CARBON AND NET ZERO IN TRANSPORT SCHEME OPTIONEERING AND APPRAISAL: A SIMPLE GUIDE TO WHAT TO DO

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1 SUMMARY

This paper aims to help and inspire practitioners who already understand the basics of Net Zero, but want to take the next steps in bringing carbon considerations into transport scheme optioneering and appraisal.

In particular, it offers a practical guide for transport planners who may (for example) be aware that carbon calculators, carbon management plans and similar tools exist, but want to know how these should feed into scheme development. What should I do? Where do I start?

The paper first sets out a generic step-by-step thinking process for assessing a scheme's carbon impact. The process breaks down a potentially daunting challenge into more manageable steps. Hints and tips are offered in each step.

It goes on to consider how we can bring carbon into optioneering and shortlisting processes. How do we deal with having a lot of options to consider, and little detail on any of them?

The paper then explains how the carbon inputs may change as the scheme development process continues and firmer numbers become available. It also introduces two helpful new items in English appraisal guidance. The Carbon Summary Table helps us see the carbon impacts in the round, and Spending Objective Analysis helps us look back at the appraisal results to ask: is the scheme actually achieving our objectives? How do we resolve any trade-offs between carbon impacts and other objectives or benefits?

2 INTRODUCTION

2.1 Background

As transport planners we are now generally familiar with the importance of climate change as a global issue, the UK's carbon[1] emissions targets that are set out in law, and the role of transport as a contributor to both carbon emissions and their reduction.

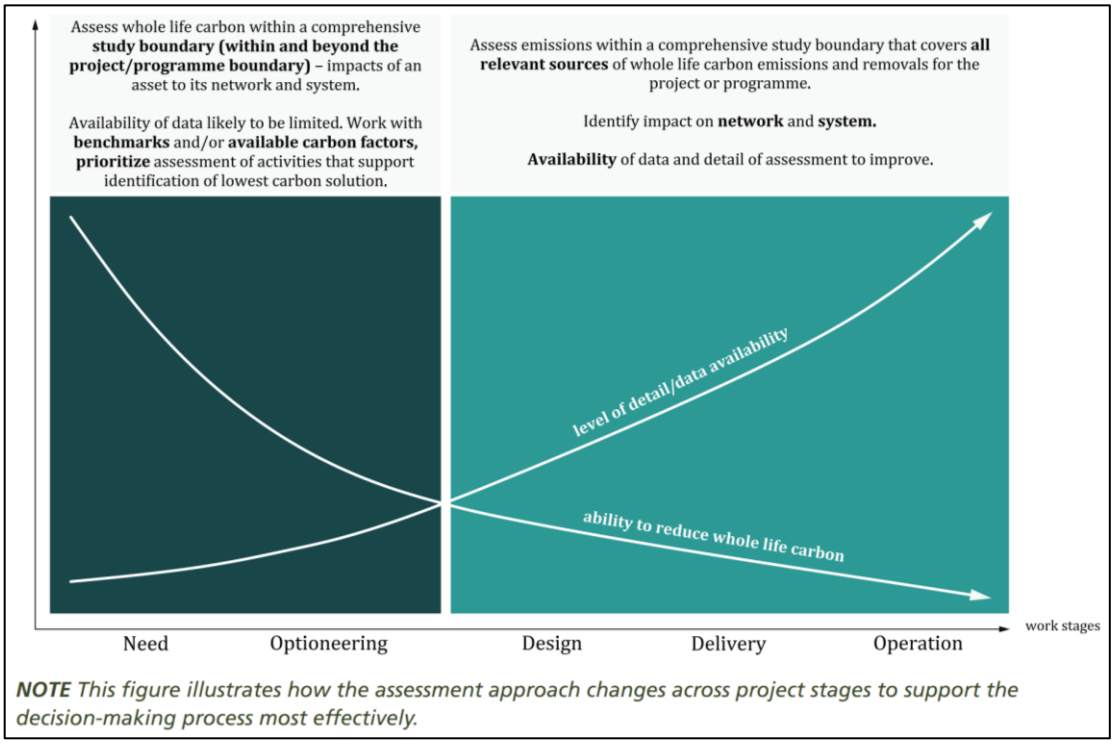
On an individual transport scheme or other intervention, it is now rare for there to be no consideration of carbon impacts. Carbon is generally part of the policy background. Sometimes it is a central issue: the intervention may be primarily about reducing carbon emissions, or there may be a requirement to choose a low-carbon option (or justify an alternative choice). In any case, good engineering practice nowadays seeks to minimise the carbon impacts of the chosen solution, and this is now widely covered in organisational and professional standards and tools across the transport world.

Transport planners take the lead in shepherding transport interventions from a broad problem or policy desire, through ideas, optioneering, option selection and scheme development, into the (more engineering-led) design stages. Our work therefore straddles the gap between net zero aspirations, policies and plans on the one hand, and detailed engineering processes and tools such as carbon calculators on the other.

In bridging this gap, we need to be able to understand, assess and present the carbon impacts of our options and our emerging scheme. There may not be much to go on, particularly in the initial stages when the options or the scheme are not developed enough to (for example) simply run quantities of material through carbon calculators. And we need to be able to feed the carbon considerations into option selection and decision-making.

Indeed our work is critical to the carbon outcomes, as we are in the lead at the early stages when – although the least detail is available – there is the greatest opportunity to influence the result (Figure 1).

Figure 1: The transport planning stages of a project are the ones with the most opportunity to influence carbon outcomes



Source: PAS 2080: 2083 Carbon management in buildings and infrastructure *(British Standards Institution, 2023)*

2.2 Aims

This paper aims to support transport planners who are asked to consider carbon, and perhaps take the lead in assessing the carbon impacts – especially in the early stages of a scheme when a wide range of options are on the table and little design detail is available.

It particularly aims to help transport planners who are familiar with the basics of net zero and carbon issues, but have been 'thrown in at the deep end' or are just trying to make sense of the range of guidance and tools that exist. What do I actually need to do? Where do I start?

The paper is applicable to any transport intervention on any mode(s), but generally focuses on infrastructure investment projects as these are the ones where the challenge can be trickiest. It is written in the English context but the principles apply anywhere. It is consistent with the British standard for carbon management in infrastructure (PAS 2080:2023) (British Standards Institution, 2023) and the accompanying ICE guidance document (Institution of Civil Engineers, 2023).

It seeks to provide not only reassurance that, by breaking the problem down into manageable steps, we can succeed, but also a positive message that we can add value along the way and help to produce well-informed decisions.

The remainder of the paper:

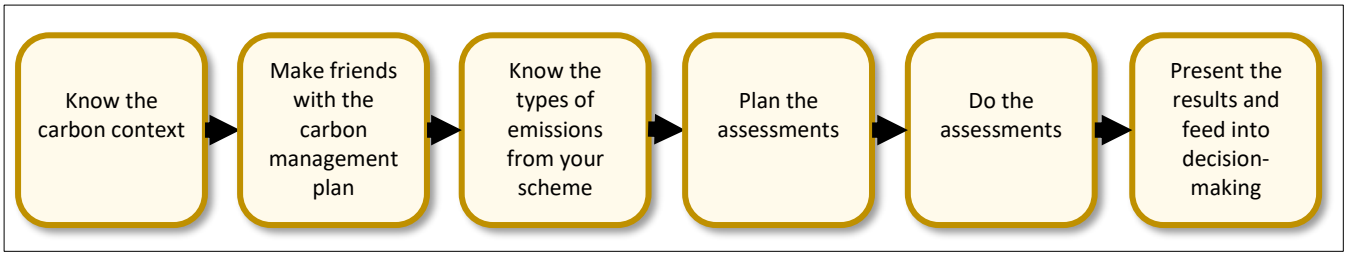
- Sets out a thinking process for carbon assessment (Section 3)
- Suggests how we can deal with carbon in optioneering and shortlisting (Section 4)
- Discusses how carbon appraisal develops as a scheme progresses (Section 5)
- Highlights two important new aspects of English appraisal guidance that should help to present carbon impacts in their own right and in relation to other objectives: the Carbon Summary Table (Section 6) and Spending Objective Analysis (Section 7)
- Offers some conclusions (Section 8)

3 WHERE DO I START? WHAT DO I DO? A THINKING PROCESS FOR CARBON ASSESSMENT

3.1 Overview

This section of the paper gives a step-by-step thinking process for assessing the carbon impacts of a transport scheme or a set of options. The aim is to break down a potentially daunting challenge into manageable steps. Figure 2 summarises the process, which can be adapted to any situation

Figure 2: The thinking process



3.2 Know the carbon context

Assuming that we are already broadly familiar with the basic concepts of Net Zero and carbon policy, we will need to home-in on the specific context for our scheme. We should understand:

- What are the policies and requirements against which the scheme's carbon impact will be tested? These could be national, local or regulatory policies, or a client's own requirements. They might be transport policies, environmental policies, planning policies such as a National Policy Statement, or funding requirements.
- Are there any other wider carbon strategies to which the scheme ought to contribute – such as a corporate net zero plan?
- Is there a carbon-budget-compliant transport strategy in place, and is this scheme part of it (see, for example, Marsden, 2021)?
- Is there a specific carbon goal or objective for this particular scheme? If not, should there be?
- How does the carbon goal relate to other goals? What happens if different objectives pull in different directions? Is the carbon objective a must-have that trumps the others, or is it just one objective to be balanced against others?

Engagement across the project team is often helpful. Colleagues in environmental, planning and other disciplines may have specific technical policy tests or requirements that are worth knowing from the outset.

3.3 Make friends with the carbon management plan

Infrastructure schemes nowadays increasingly include carbon management plans (CMPs). These are about:

- Understanding the carbon footprint of a 'business as usual' scheme design
- Setting carbon reduction targets for the scheme – aiming to deliver a lower-footprint solution than the 'business as usual' design
- Having a management process for driving the carbon footprint down towards the targets as the scheme goes through the design process.

Your project might not have a CMP, if it is non-infrastructure, a strategy exercise, or early-stage optioneering of a wide range of possible solutions – in other words if there isn't a defined 'scheme' yet. If so, it is probably down to us as transport planners and appraisal specialists to take the lead.

If there is a CMP, it might be led by the project management team, the design team or a carbon specialist. It will certainly involve estimating the scheme's carbon impacts, and may be using carbon calculators or other tools to do this. There will be considerable overlaps with what we need for transport planning purposes, so get together with the CMP team and look at what information, tools and analyses can be shared. Essentially the CMP and the appraisal are looking for the same answers, except

that the appraisal will (at least at later stages) take the process one step further by converting amounts of emissions into monetised values.

Although in principle CMPs apply from the start of developing a scheme, they tend to focus on the details of the scheme design. In particular, the carbon calculators typically take in details of exact materials and quantities, which won't be known until quite a way into the design process. It is normal for the CMP to gradually develop over the course of the project, and in the early stages it might just say that the numbers will come later.

As transport planners, however, we often need to understand the carbon impacts much earlier in the process. We can therefore expect to be running ahead of the CMP, and perhaps to need some early answers of our own.

But this is also our chance to feed in to the CMP. We can help ensure that it is not simply an exercise in low-carbon design within a given scheme definition, but properly recognises the opportunities for solutions that do not necessarily need so much infrastructure construction. We are well placed to contribute to the full "avoid-switch-improve" range of options, and (as Figure 1 showed) can influence most at this early stage.

3.4 Know the types of emissions from your scheme

The next step is to know what types of emissions the scheme will create or reduce.

We will be familiar with the basic types of whole-life carbon emissions, such as the PAS 2080 concepts of capital, operational and user carbon. We need to translate these into the specific carbon impacts that the scheme might generate. As inspiration, Table 1 gives some examples for a selection of generic scheme-types.

The tips here are:

- Don't get bogged down in generic carbon guidance that may not easily translate to a transport scheme. It may be easiest to simply think freely and widely about all the scheme's potential carbon impacts – and only then decide what formal category they fall into.
- You might not find any impacts within a particular category. In particular, non-infrastructure schemes (such as fiscal policy changes or public transport service changes) will have no embodied carbon impacts.
- You may think of some potential impacts that you quickly realise are negligible or otherwise not worth considering in any detail.

Some impacts are not necessarily 'emissions' from the scheme itself but are consequential impacts. Mode-shift is a common and routinely-quantified example. In contrast, the carbon impacts of long-term land use change and change in travel patterns, caused by a scheme in its own right or cumulatively with others, also fall into this category but will often be difficult to predict or quantify. We should nevertheless not forget that they may exist.

Table 1: The types of carbon emissions, and examples of how they translate to transport schemes

PAS 2080 category	Type of carbon impacts from a transport scheme	How they might occur in a…				
		highway infrastructure scheme	**rail infrastructure scheme**	**rail timetable enhancement scheme (no infrastructure change)**	**active travel infrastructure scheme**	**fiscal policy on demand management (no infrastructure change)**
Capital (embodied) carbon	Construction (embodied or capital carbon)	• Direct change in land-use • Construction materials • Processes • Plant • Waste/arisings disposal	• Direct change in land-use • Construction materials • Processes • Plant • Waste/arisings disposal	• Nil	• Direct change in land-use • Construction materials • Processes • Plant • Waste/arisings disposal	• Nil
	Decomm-issioning (if relevant)	• Not normally relevant	• Not normally relevant	• Not normally relevant	• Not normally relevant	• Not normally relevant
Operational carbon	Operations and maintenance	Incremental increases in….. • O&M teams & vehicles • Consumables • Cleaning • Winter maintenance • Capital repairs	Incremental increases in….. • O&M teams & vehicles • Signalling and control • Fleet or infrastructure consumables • Station operations • Depot operations • Track renewals	Incremental increases in….. • Fleet or infrastructure maintenance • Signalling and control • Renewals • Fleet or infrastructure consumables • Station operations • Depot operations	• O&M teams, vehicles, consumables. Cleaning, winter maintenance, etc. Capital repairs	• Nil
User carbon	Users' vehicle tailpipe emissions	• Tailpipe emissions from traffic	• Incremental diesel traction emissions	• Incremental diesel traction emissions	• Nil	• Change in fleet mix
	Electricity generation for users' vehicles	• Electric vehicle charging	• Incremental traction electricity usage ('EC4T')	• Incremental traction electricity usage ('EC4T')	• E-bike charging	• Change in uptake of EVs
	Induced demand and mode-shift	• Induced demand	• Induced demand • Mode-shift created	• Induced demand • Mode-shift created	• Mode-shift created	• Mode-shift created
Outside scope of PAS 2080	Indirect land-use change and long-term change in travel patterns	• Impacts on development patterns, urban form • Longer-distance commuting	• Impacts on development patterns, urban form • Longer-distance commuting	• Impacts on development patterns, urban form • Longer-distance commuting	• Impacts on development patterns, urban form	• Impacts on development patterns, urban form
	Embodied carbon in more/fewer vehicles	• Long-term / cumulative increase in car ownership	• Additional rolling stock manufactured	• Additional rolling stock manufactured	• Change in cycle ownership levels	• Change in vehicle ownership levels or replacement behaviour

The possible impacts listed are ideas to help you think through what the emissions might be for any particular scheme. The table is not exhaustive. For any particular scheme, an impact shown here may or may not be present, significant, or proportionate to measure.

3.5 Plan the assessments

Now we understand the impacts to be assessed, we need to understand what data and information we can get on each one, and where we will need to use judgment. What existing or planned assessments can we use? How can we fill any gaps? We may need to mix-and-match.

For any individual impact, you might have (or be expecting to get) a quantitative assessment from a specific process (eg emissions forecasts from TUBA) or as part of a whole-life carbon assessment (eg from an environmental statement). If not, you could:

- Look at comparator schemes and benchmarking data (see section 4.2) to understand the likely scale of impacts
- Make your own estimates from first principles – again to understand the scale rather than trying to produce a firm figure
- Simply make a qualitative judgment on the likely direction and scale of impacts, or say that these are unknown. This qualitative approach may be needed for the more indirect impacts such as long-term land-use change.

Always consider what's proportionate to do. You can use a mixture of formal assessments, comparator cases and qualitative judgments. Where relevant, keep in touch with the CMP team and the environmental team, as some of the assessments will be common to all these teams' needs.

In early stages of projects we often need to use benchmarking or qualitative judgments for the time being. As the project continues, we will get more quantification as we proceed to more detailed analysis on fewer options, and eventually detailed design of a final option (see section 5).

3.6 Do the assessments

Technical details of individual assessment processes are outside the scope of this paper. The universal tip here, for any assessment, is to always put the 'final figure' into proper context, at least in your own mind's eye:

- Is it a big or a small amount, both overall and relative to the other elements?
- What's included or excluded?
- How certain is the final figure? What does it depend on, and what is the range of uncertainty?

3.7 Feed the information into decision-making

How the results can best feed into decision-making will be situation-specific, and you are best placed to judge this for yourself on your own project. There may be a standard process to follow, and standard formats or templates for documentation.

However, the important questions for understanding a scheme's or an option's carbon impacts are fairly universal, irrespective of how this gets translated into decision-

making and documentation. For each type of carbon impact, we need to be able to articulate:

- How (if at all) have we assessed it? What's included and what's not?
- How certain are we of our assessment? What are the key uncertainties?
- What is the impact, qualitatively (in words)?
- And if we can, what is the forecast amount in tonnes and the appraisal value of that?

For the overall total, similar questions apply, along with:

- Are we confident in quoting a single 'carbon number', with caveats if need be, or are we better to present a range?
- Are there any significant unquantified or un-monetised assessments that should not be forgotten?

It is important to understand the direction, relative scale and level of certainty of each impact: more so than the precise detail of a particular number. And as so often, 'roughly right' is better than 'precisely wrong'.

Presenting the uncertainties is important. For example, if choice of materials is key to the carbon impact, the decision-makers ought to know this, especially if there is a trade-off with cost or other factors.

4 CARBON IN THE OPTIONEERING AND SHORTLISTING PROCESSES

Initial generation, assessment and shortlisting of options for a potential transport scheme is a routine part of transport planning. We are increasingly taking carbon emissions into account at this early stage, bringing it into multi-criteria assessment frameworks (MCAFs) and considering it when assessing each option.

4.1 Bringing carbon into the assessment criteria and MCAF

We may be given a set of objectives or criteria that includes one on carbon. It might be a scheme-specific objective, or in a set of wider policy goals that are also be treated as objectives. We might then have to work out how it translates into scoring criteria. This is a familiar task for us as transport planners; carbon is not necessarily different from other criteria in this respect. Understanding the carbon context (section 3.2) will help: what's the policy goal, how might our scheme contribute (or not), what's the scale of the goal and how significant might the options be towards it? Ideas for a scoring regime will flow from this.

If we are given a set of objectives or criteria that *don't* include carbon, then we may want to query this.

If it is up to us to create appraisal criteria, how does carbon fit in? We typically think about three types of criteria:

- Scheme-specific objectives – these can be criteria in their own right
- Deliverability-related criteria, such as cost and stakeholder acceptability.
- Wider policy goals or commitments that our scheme needs to support. Carbon can often fall into this category, with local and/or national net zero policies. This is another good reason for being familiar with the carbon policy background.

More general aspects of MCAF work are outside the scope of this paper, but an earlier paper (James, 2018) provided a number of hints and tips.

4.2 Assessing the options

In assessing carbon impacts at this stage of a project, there can be a lot to deal with, and little information:

- A large number of options – and potentially a lot of work to assess them all in any detail
- Options may be very loosely defined, with little hard information on which to base a carbon appraisal: eg no bills of quantities to run through a carbon calculator, or no traffic modelling. Are we therefore just guessing?
- The options maybe very wide-ranging. For example, there might be a mix of highway, public transport and behaviour change options.

The only practical approach is to be proportionate and pragmatic. We assess whatever we can, as best we can.

This goes back to the thinking-step of: what assessments do we have? What extra assessments should we do? What can we realistically do? What are the important impacts to focus on? It is a mistake to think we need detailed carbon calculations for everything based on bills of quantities (for example). We simply do what we can, most effectively within the time and budget available. This pragmatic way of thinking, applying our expertise and judgment, is what we do routinely as transport planners. And in the new carbon context, the more we do it, the easier it will become.

Benchmarks and comparators are most helpful at this stage. Although not perfect, they can be a quick way of getting a sense of scale: will it be 1 tonne, 100 tonnes or a million tonnes? Does our scheme deliver (for example) one percentage point of a 15-20% traffic reduction target, or just a trivial amount? The information could come from:

- Published benchmarks, such as those produced by Decarbon8 (Lokesh et al, 2022a, 2022b)
- Strategy-creation tools (sometimes called 'playbooks') that aim to estimate the carbon impacts of different types of policy or scheme
- Similar projects that have been implemented
- Similar projects that, although not yet implemented, are further ahead in the development process and have more-refined figures available

As time goes on, more of this information will become available.

If suitable benchmarks and comparators are not available, we will have to use our judgment to understand the likely scale of a scheme's impact, even if we cannot put numbers to it.

The biggest tip here is to be realistic about the relative scale of each impact. For example, if considering a major highway scheme with a parallel cycle track, there may be a carbon reduction from mode shift to cycling, but a carbon increase from embodied carbon and induced traffic emissions. There may be a temptation to see these as balancing each other out and producing a neutral impact, but this is unlikely to be the case in reality. We need to use our expertise to consider the scale of each impact and where the balance really lies.

5 CARBON APPRAISAL AS THE SCHEME PROGRESSES

As the scheme development process continues, the number of options reduces to a shortlist or a single preferred option, and the appraisal generally becomes more detailed and more numeric.

In terms of understanding the carbon impacts, the balance will shift away from what we did in the early stages (with transport planners often in the lead and making initial carbon estimates), towards a more intensively multi-disciplinary design and assessment focus. Technical disciplines will be providing inputs such as traffic modelling, TUBA results or environmental assessments. There will be increasing levels of design detail available.

Thus gradually, the initial assessments, comparators or qualitative statements will be replaced with actual figures based on the scheme's own details. For example, there will often be traffic modelling to give us the tailpipe emissions, and the construction material quantities can be run through a carbon calculator to get the embodied carbon. These numbers can slot into the carbon appraisal to replace the early estimates. Design changes will hopefully be about tweaking the design, materials and methods to manage-down the carbon impacts, and these can again feed in.

If not done already, the appraisal team will, where possible, be converting the quantified carbon impacts into monetary valuations that contribute to the emerging benefit-cost ratio (BCR). This uses values (£ per tonne emitted or saved) published in the DfT's Transport Analysis Guidance (TAG) Databook. All carbon impacts, whether positive or negative, come under the 'benefits' side of the BCR: a carbon increase will have a negative value (a 'disbenefit') and a decrease will have a positive value.

It is worth knowing that under TAG guidance until 2023, the embodied carbon impacts[2] were not valued and included in the BCR. This has changed and they are now to be included alongside the operational and user impacts.

Ultimately, we still need to answer the key questions: what actually is the carbon impact (and how sure are we about it)? And is that impact helping with our objectives? The next two sections cover important and relatively new elements of TAG that

address these questions. They are worth understanding even if you are not doing the appraisal yourself. And even if you are not following TAG rules, the underlying information and the thinking they represent are important parts of bringing carbon into decision-making.

6 THE TAG CARBON SUMMARY TABLE

The Carbon Summary Table (CST) (Department for Transport (DfT), 2023a) is a recently-introduced element of TAG, and should soon be appearing in all scheme appraisals and business cases. A full description of the CST is beyond the scope of this paper; this section simply introduces its role in summarising the results of the carbon appraisal work.

The CST (Figure 3) brings all the carbon impact information together in one place. Hitherto, this was not the case and it was not always easy to get a complete picture of the carbon impacts. TAG now asks for the CST to be completed for all shortlisted options as part of an appraisal. I would regard it as being an essential summary table alongside the familiar ones such as the Appraisal Summary Table (AST).

The CST includes the carbon impacts in quantified (tonnes) and monetised (£ value) terms, split between the traded and non-traded sectors and by carbon budget period. It asks for a narrative summary of the carbon impacts including information on any unquantifiable and/or non-monetisable carbon impacts, and any quantitative analysis on uncertainty. It also asks for a summary of the methodology used and the assumptions.

Essentially the CST is documenting the carbon appraisal process, results and uncertainties. DfT has provided specific guidance in the CST's 'explanation' tab and in TAG unit A3 Appendix D (DfT, 2024). The guidance confirms that the CST reporting should be proportionate to the business case stage and the availability of appraisal outputs. It should not need any information that we would not already have. For example, at the Strategic Outline Business Case (SOBC) stage, we might only be able to complete the qualitative elements.

Figure 3: The TAG Carbon Summary Table

Carbon Summary Table: Preferred Option

Price Base Year	
Name of Scheme and Option	
Preferred Option Cost (PVC) (£)	

Appraisal Period		Net Carbon Impact (£)		Net Carbon Impact (tCO2e)	

Whole Life Carbon Breakdown	User carbon (tCO2e)	Capital carbon (tCO2e)	Operating carbon (tCO2e)

Cost Effectiveness Indicator (CEI) *(£/tCO2e)*	
Weighted Average Cost Comparator (WACC) *(£/tO2e)* *(benchmark for cost effectiveness indicator)*	
Comparison of CEI and WACC and interpretation	
Carbon Efficiency Metric and Interpretation	

Disaggregated Net Carbon Impacts		Carbon Budget breakdown			
Net non-traded carbon impact *(tCO2e)*		CB4 *(2023-27)*	CB5 *(2028-32)*	CB6 *(2033-37)*	*2038 - end of appraisal period*
Net traded carbon impact *(tCO2e)*		CB4 *(2023-27)*	CB5 *(2028-32)*	CB6 *(2033-37)*	*2038 - end of appraisal period*

Sensitivity analysis	Net Carbon Impact (£)	Net Carbon Impact (tCO2e)
Scenario X *(rename for scenario used and add as many as needed)*		
Scenario Y *(rename for scenario used and add as many as needed)*		

Summary of carbon impacts
Narrative that outlines the proposal's greenhouse gas impact, information on any unquantifiable and/or non-monetisable carbon impacts, and any quantitative analysis on uncertainty

Summary of methodology and assumptions
Model used, assumptions, risks, uncertainty, version of TAG databook, GHG/carbon values, Emissions Factor Toolkit version (if applicable), Active Mode Appraisal Toolkit version (if applicable)

Mitigations
e.g. planting of habitats to increase carbon storage and offset disbenefits, reduction in traffic locally leading to improved air quality benefits etc.

Instructions and Notes:
*Where appraisal outputs are not available but scheme impacts are considered relevant, values should be reported as "unquantified"
*Where information is not relevant to the appraisal, it should be marked "N/A", with a justification for why the information is not applicable
*SOBC expectation: Summary of Carbon Impact and Mitigations boxes to be filled
*OBC/FBC expectations: Full template completed accounting for proportionality and the availability of appraisal outputs
* Explanations tab of this spreadsheet explains where to find more information on each of the metrics
* All metrics in (£) unit are to be reported in NPV terms

Source: DfT, https://www.gov.uk/government/publications/webtag-appraisal-tables This extract shows the template table for the preferred option. There is a similar, simpler, table for other assessed options.

7 SPENDING OBJECTIVE ANALYSIS

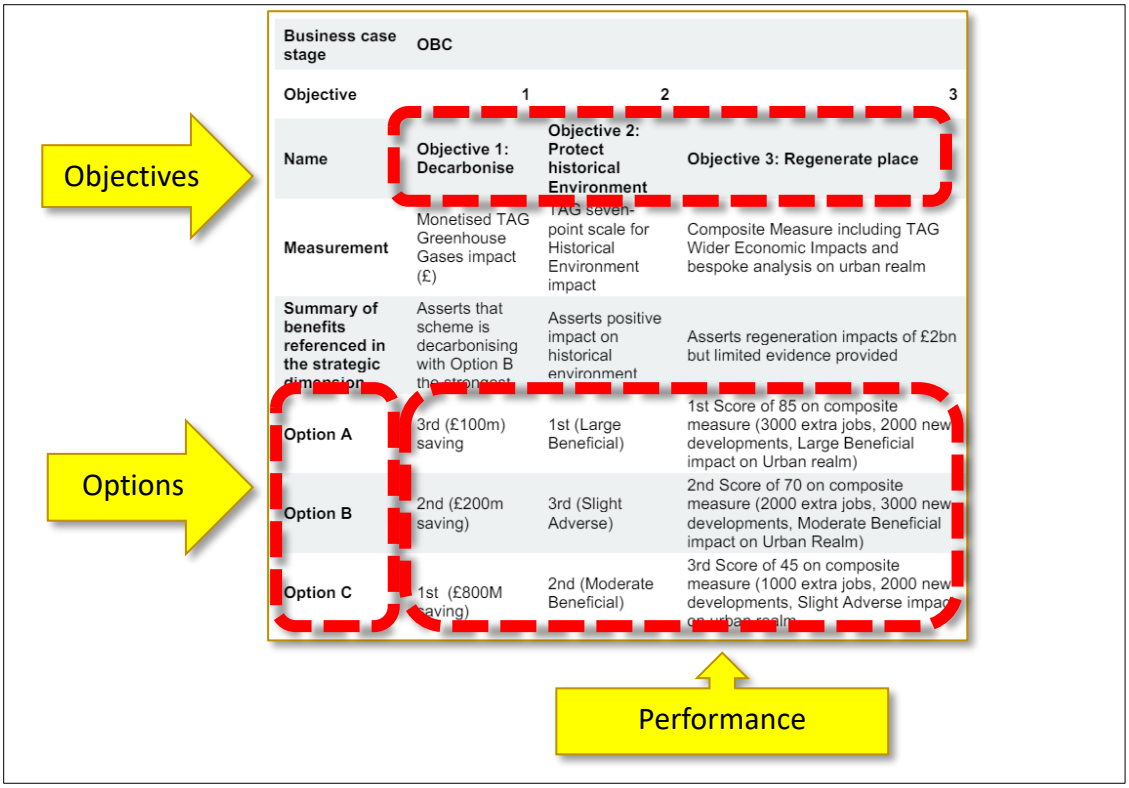
Another recent and valuable development in TAG is the new guidance on spending objective analysis (DfT, 2023b). Again, a full description of this is beyond the scope of the paper; this section just covers its relevance to carbon.

Spending objective analysis is about tying the appraisal results (in the economic case) back to the scheme objectives (in the strategic case) to show how well the scheme or the different options actually meet those objectives. Is it actually meeting the objectives? All of them, or just some?

The analysis is to be an evidence-based narrative of the proposal's contributions to strategic aims. It complements, and should be considered alongside, the traditional economic aspects. Indeed it is not a new set of analysis, but draws on the economic case results and the strategic case.

The key new concept is the Spending Objective Analysis Statement (SOAS). This is a narrative summary (based on the appraisal evidence) of the impacts on the scheme objectives, and any trade-offs between options. It starts with an initial presentation of those impacts, including each option's absolute performance and ranking their relative performance. The guidance recommends presenting this in a table, and gives an example (Figure 4). For each objective, what does each option do and where does it rank?

Figure 4: The TAG recommended SOAS table format



Source: DfT (2023b). Author's emphasis.

This is important. A scheme could, for example, be delivering well against a 'congestion reduction' objective, but (with its embodied carbon) deliver poorly against a carbon-reduction objective. Or it could be the other way round; or it could be delivering well against both.

The SOAS therefore brings the carbon 'answers' back to what they mean for option selection and ultimately a 'go / no-go' decision for the scheme. If carbon was an objective, are we actually delivering on it? Or are we delivering something else, with our eyes open in the knowledge that we're not delivering on carbon in this particular scheme? And if so, is that acceptable? Likewise, if our preferred option is delivering less on carbon than another option would, but is delivering more on other objectives instead, the trade-off being made will be clear.

8 CONCLUSION

This paper has set out a step-by-step thinking process for carbon assessment that transport planners can adapt to any transport scheme. It will be particularly helpful in the early stages of a project if we are asked to consider carbon, and perhaps take the lead in assessing the carbon impacts, when a wide range of options are on the table and/or little design detail is available. A key message is that we should be proportionate, and can 'mix-and-match' techniques to cover the full range of significant impacts as is most practical. We can start with initial estimates or ranges, based on benchmarking or comparators, and replace these with increasingly precise calculations as the scheme develops.

The paper has also set out how we can bring carbon into early option assessment and selection processes, and how (as the scheme develops) the carbon information can be refined until we have a fully mature understanding of the carbon impacts alongside other scheme impacts. We can then see how the carbon performance relates back to the original objectives.

We can therefore not only succeed in understanding and presenting a scheme's impacts, but also add value along the way and help to produce well-informed decisions.

9 ACKNOWLEDGEMENTS

The author is grateful to Galle Saliman for permission to present the paper. All opinions are nevertheless the authors' own.

NOTES

[1] 'Carbon' is a shorthand term. The climate change issue relates to a range of greenhouse gases, the main one being carbon dioxide (CO2). Emissions of other gases are measured in terms of what the equivalent impact from CO2 would be, and hence emissions figures are given in "CO2 equivalent" (CO2e).

[2] Strictly speaking, this point applies to traded sector emissions – that is, emissions from the production of materials that are covered by the UK or EU emissions trading schemes. As a generalisation, however, this corresponds broadly to the embodied carbon in most cases.

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