5.Influence the brief

Low-carbon outcomes in the built environment

Tim Chapman and Ian Firth highlight the carbon differences between civil structures and buildings projects, and propose that engineers work with their clients to target low-carbon outcomes, rather than just low-carbon structures.

In carbon strategy terms, there is a big difference between infrastructure and buildings. While 'build less' is a useful guide for both – and is nearly always right to do for buildings – for infrastructure, sometimes it is just plain wrong.

In the UK, the Climate Change Committee's 6th Carbon Budget[1] has set out in greater detail than ever before the vital steps that we need to take to transform our whole society from one utterly dependent on fossil fuels to one that can operate at net zero.

We need to make this colossal transformation in a way that preserves living standards and basic rights such as respect and equality – partially because they are the right things to do, but also because broad and consistent public support for the measures needed is vital.

As well as lots of renewables, we need big new safe nuclear power stations to fuel our decarbonised electricity grid when the wind isn't blowing; we need big new stations and new railways and electrification of old lines to encourage mode shift away from private cars; and we need whole new industries to produce low-carbon hydrogen, and to capture carbon from the air.

Making any of these a bit smaller without considering the bigger picture just increases the risk that we will tip into irreversible climate change that will plague living conditions for our grandchildren. We need to invest our scarce carbon wisely to create a new paradigm.

What matters are the *outcomes* rather than the outputs – *how* the asset will be used (and its impact on society), not just *what* the asset is. Often, in infrastructure, the lead designer is the engineer. It is therefore up to the engineer to steer the design team towards the most important decisions to achieve the best outcomes. Time is short and every decision matters now.

Whole lifecycles

We replace our infrastructure systems slowly, perhaps 1% or less per year in the developed world, so we need to make the right choices for each and every one of them. In the developing world, the problem is even more acute, with whole new infrastructure systems being created almost overnight. Those need to be chosen more wisely and not just emulate poorly chosen and much regretted systems from the developed world.

Engineers need to help clients everywhere understand how their project can be made even more successful by positively contributing to a lower-carbon world. This can only be done in whole-carbon terms – examining the full lifecycle. The UK standard PAS 2080[2] provides the framework in which these decisions can be made clearer – by breaking carbon down into **capital carbon** (CapCarb, the carbon to create the asset, the infrastructure equivalent of embodied carbon), **operational carbon** (OpCarb, the carbon taken to operate the asset) and **user carbon** (UseCarb, what society does with the asset).

> "WE NEED TO INVEST OUR SCARCE CARBON WISELY TO CREATE A NEW PARADIGM

As an example for a new road, the CapCarb builds it, the maintenance and lighting are OpCarb, and all the drivers taking benefit of it are UseCarb – which depends on the sorts of vehicles they drive.

Sometimes society judges some uses to be more virtuous and some less so. The road by itself is neither virtuous nor non-virtuous – but clearly a road that enables a region to develop and provide opportunities to its younger people to reduce emigration is good, whereas a new road that encourages shoppers to abandon a successful town centre and go out of town is less so.

A new airport runway that enables a developing country to export its produce and partake in the world economy may be justifiable, but a new runway that only encourages more people to take frivolous holidays is less virtuous.

To help us understand where most savings can be made, we can examine the most up-to-date emissions for the UK **(Table 1)**.

These data show the vital importance of reducing Total Carb – we always

TABLE 1: UK carbon emissions data for infrastructure*

	CapCarb	OpCarb	UseCarb	Total Carb
	[$MtCO_2e$/year]			
Comms	0.8	0.6	1.2	2.6
Energy	4.4	59.5	132.0	195.9
Transport	3.8	0.2	168.7	172.8
Waste	0.05	18.8		18.8
Water	1.1	4.3	17.6	23.0
Total	10.2	83.4	319.5	413.1

* 2018 data courtesy of Dr Jannik Giesekam of Leeds University's contribution to the ICE's Carbon Project, published in the ICE's 2020 Unwin Lecture (www.ice.org.uk/eventarchive/2020-unwin-lecture-zero-carbon-webinar).

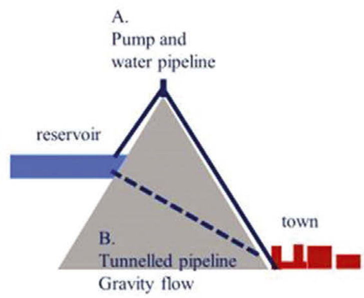
How does that work?

Consider two options to feed water to a town

Option	CapCarb	OpCarb per yr (units)	TotCarb (50yrs)
A	20	10	520
B	100	2	200

Option A has lowest CapCarb (and CapEx)

Option B has lowest TotCarb (and TotEx)



↑FIGURE 1: Example of carbon values for two options to supply water to town

need to be careful with CapCarb, and in building projects, this may be a very significant part of the total – but for infrastructure systems, the biggest prize is helping society to decarbonise its overall systems, so altering our electricity generation, transport and heating systems rapidly to become decarbonised.

The Cabinet Office's newly issued *Construction Playbook*[3] and the new version of the Treasury's *Green Book*[4] are helpful in this regard – concentrating far more on whole-life value and outcomes than just lowest tender sum – and thus should enable better solutions to be chosen by government to build.

Figure 1 shows an example which illustrates the case for a water supply to a town, with two options: pumping the water over the mountain with higher OpCarb but lower CapCarb; or a tunnelled system through the mountain with lower OpCarb but higher CapCarb. In the example, one is cheaper both for carbon and money in the immediate term, while the other is cheaper for both in the longer term.

Of course, there are many other factors to consider (not least that decarbonisation of electricity might allow the pumped option to use decarbonised power in the future and so become more virtuous), but it illustrates the point that you cannot look at one aspect of carbon independently of the others, particularly not for infrastructure projects.

Implementation

Finally, how this takes place is also important – if we are creating the basis for a new society, we need to make one that people aspire to live in, that is fair and just. Fuel taxes offer apparent advantages, but are often problematic in how they can be implemented. It would be wrong, for instance, just to tax home heating, as the outcome would be huge numbers of deprived people living in fuel poverty and many potentially freezing to death in winter. Instead, we need a huge programme to insulate all homes in the UK so that people can better afford to heat their homes using lower-carbon means – perhaps green or blue hydrogen or perhaps by heat pumps drawing power from the decarbonised grid.

Among these macro-drivers, there is huge scope for even better engineering of projects:

- We need to be far more open to whole-life principles and embrace the opportunities for a circular economy far more than we currently do; engineers need to challenge the brief more – this will also need a radical change in mindset and standards. Reducing CapCarb will always be very important – and an area in which engineers can contribute more. The UKGBC cites a total UK CapCarb for infrastructure and buildings of 48Mt for 2014[5] – and we must devise new and better ways to build for those things that need to be built.
- We need to design for future flexibility more, so that our structures have second and third lives. We already do this for the few new car parks that are being built – but we need to think how every structure in which we invest much carbon can be repurposed usefully. We should continue to design for structures to be useful for longer lives – think for 100 years and far more, not just 30 to 50 years.
- Adaptability is more important than ever. With a long service life and rapidly changing technologies, we should be designing our transport infrastructure, for example, in the light of predictable changes in modes of transport.
- Designing for longer life doesn't mean being profligate in materials – ghastly clunky structures please no one, neither aesthetes nor carbon warriors – there is always a place for elegant design.

So, in discussions about which big infrastructure schemes to promote, we believe that engineers should use their place at the centre of the decision-making process to ensure holistic thinking to create total infrastructure outcomes for society that:

- embrace long-term, low-carbon outcomes
- are carried out in a way that respects communities and nature and enables both to flourish in their wake
- still convey the joy of great, elegant design that future generations can appreciate.

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