
- Reduce Carbon, Reduce Cost e-learning module the client contributed to the development of a 30 min introductory e-learning module, developed by the Green Construction Board (GCB, 2018), which aims to demonstrate how reducing carbon dioxide reduces costs and makes businesses more competitive.
- The Rail Carbon Tool as members of an RSSB working group the client supported the development and implementation of a free-to-access carbon dioxide quantification tool for the UK rail industry (Brown, 2019).

PAS 8820:2016: Construction materials – Alkali-activated cementitious material and concrete – Specification (BSI, 2016b) – as members of the technical steering group the client informed the development of a performance-based specification for low carbon dioxide cements using alkali activators.

The client has developed a supplier scorecard that is being used during procurement, and delivery, to evaluate supplier performance (HS2 Ltd, 2018b). The scorecard has been designed to align the performance and behaviours of companies within the supply chain with the client's strategic goals and objectives (e.g. to design, construct and operate HS2 to reduce carbon dioxide). Carbon dioxide performance is embedded in the procurement processes and forms part of the procurement evaluation criteria for relevant contracts.

For example, as part of the procurement process for the phase one main work civil contracts, applicants were required to demonstrate, through an exemplar design task, their ability to manage and minimise carbon dioxide emissions associated with the construction and operation of their design solutions. In addition, whole-life carbon dioxide targets and energy performance standards were included in the train technical specification (HS2 Ltd, 2018e) that formed part of the rolling stock invitation to tender. Upon contract award, the whole-life carbon dioxide and energy performance commitments that the successful applicant makes in its bid will become contractual obligations.

Furthermore, the client has implemented contracts that allow for innovation and promote collaboration, which is vital to delivering the new thinking and efficiencies needed to address the challenges of reducing carbon dioxide emissions.

3. Next steps for carbon dioxide management

The next steps for carbon dioxide management aim to embed emissions reduction in the culture of the project and, in partnership with the supply chain, motivate and incentivise positive emissionsreduction behaviours and transformational change. They include the following.

- Develop and implement communication, engagement and training programmes to ensure clear and consistent communication of emissions-reduction objectives, so that carbon dioxide management becomes a matter of basic knowledge for most people and a core competency for some.
- Continue to identify and advance carbon dioxide reduction opportunities within the client's direct control, for example the opportunity to generate and procure low-emissions energy for the operation of the new rail network.
- Continue to improve the carbon dioxide management system to align with PAS 2080 and ensure it remains fit for purpose and drives the desired behaviours and outcomes. This includes establishing science-based emissionsreduction targets, and associated baselines, for phase two and railway operations, and investigating the opportunity for a carbon dioxide management awards scheme to recognise outstanding examples of carbon dioxide management.

The client's next steps for carbon dioxide management aim to embed emissions reduction in its culture and to motivate and incentivise positive reduction behaviours from supply chain partners

4. Lessons learned for other infrastructure projects

One of the main lessons learned on the HS2 project is that the target-setting process provides an opportunity to clarify and assert the relationships between carbon dioxide management and the delivery of the organisation or project objectives. Organisations should take advantage of the process to educate, engage and expand support for the carbon dioxide management strategy and objectives. In particular, they should engage senior leaders and those who will ultimately be involved in achieving whole-life emissions reduction.

Organisations involved in infrastructure delivery should also embed carbon dioxide reduction in procurement and other delivery processes and establish effective governance for reducing wholelife emissions to drive awareness and improve performance. Clients should trust the supply chain to respond positively to the carbon dioxide reduction challenge and encourage their ingenuity and ability to innovate.

The effectiveness of the carbon dioxide management system should be regularly reviewed to ensure it is delivering the desired outcomes and to drive continual improvement. Finally, practitioners should remember that cultural and behavioural change takes time. Clear and consistent communication of carbon dioxide reduction objectives, roles and responsibilities and visibility of emissionsreduction performance are prerequisites.

5. Summary

HS2 Ltd, the client for the planned high-speed railway, has adopted carbon dioxide reduction as a core project value and is committed to minimising the carbon dioxide footprint of the project. Robust and effective carbon dioxide management is therefore a key determinant of the success of the project.

Accordingly, the client has adopted PAS 2080 (BSI, 2016a) as a framework through which to implement its carbon dioxide management approach. Effective leadership and governance, metrics, innovation and standards and commercial solutions underpin the approach, which continues to mature with a number of lessons having been learned.

The client's next steps for carbon dioxide management aim to embed emissions reduction in its culture and to motivate and incentivise positive carbon dioxide reduction behaviours from supply chain partners.

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