
PROOF OF EVIDENCE OF
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ON BEHALF OF
GWENT WILDLIFE TRUST

In the matter of:
Public Local Inquiry into the M4 relief road around Newport: **The
Economic case: jobs, inward investment and regeneration**

February 2017

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1 QUALIFICATIONS AND EXPERIENCE

1. My name is John Whitelegg. I am a Visiting Professor in the School of the Built Environment at Liverpool John Moores University and a transport consultant.
2. My professional background is geography, economic development and as an economic development officer in a UK local authority.
3. My PhD was in the area of industrial location theory and change over time in the opening, closing, decline and growth of the firm
4. I have worked on transport projects for over 40 years, written 10 books on transport and now edit the journal "World Transport Policy and Practice". The projects include ex-post evaluation of job creation and inward investment following new highway and motorway investments, the impact of new highways on air quality and greenhouse gases and the performance of non-highway building measures on reducing congestion and pollution and stimulating local economic performance.
5. I have presented evidence on various matters at the public inquiries into the Birmingham Northern Relief Road, the Heysham M6 link, the Broughton (Lancashire) Bypass, Heathrow Terminal 5, Manchester Runway 2, Redhill Aerodrome, the Thames Gateway Bridge, Walton Bridge (Surrey), the Westbury Bypass and the BAA appeal against the decision of Uttlesford District Council to refuse planning permission for the expansion of Stansted Airport.
6. I am an advisor to the World Health Organisation on road safety and the author of transport strategies and plans for Kolkata (India) and Beijing (China).

2 SCOPE OF THIS EVIDENCE

7. My evidence will cover the following 4 topics
 - a) Road building on the scale suggested around Newport is incompatible with sustainability considerations and objectives. I identify specific Welsh Government policy statements and documents that demonstrate this incompatibility.

- b) New road building generates new traffic (so-called “induced traffic”) and adds to congestion problems in and near urban areas and city regions. This additional congestion defeats the economic justification/rationale for new roads and additional road capacity is “consumed” by trip purposes not directly related to a strong local economy.
- c) The evidence nationally and internationally is very clear and new road building is just as likely to drain jobs away from a local economy as it is to attract them.
- d) The principles that underpin Transport Appraisal have not been followed. The road building option has achieved a dominant position in a wider discussion of regional economic, public health and sustainability when the non-road building options have not been clearly specified or “worked up” in sufficient detail to be tested against the road building option.

3 ROAD BUILDING ON THE SCALE SUGGESTED AROUND NEWPORT IS INCOMPATIBLE WITH SUSTAINABILITY CONSIDERATIONS AND OBJECTIVES

- 8. Following on from the Paris agreement on climate change¹² and the acceptance by the UK government of the need to keep temperature increases to no more than 2 degrees Celsius and to aim for no more than 1.5 degrees Celsius, the issue of CO2 reduction is one of the most important public policy and sustainability issues that any national or devolved government has to pursue.
- 9. The Welsh Government (WG) has acknowledged the importance of climate change in its legislative programme. The title on the WG website summarises the policy imperative very well indeed: ‘Reducing Welsh emissions’.³
- 10. The M4 relief road around Newport will add 980,000 tonnes of Carbon Dioxide, the main greenhouse gas implicated in climate change.
- 11. WG state very clearly:
 - ***“Climate change is one of the biggest challenges facing the world in the 21st century and brings with it significant economic, social and environmental consequences. It is not just***

¹ The Paris Agreement http://unfccc.int/paris_agreement/items/9485.php

² Welsh AMs endorse Paris Agreement <http://www.bbc.co.uk/news/live/uk-wales-politics-37768005>

³ Reducing Welsh emissions <http://gov.wales/topics/environmentcountryside/climatechange/emissions/?lang=en>

*an issue that will affect future generations, but one that is already impacting us in Wales... **Wales has taken what we believe is a game-changing step by laying the foundation for our future in the Well-being of Future Generations Act** earlier this year. By doing so, we have become one of the first nations on Earth to formally place sustainable development at the heart of our public services and legislate for a set of clear goals – linked to the UN’s Global Goals – that set a clear path to a sustainable future. And with our Environment Bill, we are now going further as one of the first State or Regional Governments to propose legislation for carbon budgeting”⁴*

- The Environment (Wales) Act 2016 **“places a duty on Welsh Ministers to set targets for reducing greenhouse emissions and also to set carbon budgets.** This will help to accelerate progress against our headline targets and will help build resilience in our environment to extreme weather events. **Statutory targets and a more robust governance framework will allow us to better evaluate progress and provide certainty to help drive investment for a low-carbon Wales...** Part 2: Climate change – provides the Welsh Ministers with powers to put in place statutory emission reduction targets, **including at least an 80% reduction in emissions by 2050 and carbon budgeting to support their delivery.** This is vital within the context of **our existing UK and EU obligations and sets a clear pathway for decarbonisation.** It also provides certainty and clarity for business and investment.”⁵

12. Opting for the M4 relief road when there are many alternatives to a huge addition to the greenhouse gas inventory does not align with the declared policy objective of “accelerating action to tackle [it] across all sectors”. In the transport sector a decision has been taken to make things worse and the case of the M4 relief road does not deal with the rejection of low carbon/zero carbon options and the insertion of a “carbon maximum” option.

13. The main heading on the WG website “Reducing Welsh Emissions” would be far more accurate if it were re-worded to read “Reducing Welsh Emissions but not yet and not in the transport sector and not in South East Wales”.

⁴Minister to highlight pioneering Welsh approach to tackling climate change in Paris <http://gov.wales/newsroom/environmentandcountryside/2015/151203-minister-to-highlight-pioneering-welsh-approach-to-tackling-climate-change-in-paris/?lang=en>

⁵ Environment (Wales) Act Welsh Government Factsheet <http://gov.wales/docs/desh/publications/160321-overview-en.pdf>

14. A report from a group of independent researchers at the University of Leeds and prepared for the national Committee on Climate Change examined the relationship between carbon emissions and the cost of major infrastructure projects (See Annex 1).⁶
15. There are two sources of greenhouse gases from the M4 relief road. The first is so-called “embodied” greenhouse gases and this is described in the above report. The second is operational greenhouse gases (vehicle exhaust emissions). This second category is not discussed here but is referred to in paragraph 37.
16. Embodied emissions are the full supply chain emissions associated with the initial creation of an asset. Typically this includes emissions from: raw material acquisition, transport, processing and manufacturing of building materials; distribution of materials to site; and energy used on-site in assembly. In the infrastructure sector these are commonly referred to as capital carbon emissions to accord with the concept of capital cost.
17. Embodied emissions do not include operational emissions which in the case of the M4 relief road will be the greenhouse gas emissions generated by the traffic using the new road and as I show in section 4 of this proof of evidence these greenhouse gases will be larger than those associated with current traffic levels because of the phenomenon known as “induced traffic”. New roads generate new traffic and this is discussed in s4.
18. Embodied greenhouse gases can be very accurately calculated by a methodology that is in the public domain and described in the Leeds University report. It is not described here.
19. The key findings are summarised in Table 3:

Table 1: Carbon intensity, spend and embodied emissions of the UK’s NIP to 2021

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Carbon intensity (kgCO₂e/ £)	1.11	1.09	1.08	1.06	1.04	1.03	1.02	1.01	0.99	0.98
Total NIP expenditure minus wages at 2010 prices (£M)			27,184	28,314	24,386	24,074	25,194	19,512	19,045	71,451
NIP expenditure minus wages at 2010 prices (£M) for projects under construction			23,963	20,779	15,134	13,135	11,133	4,945	4,755	6,856
Embodied emissions for desired expenditure (Kt CO₂e)			29,334	30,120	25,580	24,906	25,194	19,670	18,929	70,098
Embodied emissions for projects under construction (Kt CO₂e)			25,857	22,104	15,875	13,589	11,363	4,980	4,726	5,726

NIP= National Infrastructure Pipeline

20. I have assumed that the cost of the M4 relief road is “approximately £1 billion”⁷ but I am aware that new road construction very often exceeds the cost estimates that are fed into the Benefit:

⁶ Scott, Gieseckam, Owen and Barrett (May 2015) Embodied greenhouse gas emissions of the UK National Infrastructure Pipeline, Sustainability Research Institute, University of Leeds

Cost Assessment (BCA) and as a consequence the BCA used to inform the approval process is over-optimistic. I am also aware that FoE Cymru estimate a total cost of £2.3 billion.⁸ For ease of calculation and subsequent ease of uplift I will take the “approximately £1 billion” cost estimate as the basis for calculating embodied greenhouse gas emissions.

21. Referring to table above from the Leeds University report we can see that the calculation produces an estimate of embodied kgCO₂eq of 0.98 per £spent (2021 estimate). I therefore calculate that the embodied CO₂ in the M4 relief road is 1 billion x 0.98kg= 980,000,000 kgs or 980,000 tonnes.
22. If the out-turn cost of the M4 relief road should be greater than the estimated cost of “approximately £1 billion” then the 980,000 tonne CO₂ burden calculation can be adjusted. In the case of the FoE Cymru estimate it would be multiplied by 2.3.
23. This additional burden of 980,000 tonnes of CO₂ is an avoidable and unacceptable move in the wrong direction. Numerous UK and WG documents have emphasised that we must achieve an 80% reduction in greenhouse gases on a 1990 base by 2050. This huge additional burden makes this task much more difficult than it need be and is directly contrary to the intentions, aspirations and objectives of The Environment (Wales) Act 2016.
24. The point I am making was very clearly put by Paul Stinchcombe QC of 4-5 Grays Inn Sq (now at 39 Essex Chambers) at the Stansted Airport public Inquiry on 30th May 2007:

We invite you in particular, to reject the two arguments advanced in Mr Rhodes’ evidence⁹ for ignoring the carbon emissions of the Appellant’s proposed increase in aviation: first, that climate change is not an issue to be addressed in individual planning applications because the effect on global temperatures of any individual proposal, even the thousands of additional flights that the Appellant proposes, would be insignificant; and second, that aviation emissions are properly to be addressed by other means in any event, the introduction of aviation into international carbon emissions trading as contemplated by The Future of Air Transport Progress Report¹⁰.

So far as the first argument is concerned, Mr Rhodes is simply wrong. The carbon emissions of any proposed development is manifestly a material planning consideration to be taken into account when deciding whether or not it should be permitted. Moreover, it is especially so in an application such as this, whereby permission is sought to increase aviation - known to be a major contributor to global warming. In particular,

7 <http://gov.wales/topics/transport/roads/schemes/m4/corridor-around-newport/?lang=en>

8 http://m.southwalesargus.co.uk/news/14343225.M4_relief_road_will_cost__2_3_billion_say_environmental_campaigners/

9 Rhodes [BAA/1/A] at paras 14.8-20.

10 [CD/88].

the proposed expansion at Stansted would emit in the range of 2.124m tonnes to 4.248m tonnes of additional CO₂e (carbon dioxide equivalent)¹¹. Quite simply, that has to be a relevant consideration to take into account, given the consistent thrust of every recent policy document - that global warming is a threat of such gravity that we must make decisions now to dramatically reduce emissions, not increase them incrementally.

Indeed, Mr Rhodes' first argument is a paradigm of the incrementalist approach which so threatens the environment. Rather than take into account the carbon emissions of all proposed developments, he would have us take into account the carbon emissions of none since individually they will make no measurable difference to world temperatures.

The Government will not achieve its carbon emissions targets that way. It might, however, if it decides not to pander to the unconstrained demand to fly, but seek instead to test rigorously any such proposal against the evidence adduced in each particular case of economic need and benefit.¹²

25. This departure from legislative intention is a serious matter. It is even more serious that it is a specific WG decision made in the full knowledge that there are many low carbon and zero carbon alternatives to the most damaging option, the one that is before this Inquiry. This perverse and unreasonable decision brings the whole UK and WG effort on climate change into disrepute and should be brought to a halt

26. I suggest that on these grounds the M4 relief road should be rejected.

27. At this point and to avoid duplication I would refer the Inquiry to the evidence submitted by Sophie Howe which I fully endorse and support.

4 NEW ROAD BUILDING GENERATES NEW TRAFFIC (SO-CALLED “INDUCED TRAFFIC”) AND ADDS TO CONGESTION PROBLEMS IN AND NEAR URBAN AREAS AND CITY REGIONS

28. Professor Phil Goodwin, one of the UK's leading transport experts, a government advisor and a member of the Standing Advisory Committee on Trunk Road Assessment has described the phenomenon known as “induced traffic” or more commonly as “new roads generate new traffic”. He says:

It was way back in 1925 that the opening of a new section on the Great West Road demonstrated “the remarkable manner in which new roads generate new traffic”, as Bressy wrote in 1937, but the notion was soon forgotten. Glanville and Smeed at the Road Research Laboratory rediscovered it in 1958, however, as did Foster, at Oxford, in

11 Figures calculated from those produced by the Appellant in Table 5.3 in Pratt's Appendices using the multipliers from the Stern Report [BAA/4/c].

12 Opening submission on behalf of Stop Stansted Expansion at the public inquiry on 30th May 2007 paras 29-32. Planning Inspectorate ref: APP/C1570/A/06/2032278

1963, and it was also remembered long enough to appear in Ministry of Transport advice in 1968, which said:

"Generated traffic on large schemes has often amounted to between 5% and 25% over and above the normal forecast traffic level... larger in exceptional cases."

Within three years the advice disappeared, however, (nobody ever said why) and generated traffic was routinely not calculated for road schemes and the DoT even took a legal case to the House of Lords to prevent such forecasts being challenged by objectors. But the evidence kept re-appearing: a GLC study demonstrated it empirically in 1985, as did Martin Mogridge and his colleagues in 1987, and it was sharply reinforced in 1988 after the M25 exceeded its long term forecast traffic growth within months of opening.

29. He goes on to say:

In 1994 SACTRA, the Standing Advisory Committee on Trunk Road Assessment, published its best-known report, on what it renamed 'induced' traffic. The average traffic flow on 151 improved roads was 10.4% higher than forecasts that omitted induced traffic and 16.4% higher than forecast on 85 alternative routes that improvements had been intended to relieve. In a dozen more detailed case studies the measured increase in traffic ranged from 9% to 44% in the short run and 20% to 178% in the longer run. This fitted in with other evidence on elasticities and aggregate data. The conclusion was:

"An average road improvement, for which traffic growth due to all other factors is forecast correctly, will see an additional [i.e. induced] 10% of base traffic in the short term and 20% in the long term."¹³

30. The SACTRA report was published in 1994. Its research and conclusions are very important indeed and have not been refuted by any subsequent independent research. Its main findings were:

Considering all these sources of evidence, we conclude that induced traffic can and does occur, probably quite extensively, though its size and significance is likely to vary widely in different circumstances (para 10, page (ii))

These studies demonstrate convincingly that the economic value of a scheme can be overestimated by the omission of even a small amount of induced traffic. We consider that this matter is of profound importance to the value for money assessment of the road programme (paragraph 12, page iii)

Induced traffic is of the greatest importance where the network is operating or expected to operate close to capacity (paragraph 13, page iii)¹⁴

13 Local Transport Today LTT450 24 August, 2006,
<http://stopcityairportmasterplan.tumblr.com/post/19513243412/induced-traffic-again-and-again-and-again>

31. Professor Phil Goodwin then brings the story up to date with a review of a major report

“Beyond Transport infrastructure” published in 2006:

This report looked in detail at three big schemes on the A27, A34 and M65, and a further ten schemes on the A5, A6, A41, A43, A46, A66, A500 and A1033. These were schemes undertaken after SACTRA’s 1994 report had been finished and accepted.

They reported:

“Careful scrutiny of the traffic flow data suggests that traffic growth after the scheme opened has been significantly higher than growth on other nearby road corridors or national traffic growth.”

They also said that:

“In all three case studies the current traffic flows are near or already in excess of what was predicted for 2010. In towns with bypasses, such as Newbury and Polegate, the new roads did significantly reduce the town centre traffic levels. However, these reductions are not as great as originally forecast and there has subsequently been regrowth in traffic levels on the bypassed roads. The net effect in combination with the new road is generally a considerable overall increase in traffic.”

Their final conclusion is remarkably restrained. After noting the Highways Agency’s own explanations for the extra traffic growth (which were intriguingly similar to those rejected by SACTRA 12 years earlier), they write: “Nevertheless, in view of the fact that many of the schemes reviewed have demonstrated significant increases in traffic volumes (in the range of 10-35%, within a period of one to two years after opening), there would seem a strong case to consider the issue of induced traffic in more detail in future evaluations.”

So 1925, 1937, 1958, 1963, 1968, 1985, 1987, 1988, 1994, 1996, now 2006: for 80 years, every eight years on average, there has been the same experience, the same conclusions - even, for goodness sake, more or less the same figures. The evidence has been consistent, recurrent, unchallenged by serious countervailing evidence but repeatedly forgotten. CPRE have done us a service, I think, but really it should just not have been possible for them to find, 12 years after SACTRA, the same mistakes.¹⁵

32. Induced traffic is very important because of the effects it has on traffic forecasts, time savings, Benefit: Cost Ratios (BCR) and Value for Money (VFM). A large amount of induced traffic will usually have the effect of cancelling out or minimising the travel time savings that have been

14 SACTRA (1994) Trunk Roads and the Generation of Traffic, Standing Advisory Committee on Trunk Road Assessment, Department of Transport, London, HMSO, <http://www.bettertransport.org.uk/sites/default/files/trunk-roads-traffic-report.pdf>

15 Beyond Transport Infrastructure. Lesson for the future from recent road projects, CPRE, 2006, <http://www.transportforqualityoflife.com/u/files/Beyond-Transport-Infrastructure-fullreport%20July2006.pdf>

predicted for a road scheme and then converted into a monetary estimate of benefits. The benefits will therefore be much less in situations where induced traffic materialises than they would be without this induced traffic. Road improvements and bypasses that have been justified on optimistic BCRs will fail to perform at the predicted level and the promised reductions in congestion that have fed political support will not materialise.

33. A recent article by Naess, Nicolaisen and Strand put this very succinctly. The authors take the view that “the traffic generating effects of road capacity expansion are still often neglected in transport modelling” and this omission “can lead to serious bias in the assessments of environmental impacts as well as the economic viability of proposed road projects, especially in situations where there is a latent demand for more road capacity”. They demonstrate empirically that if induced traffic is not fully taken into account or ignored “the results show lower travel time savings, more adverse environmental impacts and a considerably lower benefit-cost ratio when induced traffic is partly accounted for than when it is ignored”. The authors conclude “By exaggerating the economic benefits of road capacity increase and underestimating its negative effects, omission of induced traffic can result in over-allocation of public money on road construction and correspondingly less focus on other ways of dealing with congestion and environmental problems in urban areas”.¹⁶
34. John Elliott (a national expert on induced traffic) in an article in the journal “World Transport Policy and Practice” (February 2016) has provided an update on the debate on induced traffic. He says:

“There is very strong evidence (but not as widely known as it should be) that road building can increase traffic levels enormously within a few years of opening and is likely to cause more congestion in the area rather than reducing it. Mechanisms which can account for a substantial proportion of the additional traffic are mode and destination change. These are often modelled for larger schemes but rarely do the results of the modelling reproduce what actually happened after opening. Occasionally land use effects are modelled though usually are not; completely new trips and peak narrowing are sometimes mentioned qualitatively. Psychological and social mechanisms are not usually in the competence of traffic models.”

“Many of the road schemes presently being proposed by the government are in the vicinity of cities and conurbations, in places where it is recognised that there is serious congestion. However all the evidence suggests that enlarging roads in such

16 Naess, P, Nicolaisen, M and Strand, A (2012) Traffic forecasts ignoring induced demand: a shaky foundation for cost-benefit analyses, European Journal of Transport Infrastructure Research (EJTIR), Issue 12 (3), pp 291-309, http://www.ejtir.tbm.tudelft.nl/issues/2012_03/pdf/2012_03_02.pdf

*places will increase traffic and is likely to cause more congestion in the area, rather than reducing it, within a very few years. Even the arguments on calculated or predicted economic benefits seem very spurious indeed. While many Transport Planners, especially those who might read WTPP journals, are well aware of the level of induced traffic and its consequences, government should also be well aware and be adjusting policies accordingly. It should be noted that the Local Government Technical Advisers Group has outlined these issues to government on a regular basis - the last occasion was in December 2014 to the House of Commons Scrutiny Committee on the Infrastructure Bill.*¹⁷

35. In paragraph 28, I have referred to the empirical finding about increased traffic flows after new road building: “In a dozen more detailed case studies the measured increase in traffic ranged from 9% to 44% in the short run and 20% to 178% in the longer run”
36. Induced traffic on this scale translates directly into increased greenhouse gas emissions from operational sources (vehicles). This adds to the weight of evidence I have presented in section 3 above about embodied greenhouse gases and confirms my assessment that this road proposal is a major blow against WG, UK Government and EU climate change targets and ambitions.
37. For the avoidance of doubt it is my settled view that the decision making process around the M4 relief road cannot be regarded as sound and reliable if it does not follow the findings of the SACTRA 1994 report and the detailed empirical evidence presented in the CPRE, 2006 report “Beyond Transport Infrastructure” report, and the detailed review of induced traffic by an acknowledged expert in this field (John Elliott in World Transport Policy and Practice, 2016). Induced traffic renders the VFM calculations unsound and undermines the BCR and it would not be in the best traditions of evidence-based UK decision taking on major investments to proceed with a very expensive project that is based on deeply flawed calculations.
38. It is most regrettable that the Welsh Government report on traffic forecasting issued in December 2016 makes no reference to the SACTRA report (para 29 above) or induced traffic or the many studies showing that corridor level traffic volumes are much greater than predicted in the years following the opening of a scheme. The simple fact that a major government report on newly generated traffic has been ignored exposes the inadequacies of the arguments in favour of the M4 relief road. For the avoidance of doubt the existence of newly generated traffic means that traditional traffic forecasting excludes an important component of growth that is created by the project itself. It also means that predicted travel time savings do not

17 <http://worldtransportjournal.com/wp-content/uploads/2016/02/9th-Feb-final-opt.pdf>

materialise because the newly generated/induced traffic adds to congestion and as a consequence reduces travel time savings and it means that the benefit-cost ratios and VFM calculations are inaccurate.

39. The Welsh Government report on traffic forecasting¹⁸ also ignores the reality of exaggerated and inaccurate forecasts made in the past. The traffic engineering and modelling world is well aware that forecasting is based on flawed assumptions and this has been expertly illustrated by Professor Phil Goodwin in his many writings and presentations e.g.¹⁹

A progressive, systematic and continuing tendency for long term trends in car use to be over-forecast.
(not attributed to peaking or saturation, but to faulty external input data)

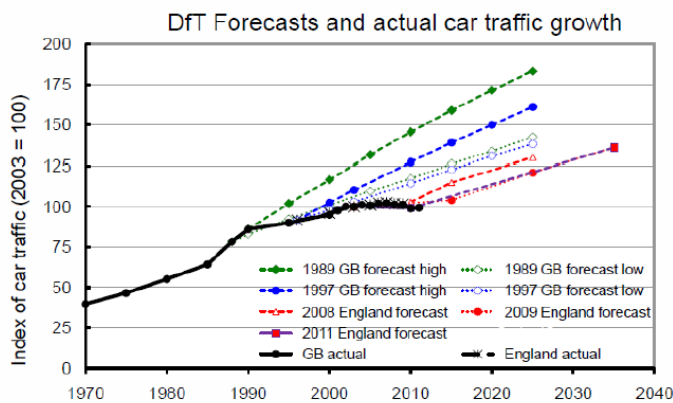


Figure 1

40. The black line in Professor Goodwin’s diagram (above) shows that actual traffic growth is much less than predicted traffic growth. This in turn means that the arguments made in support of road building, as in the case of the M4 relief road, are based on unreliable traffic forecasts. A decline in traffic volumes would suggest that the case for a new road or an increase in road capacity is very weak. The reasons for lower out-turn traffic data are many and discussed in the traffic and transport literature. They embrace a clear shift in choices and preferences on the part of younger people away from the car, the success of travel plans (heavily promoted by DfT) and the success of best practice city-wide transport strategies of the kind not yet seen in the Newport-Cardiff corridor. The successes of Reading buses, Brighton buses and Nottingham’s Workplace Parking Levy combined with Nottingham’s bus and tram projects are well documented and show that it is possible to reduce car travel and boost alternatives to the car.

18 <http://gov.wales/docs/det/publications/161214-revised-traffic-forecasting-report.pdf>

19 [Prof Goodwin – Peak Car?](#)

It is remarkable that this very important dimension often referred to as “demand management” is absent in the Welsh Government’s traffic forecasting work and its consequences are serious. The lack of attention to demand management artificially and unreasonably boosts the case for new road building and supports very expensive infrastructure projects that damage the countryside, nature reserves and the environment.

41. The promotion of new road building at very great expense against a background characterised by lack of serious attempts to develop and fund non-road building options (so-called “predict and provide”) is poor quality public decision-taking and should be rejected.

5 THE EVIDENCE NATIONALLY AND INTERNATIONALLY IS VERY CLEAR ON WIDER ECONOMIC IMPACTS AND NEW ROAD BUILDING IS JUST AS LIKELY TO DRAIN JOBS AWAY FROM A LOCAL ECONOMY AS IT IS TO ATTRACT THEM.

42. In 1959 Britain opened its first motorway (the Preston bypass, now the M6). We have now had 57 years’ experience of adding high quality, generously proportioned and expensive transport infrastructure to our national landscape and we still do not know the degree or extent of its impact on simple variables such as numbers of jobs created, new firm formation, the growth of firms, re-location versus new investment, regional inequalities, disadvantage and the widening of opportunities for all sections of society. James Drake writing in his book “Motorways” in the early 1960s argued at page 26 that “...*the proximity of a motorway makes a town far more attractive from an industrial point of view. Adequate road communications are always a prime consideration of an industrialist looking for a site for his new works; a convenient connection to the motorway system is a great advantage.*”
43. James Drake would be very surprised indeed to learn about the significant unemployment and structural economic problems of areas very well served by motorways in the 21st century (Glasgow, Skelmersdale, Hull, Blackburn and Burnley). High quality transport infrastructure is not a “magic bullet” cure for deeply rooted economic and social problems.
44. The research evidence in support of the general proposition that adding highway infrastructure including bridges and roads will inevitably and necessarily lead to a reversal of economic decline and an increase in job opportunities is just not there.
45. The research evidence that points to the absence of such a clear link does exist and has frequently been confirmed by economists, geographers and regional development specialists.

Table 2 lists a selection of the published research material that refutes the proposition of an unambiguous link between transport investment and local economic gain. The clear evidence of these studies is that it would be perverse to proceed with a large transport infrastructure investment on the unsubstantiated assumption that such an investment will lead inexorably and unambiguously to job creation in disadvantaged areas and to the removal of social exclusion.

46. The research evidence in Table 2 is reinforced by official and governmental evidence and this is summarised in Table 3

47. The Inspector's report into the proposed M74 motorway in Glasgow is especially relevant to a discussion about the impact of additional highway capacity in South Wales. Most if not all the issues relevant to the debate around social exclusion, relative disadvantage, business growth, job creation and new transport infrastructure were dealt with in a thorough manner by the Inspector and have a direct transferability to the sub-region centred on Newport. The Inspector came down firmly against the M74 and accepted the case made by the objectors (Table 4).

48. An objective assessment of the weight of evidence both scientific and public policy would lead inevitably to the rejection of a proposal that claimed economic and social gains from a large item of transport infrastructure. It would further reject the assertion that such investments could maintain accessibility improvements over time as traffic levels rise and erode the temporary gains made in the few months following opening of a scheme.

49. The clear view of the Royal Commission on Environmental Pollution in its 1994 report "Transport and the Environment" still stands as a significant and telling finding from an authoritative, independent and prestigious government body:

"In the Treasury's view it is not possible to generalise about the importance of transport infrastructure as a factor in bringing about economic growth in depressed or deprived regions...a recent study concluded that road building is not the key to economic growth in the regions...indeed it seems that good roads can sometimes speed the decline of less prosperous areas by allowing their needs to be met conveniently from sources outside the area" [para 2.14, page 15]

50. The importance of this finding has not been addressed by the supporters of the M4 relief road around Newport.

Table 2 Published scientific work on transport investment and local economic gain

Author	Date	Headline Finding
Dodgshon, J S	1973	Little evidence of transport development encouraging regional development
Cleary, M J and Thomas R E	1973	The Severn Bridge..(has produced) no significant relocation of manufacturing establishment as a consequence of the bridge
Gwilliam, KM	1970	Little evidence of a transport-economic development link
Gwilliam and Judge	1978	(M62)..as far as regional development is concerned we have seen little strong evidence to suggest that the motorway is a powerful influence on inter-regional location of activity
Leitch Committee Report,	1977	Largely rejected the view that trunk road construction engenders economic growth
Bonafous, A	1979	Regional development is not a normal consequence of the improvement in the transport supply...it can, on the contrary, aggravate inequalities of development
Blonk, W A G	1979	A new link between an area of concentration and an underdeveloped region improves the flow of traffic not in one direction but two. This entails a risk of competition from outside and a draining of resources for the underdeveloped region
Sharp, S	1980	Transport investment, by itself, is unlikely to encourage economic growth in less prosperous regions...the effect of providing improved transport facilities to a poorer region is even more uncertain
European Conference of Ministers of transport (ECMT)	1991	When companies are deciding where to locate their activities, transport is a secondary criterion.. by and large businesses do not consider transport costs to be an important factor as they average only 3-5% of operating costs
ECMT (Plassard)	1991	Nagoya in Japan has lost 20% of its employment since the opening of the high speed rail link between Tokyo and Osaka
Goodacre, C	1993	(M65) local authorities through which the M65 passes have not performed any better than those through

		which the road does not pass
Whitelegg, J	1994	The analysis of variation in economic performance and variation in accessibility has found no evidence of a positive relationship.
Lawless and Dabinett	1995	The link between transport investment and regeneration is weak because the two policy areas are poorly co-ordinated
ESRC Urban and Regional Seminar Series (quoted in Cole, 2005, page 425)	2002	Found very little evidence of positive benefit to Kent as a result of the Channel Tunnel
Cole, S	2004	Road improvements in North Wales (A55) and South Wales (M4) opened up the region to new competition from outside (the two-way road effect)
OECD	2002	Greater social inclusion was unlikely to be achieved through improved accessibility and transport alone but also required parallel initiatives including work skills, housing and social policy
University of Kent	2004	(The Channel Tunnel) has not had the expected impact on economic development locally or more widely in Kent

51. The evidence from authoritative, independent sources on the economic impact of major infrastructure schemes, including roads, points unequivocally to “not proven” and in some cases negative. The negative dimension is specifically mentioned in the RCEP (1994) report quoted in paragraph 48 above and in the SACTRA (1999) report listed in Table 3. The results of studies of the economic impact of completed transport projects *do not offer convincing general evidence of the size, nature or direction of local economic impacts*

Table 3 UK government documents on transport and the economy

RCEP, 1994	In the Treasury's view it is not possible to generalise about the importance of transport infrastructure as a factor in bringing about economic growth in depressed or deprived regions..a recent study concluded that road building is not the key to economic growth in the regions..indeed it seems that good roads can sometimes speed the decline of less prosperous areas by allowing their needs to be met conveniently from sources outside the area (para 2.14, page 15)
SACTRA 1999	The SACTRA report on Transport and the Economy was the culmination of a 3 year inquiry chaired by Eileen Mackay CB into claims of economic benefit from road schemes. The report notes (summary, page 17, paragraph 11) that the contribution of road construction to sustainable economic growth of a mature economy, with well-developed transport systems, is likely to be modest. It states that the results of studies of the economic impact of completed transport projects " <i>do not offer convincing general evidence of the size, nature or direction of local economic impacts</i> ". The report goes on to state " <i>Our studies underline the conclusion that generalisations about the effects of transport on the economy are subject to strong dependence on specific local circumstances and conditions.</i> "
SACTRA 2000	While in certain circumstances transport schemes may bring added economic benefits to an area needing regeneration, in other circumstances the opposite might occur. Better communications will enlarge markets for goods, services and workers: the area as a whole may gain or lose from this depending on the structure and competitiveness of the local economy. It follows that there is no simple, unambiguous link between transport provision and local regeneration. http://www.dft.gov.uk/stellent/groups/dft_econappr/documents/page/dft_econappr_504831.hcsp
Inspectors Report into the M74 motorway extension in Glasgow, 2004	M74 will encourage traffic growth (11.85); business benefits will be short lived and/or will disadvantage other areas in Scotland (11.86); will worsen social exclusion (11.88); the M74 extension should not be authorised and the compulsory purchase orders should not be confirmed (11.99) http://www.scotland.gov.uk/library5/transport/m74r-00.asp
Professor David Begg, Chairman of CfIT	Summing up, David Begg cautioned against what he described as an "infrastructure junky" approach. The starting point needed to be asking what kind of communities we want to see and how transport can help deliver them. Conference organised by the Office of the Deputy prime Minister C4: Opening up potential - the role of transport in sustainable communities

TfL, 2004, para 131, page 33 of TfL/61	<i>“when accessibility is improved in areas of very poor accessibility, there is no guarantee that this will be associated with an increase, on average, in either employment or population density”</i>
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52. The SACTRA report (1999) is central to the consideration of any claims made for the M4 relief road in terms of regeneration, job creation, inward investment and local economic gain. SACTRA, a UK government committee, has concluded that *“there is no convincing general evidence”* in support of these desirable outcomes and that improved highway connectivity can also lead to the *“2-way road effect”* where economic activity drains away from less prosperous regions to stronger regions.

Table 4 Extracts from the final report of R M Hickman, Inquiry Reporter into the proposed M74 extension in Glasgow, July 2004

- *11.96 Drawing these numerous elements together, the evidence has shown that the proposal would be likely to:*

seriously hinder the achievement of important Scottish Executive commitments and objectives for traffic reduction, public transport improvements, and CO2 emissions;

have very serious adverse impacts on the environment of communities along the route, both during construction and in operation;

be at variance with policies to promote social inclusion and environmental justice;

temporarily ease traffic congestion, to the benefit of car commuters and road freight transport, but that these benefits would be progressively lost due to continuing traffic increases, in the absence of measures to restrain and reduce traffic; and

make a positive contribution to the local economy in Glasgow, South and North Lanarkshire, Renfrewshire, and East Renfrewshire, at the expense of the Forth valley, the Stirling area, Ayrshire, Inverclyde, and West Dunbartonshire.

- *11.97 Drawing these various strands together, and looking at all the policy, transport, environmental, business, and community disadvantages of the proposal as a whole, it must be concluded that the proposal would be very likely to have very serious undesirable results; and that (in the context of the advice in the SACTRA report, the transfer of jobs from other parts of Scotland, and the potential harm to existing businesses along the route) the economic and traffic benefits of the project would be much more limited, more uncertain, and (in the case of the congestion benefits) probably ephemeral*

- 11.98 *In this context, it cannot be concluded that the public benefits of the proposal would be sufficient to outweigh the considerable disadvantages that can be expected, nor that it is necessary in the public interest to acquire compulsorily all of the properties where objections to the CPO have been maintained*
- 11.99 *Accordingly, on the basis of the consideration of the material put forward by objectors... and those who support the project, the conclusion is that this proposal should not be authorised, and that the compulsory purchase order should not be confirmed.*²⁰

53. The conclusion of the Inspector at the M74 inquiry quoted above (paras 11.96-11.99) mark the conclusion of a very thorough and rigorous evaluation of the evidence and the simplistic argument that new motorway capacity would solve congestion and regeneration problems was found to be flawed and rejected. The supporters of the M4 relief road around Newport have presented no evidence to refute the findings of the RCEP (para 48), SACTRA (Table 3) and the M74 Inspector (Table 4).

54. A 2015 report reviewed over 2000 studies of the economic impact of transport infrastructure projects including new roads and concluded:

The economic benefits of transport infrastructure spending – particularly as a mechanism for generating local economic growth – are not as clear-cut as they might seem on face value.

Arguments for spending more in areas that are less economically successful hinge on the hope that new transport is a cost-effective way to stimulate new economic activity. We do not yet have clear and definitive evidence to support that claim.

Our findings raise fundamental questions about scheme appraisal and prioritisation, and about the role of impact evaluation in improving decision-making around transport investment.

*Evaluations of economic impact rarely consider the negative economic impacts of transport improvements – they could export economic activity to neighbouring regions by improving market access and workforce mobility.*²¹

55. The finding that “The economic benefits of transport infrastructure spending – particularly as a mechanism for generating local economic growth – are not as clear-cut as they might seem on face value” is a serious matter at a time of very large government cuts in public spending and a proposed £1 billion plus project on 14 miles of new highway around Newport. Such a large expenditure requires much more certainty about the impacts and that certainty is not there.

20 <http://www.scotland.gov.uk/library5/transport/m74r-13.asp>

21 <http://www.whatworksgrowth.org/policy-reviews/transport/>

56. In spite of the very large literature casting doubt on the links between building new roads and undiluted economic gains to the areas served by that new road the Welsh Government has re-emphasised its belief in the wider economic benefits that are expected to flow from the M4 Relief Rd.²²

57. The “Wider Economic Impact assessment” (WEIA) makes a completely unsubstantiated assertion in the Executive Summary:

“This research has indicated that spatial factors – the lack of economic mass or density and the relative peripherality of Wales – play a role in determining Wales’ relative performance. This hypothesis is supported by UK and international evidence on the link between transport and economic performance”

58. No evidence at all is presented in support of this assertion either by definition of peripherality or size of economic mass or in a rigorous ex-post situation looking at economic performance. An “ex-post” approach would be to identify an area defined as “weak” in terms of connectivity or peripherality and then build a new road to improve the situation and then use the same measure of economic success to compare before and after. This approach to evidence has not been adopted and we are left with unsubstantiated assertions.

59. A frequently used measure of economic success is GDP (Gross Domestic Product) per capita. So for instance in the CIA World Factbook dataset²³ the UK is ranked 37 by size of the GDP per capita measured in US dollars. The UK is listed at \$42,500 per capita. This means 36 countries have a higher GDP per capita and are, therefore, economically more successful. A number of countries that can be defined as “peripheral” have much more successful economies (all data is per capita):

- *Isle of Man (rank 7) \$83,100*
- *Ireland (rank 11) \$69,300*
- *Guernsey (rank 22) \$52,300*

60. It can be concluded that peripherality is not linked to economic performance

61. The Welsh Government also uses another undefined term “economic mass”. It can be assumed that the Netherlands, Denmark and Sweden have a smaller economic mass than the UK and GDP per capita is as follows:

22 <http://gov.wales/docs/det/publications/161214-revised-economic-appraisal-report.pdf>

23 <https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html>

- UK \$42,500
- Netherlands \$50,800
- Sweden \$49,700
- Denmark \$46,600

62. It can be concluded that "economic mass" is not related in any predictive capacity to economic performance.

63. The case for a new road based on reference to peripherality and economic mass is illogical, misleading and not supported by data.

64. The Executive Summary in the WEIA relies on a level of vagueness and assertion that has no place in the evaluation of a £1.1 billion project:

“More generally, the M4CaN is expected to contribute positively to perceptions of South and South West Wales as a location for investment. This conclusion is supported by many in the business community. Furthermore, the vast majority of overnight holidaymakers to Wales travel by car. Therefore, it would be reasonable to assume that the majority of tourists visiting South and South West Wales will experience the M4 around Newport during their visit. Delays caused by disruption on the M4 corridor will impact negatively on visitor’s perceptions of South and South West Wales as a place to visit.”

65. There is no evidence that “perception” works in this way. Businesses make complex decisions based on a large number of factors including as a minimum the cost of acquiring or leasing land and buildings, the availability of a skilled workforce, labour costs, house prices, high quality schools, attractive countryside nearby and prevailing levels of taxation and incentives. To reduce all these factors to a vague concept of perception linked to an experience on the M4 is not credible and lacks substantiation. To make a similar point about tourist visits is also stretching credulity. Many millions of tourists visit the Lake District and Cornwall each year in spite of difficult journeys by car and there is no evidence that they are persuaded to take holidays in Warrington (highly connected at the junction of the M6 and M62) rather than Grasmere or Penzance.

66. The WEIA Executive Summary emphasises the impact of the proposal on reducing journey times and reducing transport costs and generating an economic benefit based on the monetarisation of those time savings:

“The EAR sets out that the M4CaN scheme will result in lower journey times and reduce transport costs for businesses in the study area defined for this assessment. Even before the effects of traffic incidents and abnormal delays are considered, cost savings for businesses in the study area are estimated to be £30m (2016 prices) each year by the design year of 2037. In practice, however, the scheme will also improve journey time reliability and will reduce the delays associated with traffic incidents which will result in further cost savings and efficiency benefits for businesses.”

67. There are two problems with this approach to economic impact assessment. Firstly it takes no account of newly generated traffic discussed in section 4 of my evidence. If, as the evidence suggests, there is an increase in newly generated traffic, then this reduces journey time savings and reduces the amounts claimed in benefits from the valuation of time. The proposal makes no attempt to carry out a sensitivity analysis of newly generated traffic. A sensitivity analysis would test the time saving estimates and their monetary value against different level of newly generated travel. The second problem is the degree to which time savings and reduced transport costs are translated into tangible benefits e.g. newly created jobs and inward investment. The transport literature over many years (including SACTRA, “Transport and the Economy” (1999)) has pointed out the “2-way road effect”. If there is a reduction in transport costs it becomes possible for a company based in Bristol or Swindon (for example) to service its entire South Wales market from those locations and to terminate any activities it may have in Newport, Cardiff, Bridgend or Swansea. The economies of scale that flow from this locational strategy are very large and are made possible by reduced transport costs.

68. The 2-way effect is very important. The SACTRA report, “Transport and the Economy” (1999) is very clear:

“10 We consider these theories, which deal with the linkages between transport improvements and economic activity, to be strong. They are internally consistent, and provide insight into a complex pattern of effects leading in different directions, not all of which are intuitively obvious - notably, for example, the 'two-way road' argument: this reminds us that improved accessibility between two countries (and, similarly, between cities, areas or regions) may sometimes benefit one of them to the disbenefit of the other. We emphasise that these theories as a whole should be subject to empirical testing before any of them can be taken as proved”

Further, we cannot assume simplistic cause and effect links between a large new road and positive economic consequences

“11 In the search for empirical evidence, we find that direct statistical and case-study evidence on the size and nature of the effects of transport cost changes is limited. Some authors have claimed that national programmes of public investment, including road construction, lead to high rates of social return measured in terms of

economic growth and productivity improvement. Other authors suggest that such effects do occur but on a smaller scale than has been claimed, and that, in general, any contribution to the sustainable rate of economic growth of a mature economy, with well-developed transport systems, is likely to be modest. Our investigations support the latter assessment. We have also reviewed available evidence from specific local studies seeking to detect economic impacts from completed transport investment projects in the recent past. The state of the art of this important field is poorly developed and the results do not offer convincing general evidence of the size, nature or direction of local economic impacts.”²⁴

69. The WEIA has provided no evidence based on completed highway projects that there are economic gains to be harvested as a result of building new roads. References to SACTRA and the A55 (para 3.4.6) and Merthyr (para 3.5.4) are not supported by the SACTRA document. No data is provide on the impact of the A55 in the SACTRA document and the impact on Merthyr of the A470 improvements is described as “marginal” (para 5.115 of SACTRA, 1999).

70. An important conclusion in SACTRA (1999) is relevant to the evaluation of any economic evidence supplied in support of the M4 relief road:

Empirical evidence of the scale and significance of such linkages is, however, weak and disputed.

71. Given the very clear SACTRA conclusions and given the lack of case study evidence from the promoters of similar UK projects showing links between infrastructure and local economic performance, the M4 relief road fails the test of soundness.

72. Para 3.9.1 of the WEIA stretches our understanding of the word “evidence” beyond normal limits:

3.9.1 The evidence presented here supports the view that investment in roads and highway infrastructure has positive effects on economic performance

73. The evidence of SACTRA (1999) and numerous other studies quoted in my proof of evidence shows that there is no clear link between building a new road and local economic gains

24 SACTRA (1999) Transport and the Economy, Department of Environment, Transport and Regions, http://webarchive.nationalarchives.gov.uk/20050301192906/http://dft.gov.uk/stellent/groups/dft_econappr/documents/pdf/dft_econappr_pdf_022512.pdf

74. A paper I authored (Whitelegg 1994)²⁵ carried out a detailed scientific study looking at 4 areas of England and Wales and examining data on economic performance before the construction of new highway infrastructure and after construction. Four areas were chosen for this analysis:

1. NE Lancashire
2. Humberside and Doncaster
3. East Midlands
4. West Glamorgan

75. The West Glamorgan area was relevant to the subject under examination at this Public Inquiry:

“In the case of West Glamorgan both Travel to Work Area are located less than 12 minutes driving time from the M4. Neath/Port Talbot and Swansea have been compared in accessibility terms to the M5/M4 junction and to Reading.”

76. The conclusion across all 4 areas was very clear:

“The analysis of economic performance and accessibility has produced results that could not be clearer. The R2 statistic ranges from 0.010 to 0.30. Only in the case of Figure 6 and access to Manchester airport from Humberside and the East Midlands does the R2 statistic rise above 0.04. There is no relationship between accessibility and economic performance. “

“The analysis of variation in economic performance and variation in accessibility has found no evidence of a positive relationship. Areas of poor accessibility out-perform areas of high accessibility and areas with very similar accessibility characteristics have very different economic performance characteristics. This should not come as a surprise. The accumulated evidence from previous studies points unequivocally to the same conclusion. There is no basis in experience or empirical evidence for road investment stimulating economic development.”

77. Since this report was published in 1994 there have been many opportunities for central government, the Welsh Government, local authorities, development agencies and construction companies to replicate the analysis and carry out a rigorous statistical analysis comparing specific economic indicators with specific measures of accessibility. To the best of my knowledge this has not been done and on one side we have scientific evidence that there is no relationship between accessibility and economic performance and on the other side we have vague, subjective assertions without data and analysis that there is a relationship. I suggest

25 Whitelegg, J (1994) Roads, jobs and the economy, Eco-Logica Ltd, Lancaster,
<http://worldtransportjournal.com/wp-content/uploads/2015/02/GPRoadsJobsEconomy.pdf>

that it is not in the best traditions of British governance and decision-taking to spend £1.1 billion on the basis of vague assertion and the rejection of scientific evidence

6 THE PRINCIPLES OF TRANSPORT APPRAISAL HAVE NOT BEEN FOLLOWED AND THE ADOPTION OF A ROAD-BUILDING OPTION HAS NOT FOLLOWED CAREFUL EVALUATION OF ALL OPTIONS INCLUDING THE NON-ROAD BUILDING OPTIONS

78. The world has moved on a great deal since the time when the perception of a transport problem was automatically met with the bypass, additional lanes or road widening response.
79. The UK government's guidance on transport appraisal, known as WebTag, makes it very clear that there should be a sequential approach to dealing with transport problems followed by option listing and scoping and concluding with a clear and transparent comparison and evaluation of the options leading to the selection of the best performer.
80. This sequential approach has not been followed in the case of the M4 relief road.
81. In addition to the lack of sequential approach the decision-making processes leading to the matter now before this public inquiry did not include the richness and diversity of non-road building options. They were not given the opportunity to reveal how they would perform when compared to the road building option.
82. The sequential approach is very clear in WebTag and the Welsh Government report on forecasting referred to in para 37 above relies on this same DfT WebTag guidance:²⁶

The three stages in the Transport Appraisal Process are as follows:

Stage 1 – Option Development. *This involves identifying the need for intervention and developing options to address a clear set of locally developed objectives which express desired outcomes. These are then sifted for the better performing options to be taken on to further detailed appraisal in Stage 2. See Section 2.*

Stage 2 – Further Appraisal *of a small number of better performing options in order to obtain sufficient information to enable decision-makers to make a rational and auditable decision about whether or not to proceed with intervention. The focus of analysis is on estimating the likely performance and impact of intervention(s) in sufficient detail. See Section 3.*

Stage 3 – Implementation, Monitoring and Evaluation. *See Section 4.*

²⁶ Transport Analysis Guidance. The transport appraisal process, January 2014, DfT, Transport Analysis Guidance, <https://www.gov.uk/guidance/transport-analysis-guidance-webtag>

82 The WebTag document identified in paragraph 81 is very clear that there are principles that must be followed:²⁷

There must be a clear rationale for any proposal and it must be based on a clear presentation of problems and challenges that establish the 'need' for a project.

There must be consideration of genuine, discrete options, and not an assessment of a previously selected option against some clearly inferior alternatives. A range of solutions should be considered across networks and modes.

There should be an auditable and documented process which identifies the best performing options to be taken forward for further appraisal.

There should be an appropriate level of public and stakeholder participation and engagement at suitable points in the process. In most cases this should inform the evidence-base which establishes the 'need' for an intervention, guide the option generation, sifting and assessment steps, as well as informing further appraisal in Stage 2.

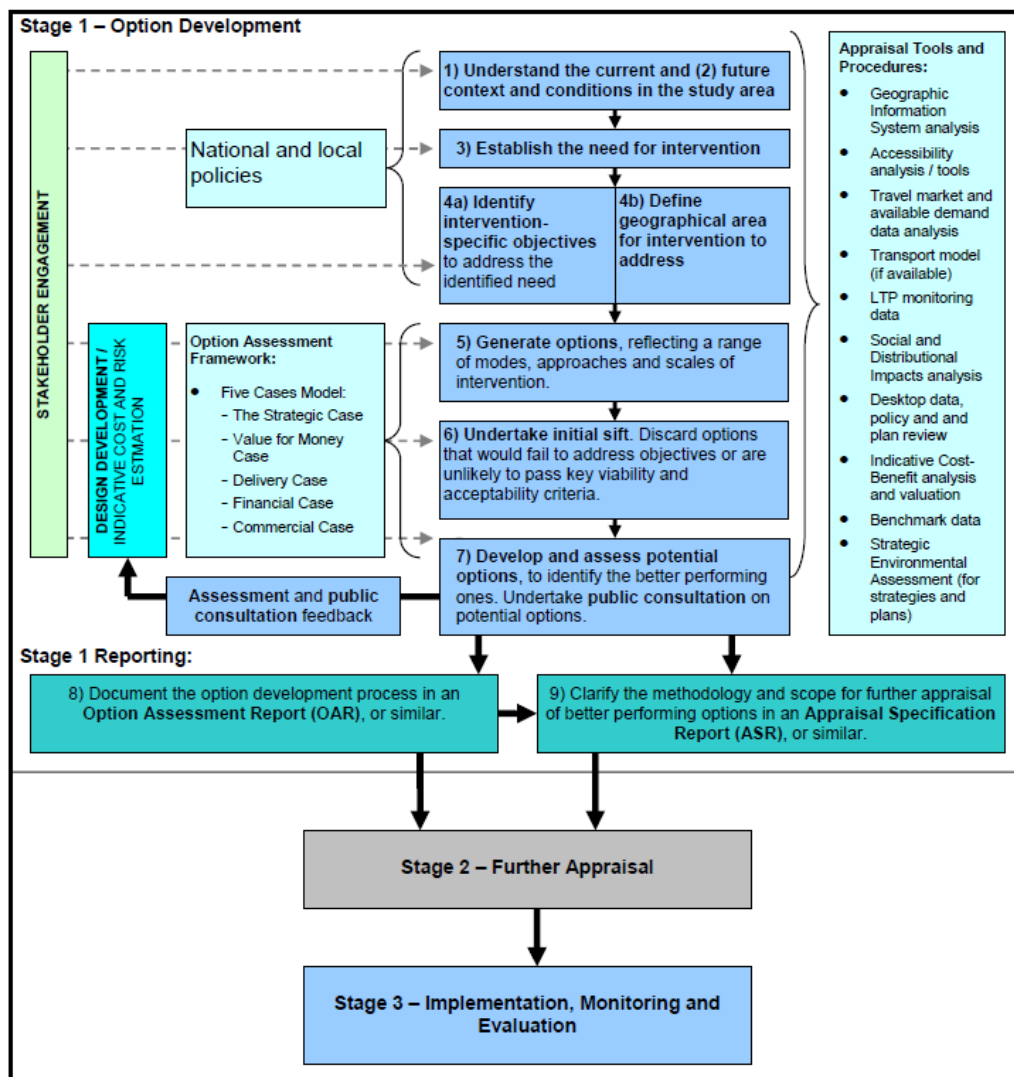
83 There is no evidence in the M4 relief road proposal that “genuine, discrete options” have been identified and pursued and “ and no evidence of the requirement to include “A range of solutions... across networks and modes.”

84 For the avoidance of doubt “a range of solutions ”across networks and modes” would include the “smarter” options discussed below in and the systematic application of workplace travel plans across the whole Cardiff-Newport corridor to reduce single occupant vehicle use (SOV) and encourage modal shift to non-car alternatives and there has been no detailed evaluation of the extent to which significant improvements in rail based commuting opportunities could reduce vehicle numbers on this same corridor.

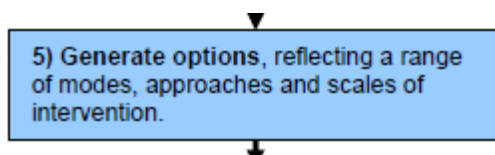
85 Figure 2 below is taken from the same document referred to in paragraphs 81 and 82 and clearly shows that a wide range of options “across modes and networks” must be factored into the discussion about solutions and preferred options. This has not been done in the case of the

27 <https://www.gov.uk/guidance/transport-analysis-guidance-webtag>

matter before this inquiry.



86 There is no sign in the gestation of the M4 relief road proposal of the requirement to carry out step number 5 in Figure 2



87 The lack of robust and wide ranging option generation is a particularly serious defect in the case for the M4 relief road. The WebTag document referred to above is very clear indeed:

2.8.2 It is important that as wide a range of options as possible should be considered, including all modes, infrastructure, regulation, pricing and other ways of influencing behaviour. Options should include measures that reduce or influence the need to travel, as well as those that involve capital spend. Revenue options are likely to be of particular relevance in bringing about behavioural change and meeting the Government's climate change goal.

88 It is abundantly clear that the promoters of the M4 relief road have sidestepped any matter related to regulation, pricing and the reduction of the need to travel. Indeed a major expansion of road capacity can be expected to reinforce existing behavioural choices and the use of the car and cannot contribute to behavioural change or the Government's "climate change goal".

89 The importance of wide option generation is reinforced by paragraph 2.8.3 in the WebTag document

2.8.3 Studies should not start from an assertion about a preferred modal solution, or indeed that infrastructure provision is the only answer. Following the Eddington Transport Study², Sponsoring Organisations will be looking to encourage the better use of existing infrastructure and avoiding "solutions in search of problems". In this context, it is recognised that small schemes can represent high value for money.

90 It is very difficult indeed to avoid the conclusion that the M4 relief road from the beginning has been a "preferred modal solution" and a "solution in search of problems"

91 Options must also be assessed one against another in terms of the business case and if wider modal options and behavioural change options are simply excluded from detailed evaluation it is difficult to see how the requirements around Value for Money and business case objectives can be met

2.10.3 Potential options should be assessed against the [Transport Business Case](#) criteria using the Option Assessment Framework set out in Appendix A.

92 The neglect of option generation goes wider than WebTag considerations and includes the work of Highways England (formerly the Highway Agency.)

93 The Highways Agency has made a substantial contribution to corridor level traffic management and traffic generation through a distinctive approach to demand management that is directly relevant to the A350 corridor.

94 The Highways Agency describes this approach as follows:²⁸

28 Highways Agency, Tackling congestion by influencing travel behaviour
<http://www.highways.gov.uk/knowledge/9561.aspx>

Introduction

*The Influencing Travel Behaviour programme is designed to promote sustainable travel and reduce congestion on England's 'strategic road network'. Through this the Agency aims to cut congestion by influencing travel behaviour, providing access to information to help people make *smarter travel choices and introducing demand management measures in areas prone to congestion.*

Our strategy in taking this forward aims to balance the needs of people to travel with the available capacity of the road network. We aim to support the country's economic success whilst addressing environmental objectives. Key to achieving this is to reduce the amount of traffic on the road, in particular, the demand for private car journeys.

Congestion

Traffic Congestion seriously affects our economy, quality of life and environment. The Highways Agency's plans to improve motorways and trunk roads will help to tackle congestion. However, road building alone will not solve the problem.

The Department for Transport's congestion target challenges us to make journeys more reliable on the strategic road network. The Influencing Travel Behaviour Programme has been identified as being able to contribute to meeting this target.

- 95 The Highways Agency has developed travel plans for both car traffic and HGV traffic at several sites including Blythe Valley, Shellhaven (a freight travel plan) and Wellingborough East. Wellingborough East is of particular relevance to the West Wiltshire Trading Estate since it is a growth area for jobs and economic activity. These plans are designed to deliver economic benefits whilst at the same time reducing traffic that would normally be generated by the developments and thrown onto the highway system. Information on these travel plans can be found on the Highways Agency web site <http://www.highways.gov.uk/knowledge/18297.aspx>
- 96 The Highways Agency has developed a strategy for the A45 corridor (Northampton) designed to cope with large traffic generators on this corridor and reduce the traffic generation from key sites. The A45 plan is **directly** relevant to the A350 corridor but regrettably best practice on travel plans, spatial planning and traffic reduction has not been implemented on the A350 corridor.
- 97 The “smarter choices” agenda has been accepted and promoted by government and a full list of specific measures described as “smarter choices” can be found in a DfT report on the use of smarter choices in LTPs.²⁹

29 <http://www.dft.gov.uk/pgr/sustainable/smarterchoices/smarterltps/pdfinitialfindltps>

98 A recent review of all the “smarter choices” results and documented case study material concluded:³⁰

There is a growing body of practical experience and understanding of the role for smarter choice measures in transport policy. Such interventions provide a number of different ways of encouraging better informed traveller attitudes, and more benign or efficient ways of travelling. The results reported here suggest that within approximately ten years, such measures have the potential to reduce national traffic levels by about 11%, with reductions of up to 21% in peak period urban traffic. Moreover, they represent relatively good value for money, with schemes potentially generating benefit: cost ratios which are in excess of 10:1.

99 The main findings of the DfT smarter choices research project were as follows:

“In recent years, there has been growing interest in a range of transport policy initiatives which are now widely described as ‘soft’ measures. Soft measures usually seek to give better information and opportunities which affect the free choices made by individuals, mostly by attractive, relatively uncontroversial, and relatively cheap improvements. They include:

- Workplace and school travel plans;*
- Personalised travel planning, travel awareness campaigns, and public transport information and marketing;*
- Car clubs and car sharing schemes;*
- Teleworking, teleconferencing and home shopping.”*

“Following this review, we can say that sufficient evidence now exists to have some confidence that soft factor interventions can have a significant effect on individual travel choices.”

“The assessment focuses on two different policy scenarios for the next ten years. The ‘high intensity’ scenario identifies the potential provided by a significant expansion of activity to a much more widespread implementation of present good practice, albeit to a realistic level which still recognises the constraints of money and other resources, and variation in the suitability and effectiveness of soft factors according to local circumstances. The ‘low intensity’ scenario is broadly defined as a projection of the present (2003-4) levels of local and national activity on soft measures. The main features of the high intensity scenario would be

- A reduction in peak period urban traffic of about 21% (off-peak 13%);*

³⁰<http://webarchive.nationalarchives.gov.uk/20100304134509/http://dft.gov.uk/pgr/sustainable/smarterchoices/ctwwt>

- A reduction of peak period non-urban traffic of about 14% (off-peak 7%);
- A nationwide reduction in all traffic of about 11%.³¹

100 A reduction of peak hours traffic around Newport as a result of these non-road building measures by 21% is sufficient to deliver significant amounts of congestion relief without triggering the phenomenon known as “induced traffic” or more colloquially referred to as “new roads generate new traffic”. The cost of implementing these measures is much lower than a new highway and the BCA is much higher and the Value for Money is correspondingly much superior to road building.

101 On BCA the report concludes that each £1 spent on soft measures could produce benefits of about £10 on average:

“With these rather cautious assumptions, our calculations suggest that soft factor interventions offer very acceptable value for money. Using current DfT practice for estimating the value of the effects on travel times of a reduction in the number of vehicles, each £1 spent on soft measures could produce benefits of about £10 on average, and considerably more in congested conditions. Inclusion of values for potentially positive effects on safety, health or the environment would further increase the value for money. This gives a good margin of robustness to changes in assumptions or methods of calculation.”

102 In congested urban areas and in wider city-region areas there is considerable potential to reduce congestion in the peak through the workplace travel plan (WTP):

“Workplace travel plans typically reduce commuter car driving by between 10% and 30%, though the best ones achieve significantly more than that. Typical cost to the local authority is £2-£4 per head. So far, city authorities prioritising workplace travel plans have typically managed to engage with organisations representing about 30% of the workforce, whilst county authorities have managed to engage with organisations representing about 10%.

103 I have designed a WTP at two sites referred to by DfT as best practice examples: (1) Derriford Hospital in Plymouth and (2) Pfizer Pharmaceuticals in Sandwich in Kent. Both achieved reductions in car commuting of over 10% and the WTP approach has been documented in the world’s first WTP standard (British Standards Institution, PAS500) PAS 500 has a very powerful contribution to make to reduce congestion without road building:

31 “Smarter Choices” report, section 14.1, Conclusions,
<http://webarchive.nationalarchives.gov.uk/20100304134509/http://dft.gov.uk/pgr/sustainable/smarterchoices/ctwwt/chapter14conclusions.pdf>

BSI PAS 500:2008 National specification for travel plans

Finding ways to make the best possible use of transport infrastructure and minimizing loss of time and economic damage is a clear priority and an activity in which all businesses and sectors of the economy can engage.

Workplace travel plans (WTP) offer one proven methodology for bringing about this change.

A travel plan is a long-term management strategy for an organisation and its various sites that seeks to deliver transport objectives through positive action and is articulated in a document that is regularly reviewed. It provides a coherent approach to transport management that brings benefits to commuters, business travellers, businesses and the urgent need to address climate change, congestion and air pollution problems.

This Publicly Available Specification (PAS) defines requirements for developing and implementing a WTP, including public availability, resources and claims of conformity.

It is intended for use by any organisation planning or developing WTPs and applies to all WTPs and all the situations in which WTPs are initiated, developed and implemented. This includes WTPs:

initiated as part of an organisational policy to manage transport impacts for the benefit of staff, the environment, corporate social responsibility, the reduction of congestion, the better management of parking and to foster good relationships with neighbours

submitted with planning applications and/or transport assessments as part of the development control process

designed to reduce pollution from motor vehicles as part of an air quality strategy.

PAS 500 is applicable in all situations where the term “travel plan” is likely to be used and is deemed relevant to all those involved in the travel plan process. It applies to all the main components of transport generated by a particular site. These include:

commuter trips made by staff

trips made by staff in undertaking their duties

visitors to the site

contractors involved in carrying out projects at a particular site

students travelling to university and college campuses

trips made by all those carrying out work related tasks at premises covered by the travel plan

trips made by delivery vehicles.

WTPs generate benefits to the business, the local economy, the individual members of staff, the community, the environment and increase the quality of life for all those who live and work in the area or location addressed by the travel plan³²

104 The combination of policies, interventions and measures described by the then Highways Agency, the WebTag requirement to consider wider networks and modes and the government's smarter choices agenda have a great deal to offer to deliver all transport policy objectives in and around Newport and on the key strategic Newport-Cardiff corridor. It is regrettable that they have not been pursued with vigour, substance and determination and have not been appraised in a clearly audited fashion so that all observers can see how they perform in comparison to the M4 relief road.

105 It is also impossible to demonstrate a sound business case for the M4 relief road and Value for Money superiority when a large number of non-road building options, public transport improvements and behavioural change interventions have been given such a low priority and not worked up as valid alternatives to highway construction

7 CONCLUSIONS

106 The M4 relief road around Newport has been promoted and justified on the grounds that it will reduce congestion and contribute to local economic viability in the Newport area and in the wider sub-region.

107 I have shown that the project as a whole is not in conformity with Welsh Government sustainability policies (section 3).

108 This departure from legislative intention (Environment Act (Wales) 2016)) is a serious matter. It is even more serious that it is a specific WG decision made in the full knowledge that there are many low carbon and zero carbon alternatives to the most damaging option, the one that is before this Inquiry. This perverse and unreasonable decision brings the whole UK and WG governmental effort on climate change into disrepute and should be brought to a halt.

109 The M4 relief road is directly contrary to WG, UK government and EU climate change policies. It renders the task of reducing greenhouse gases much more difficult than it need to be and

³² <http://shop.bsigroup.com/ProductDetail?pid=000000000030180397>

represents a serious departure from legislative commitments. It is perverse and unreasonable for a well-directed Government to sign up to serious Climate Change policy objectives and then identify a preferred project option that maximises those same greenhouse gases that it is committed to reduce.

110 I have shown (section 4) that there is a remarkably robust and wide ranging body of evidence on the impact of road building and adding additional highway capacity and the outcome that additional traffic levels are generated. The so-called “induced traffic” impact is clear and evidence-based. The M4 relief road proposal has not adopted a rigorous review of induced traffic and incorporated the findings from empirical evidence into the development of a road building option and the exclusion of non-road building options. The lack of attention to induced traffic means that congestion level is likely not to be reduced and a great deal of public money will be deployed in ways that cannot deliver the primary objectives of the project. It also means that VFM and BCA calculations are unsound and it cannot be right to proceed with a project based on flawed VFM and BCA calculations.

111 I have shown (section 5) that assumptions and aspirations around a local economic stimulus and/or a regeneration benefit triggered by new road building are unproven. In fact, it is likely that new road building will to some extent drain away economic activity as a result of improved connectivity with stronger regions. This finding is contained in the 1994 SACTRA report, a UK government report, and remains unchallenged. It is unacceptable that a major public investment of the scale contemplated by the matter before this Inquiry should proceed when there is an evidence base pointing to highly uncertain and contradictory outcomes that have not been addressed by the promoters.

112 Finally, I have shown (section 6) that there is a well-developed approach to Transport Appraisal in the UK. This is described in WebTag. This is based on very clear steps involving a wide ranging option listing process that includes all modes and non-road building alternatives. This process has not been followed in the case of the M4 relief road. The proposal is not in conformity with guidance on Transport Appraisal and it is not acceptable to proceed with a very expensive project that has so blatantly ignored guidance.

113 The M4 relief road has been promoted and developed in an evidence-free environment and cannot deliver its key objectives. It is a road building solution to a complex web of problems that has ignored the large number of ways in which specific problems can be clearly described

and specific solutions based on evidence can be designed to target those problems. It is very expensive and deeply flawed and has been justified on inaccurate VFM and BCA calculations.

114 There is a very strong case for going back to the drawing board and designing solutions to problems where there is evidence that they do work and they do have very high BCA ratios. South East Wales and the Newport sub-region require an intelligent, evidence-based answer to a number of problems and this new road is neither intelligent nor evidence-based. Progress in a genuinely sustainable development and sustainable transport context focussing on sub-regional problems and needs requires this road proposal to be rejected and we can all begin to work on interventions that will actually deliver key objectives.

ANNEX 1

Embodied greenhouse gas emissions of the UK National Infrastructure Pipeline (NIP)

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This report documents the methodology and data sources used to estimate the embodied greenhouse gas emissions of the UK's National Infrastructure Pipeline (NIP). The NIP (first published in 2013) contains an overview of planned and potential UK infrastructure investment to 2020 and beyond. Over this period, the government anticipates public and private investment of more than £466 billion to meet the infrastructure needs of the UK economy, whilst achieving emissions reductions aligned with the UK's carbon reduction commitment to reduce 1990 greenhouse gas emissions by 80% by 2050. Therefore it is important to estimate the emissions requirements of planned infrastructure developments so as to ensure the target is not exceeded. Embodied emissions are the full supply chain emissions associated with the initial creation of an asset. Typically this includes emissions from: raw material acquisition, transport, processing and manufacturing of building materials; distribution of materials to site; and energy used on-site in assembly. In the infrastructure sector these are commonly referred to as capital carbon emissions to accord with the concept of capital cost. This study does not calculate the operational emissions from using the infrastructure e.g. the additional travel emissions from extending the road network. The emissions are calculated using a top-down input-output analysis, and the challenges associated with producing a comparable bottom-up estimate are discussed. Upper and lower emissions estimates are calculated to reflect (1) the desired expenditure of £466 billion and (2) the £196 billion of expenditure assigned to projects under construction.

UK's NIP

Historically the UK has invested around £30 billion per annum in infrastructure³³. However, public and private investment of £466,031 million is anticipated from 2014/15 to post 2020/21 across a range of infrastructure projects, summarised in Table 2. This represents expenditure of the order of £50 billion per annum. However, of this anticipated investment only £196,208 million is assigned to projects that are *active, approved or in construction* (Table 3). Therefore we have calculated emissions corresponding to an upper desired level of spend and a lower level of spend on projects under construction³⁴ which represent embodied emissions we are already committed to. Expenditure includes the physical resource inputs as well as wages. Prices are held constant at 2013/14 levels (i.e. the change in expenditure reflects a change in quantity, not price changes due to inflation).

³³ Average of 2005-2012 public and private investment based on HM Treasury figures published in National Infrastructure Plan 2012 update.

³⁴ The definition of 'under construction' used here refers to projects that are *active, approved or in construction*. The headline £277bn 'under construction' figure from the National Infrastructure Plan 2014 update also incorporates projects with a scheme status of *various*. As, upon inspection, many of these projects are not yet under construction, these have been excluded from the definition used in this report.

Table 2: Planned investment by infrastructure category (constant 2013/14 prices, £M)

Infrastructure category	Total	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	Post 2020/21
Communications	£10,954	£4,746	£5,449	£759	£0	£0	£0	£0	£0
Energy	£274,931	£25,000	£25,718	£24,374	£24,902	£27,466	£21,184	£23,274	£103,013
Flood	£3,654	£494	£435	£405	£407	£403	£386	£396	£729
Science and Research	£1,375	£388	£531	£270	£105	£63	£17	£0	£0
Transport	£142,273	£16,499	£17,689	£16,216	£16,085	£15,801	£11,681	£12,985	£35,317
Waste	£1,984	£899	£693	£351	£40	£0	£0	£0	£0
Water	£30,861	£4,940	£4,654	£5,140	£5,367	£5,356	£4,789	£454	£160
Grand Total (£M)	£466,031	£52,967	£55,169	£47,514	£46,906	£49,089	£38,057	£37,109	£139,219

Table 3: Investment in projects that are active, approved or in construction by infrastructure category (constant 2013/14 prices, £M)

Infrastructure category	Total	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	Post 2020/21
Communications	£10,954	£4,746	£5,449	£759	£0	£0	£0	£0	£0
Energy	£120,411	£21,737	£20,953	£18,790	£17,056	£14,880	£7,152	£6,601	£13,242
Flood	£1,082	£411	£241	£142	£84	£48	£41	£35	£80
Science and Research	£1,001	£376	£389	£198	£21	£11	£6	£0	£0
Transport	£57,634	£15,095	£12,889	£9,376	£8,418	£6,753	£2,436	£2,629	£36
Waste	£1,549	£749	£565	£223	£13	£0	£0	£0	£0
Water	£3,576	£3,576	£0	£0	£0	£0	£0	£0	£0
Grand Total (£M)	£196,208	£46,691	£40,487	£29,487	£25,592	£21,692	£9,635	£9,265	£13,358

Embodied emissions

There are two common methods for calculating supply chain or embodied emissions: bottom-up life-cycle assessment (LCA) and top-down environmentally-extended input-output analysis (EE-IOA).

LCAs are conducted by collecting primary emissions data at every stage in the lifecycle of a process or product. This is in contrast to EE-IOA which redistributes on-site emissions data reported at 100 or so aggregated sectors (depending on the model used) by countries to the equivalent number of final products through monetary trade transactions. LCA is therefore more product specific yet due to the complexity and number of supply chain components involved, is restricted to measuring a proportion of the full upstream impacts, whilst excluding others. On the other hand, EE-IOA provides a 'boundary-less' system in which all emissions are captured, yet it is constrained by aggregated sector representation.

This study adopts a top-down EE-IOA approach, presented in Section 2.1. The factors preventing a comparative bottom-up estimate are discussed in Section 2.2. An approximate allocation of emissions to NIP categories based on anticipated expenditure is presented in Section 2.3.

Top-down estimate for embodied emissions

EE-IOA generates an emissions intensity factor for the emissions embodied in UK construction per pound spent on the construction sector's output (kgCO₂e/ £), which we take as representative of the emissions intensity of infrastructure. This relates to all the physical goods and services required along the construction sector's supply chains, whether produced in the UK or abroad. The model accounts for different carbon intensities of production abroad. For example, components sourced from China have been produced with a more coal-rich and hence carbon-intensive energy supply. We use the UK EE-IOA database³⁵ to calculate an emissions intensity factor for UK construction for each of the years 2008-2012. The data is presented in constant prices, using 2010 as our constant price year. Over the 5 years from 2008 to 2012, the emissions intensity of UK-consumed

³⁵ The UK EE-IOA database is used to calculate the UK's CO₂e consumption-based account and this figure is reported annually by Defra

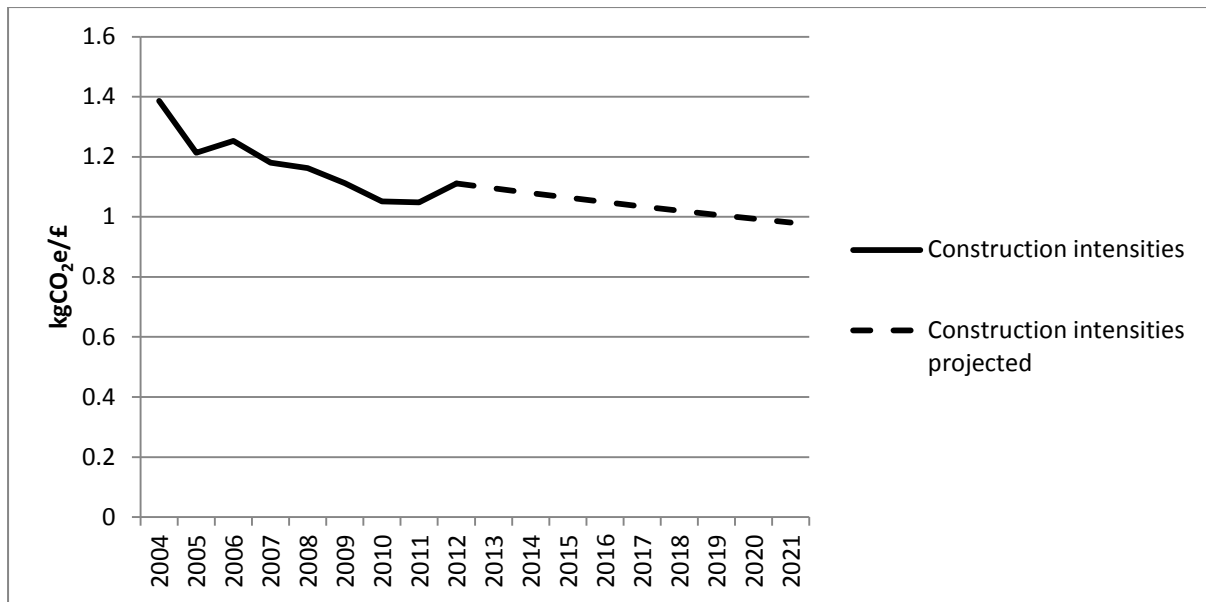
construction products has reduced by 4.4%. This is equivalent to an average of 0.9% efficiency improvements every year. In 2012, UK electricity inputs contributed 5.1% of the total embodied carbon, which is set to decarbonise from 500 gCO₂/kWh to 50 gCO₂/kWh between 2014 and 2030, at a rate of 5.6% per year. Imported electricity inputs contribute 7.1% of the total embodied carbon and we assume the same annual rate of improvement as the UK electricity decarbonisation. If all non-electricity inputs to the construction sector's carbon intensity improve at 0.9% and electricity at 5.6%, we find the overall construction multiplier reduces by around 1.35% per year. Table 1 shows the latest (2012) and projected carbon intensities for UK construction to 2021 and Figure 1 shows the trend from 2004 to 2021.

The upper and lower estimates for annual government infrastructure expenditure are multiplied by the embodied carbon intensity of construction for the equivalent year to calculate the absolute embodied emissions of the NIP. Before multiplying the expenditure by the carbon intensity, the gross value added, which is mainly paid wages, must be removed to get a figure representative of physical inputs only (i.e. carbon is not embedded in workers). To do this we take the proportion of the construction sector's spend on gross value added from the UK National Accounts for the year 2012 and assume that this proportion is valid for the years 2013-2021. In 2012, the percentage of construction expenditure on gross value added was 42.6%. In addition, the expenditure values are deflated to the year 2010's prices, since the carbon intensity figures refer to prices for that year. The cumulative embodied emissions using the top-down approach are estimated to be 243,831 kt CO₂e for the desired NIP spend and 104,220kt CO₂e for the NIP spend on projects under construction.

Table 4: Carbon intensity, spend and embodied emissions of the UK's NIP to 2021

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Carbon intensity (kgCO₂e/ £)	1.11	1.09	1.08	1.06	1.04	1.03	1.02	1.01	0.99	0.98
Total NIP expenditure minus wages at 2010 prices (£M)			27,184	28,314	24,386	24,074	25,194	19,512	19,045	71,451
NIP expenditure minus wages at 2010 prices (£M) for projects under construction			23,963	20,779	15,134	13,135	11,133	4,945	4,755	6,856
Embodied emissions for desired expenditure (Kt CO₂e)			29,334	30,120	25,580	24,906	25,194	19,670	18,929	70,098
Embodied emissions for projects under construction (Kt CO₂e)			25,857	22,104	15,875	13,589	11,363	4,980	4,726	5,726

Figure 1: CO₂e intensities of construction products from 2004-2021



Bottom-up estimate for embodied emissions

Bottom-up estimates of embodied emissions are often preferred owing to their greater specificity and reduced dependence on monetary proxies. However, two principal barriers prevent a bottom-up estimate in this instance: the lack of emissions data for certain infrastructure categories; and the presence of aggregated/unspecified expenditure data in the NIP.

The 2013 Infrastructure Carbon Review highlighted the lack of detailed industry data on embodied carbon in many categories. The Review authors were unable to gather sufficient data to compute a bottom-up estimate of baseline emissions for the sector, despite widespread industry engagement and a sizeable literature review. Good quality data is available for certain NIP categories. For example, Water, where the assessment of embodied carbon is commonplace, motivated by requirements from the regulator. See Keil et al. (2013) for a detailed review of embodied emissions estimates gathered as part of Ofwat's 2009 price review³⁶. However, other NIP categories, such as Communications have little or no embodied emissions data.

Even if bottom-up figures could be estimated for the missing categories, it would still not be possible to assign carbon intensities to all expenditure set out in the NIP. A significant proportion of expenditure in the NIP is accredited to regionally allocated funds, for example Local Growth Funding allocated to Transport, without specific project details. Numerous other NIP entries also designate packages of regional funding that include a mix of project types. Without further detail it is not possible to assign an appropriate carbon intensity to these funds.

³⁶ Keil, M., Perry, H., Humphrey, J., & Holdway, R. (2013). Understanding embodied greenhouse gas emissions in the water and sewerage sectors. *Water and Environment Journal*, 27(2), 253–260. doi:10.1111/wej.12001

Allocation of embodied emissions to infrastructure categories

In the absence of a comparative bottom-up estimate of embodied emissions, the top-down estimates have been allocated to NIP categories in proportion to their share of total expenditure. Estimates have been computed for both desired expenditure (see Table 4) and expenditure on projects under construction (see Table 5).

Results

244 Mt CO₂e are estimated to become embodied in UK infrastructure from 2014/15 if the desired level of spending is met. A minimum of 104 Mt CO₂e will be embodied if only projects under construction are completed. The bulk of planned expenditure is on Energy and Transport projects. These are assumed to be responsible for the bulk of embodied emissions (see Table 4).

Table 5: Absolute embodied emissions by infrastructure category for desired investment

Infrastructure category	Embodied emissions (Kt CO ₂ e)								
	Total	14/15	15/16	16/17	17/18	18/19	19/20	20/21	Post 20/21
Communications	6,012	2,628	2,975	409	0	0	0	0	0
Energy	143,016	13,845	14,041	13,122	13,222	14,096	10,949	11,872	51,868
Flood	1,921	274	237	218	216	207	200	202	367
Science and Research	747	215	290	145	56	32	9	0	0
Transport	74,619	9,137	9,657	8,730	8,541	8,110	6,037	6,624	17,782
Waste	1,086	498	378	189	21	0	0	0	0
Water	16,430	2,736	2,541	2,767	2,850	2,749	2,475	232	81
Total	243,831	29,333	30,120	25,581	24,906	25,194	19,670	18,929	70,098

Table 6: Absolute embodied emissions by infrastructure category for projects under construction

Infrastructure category	Embodied emissions (Kt CO ₂ e)								
	Total	14/15	15/16	16/17	17/18	18/19	19/20	20/21	Post 20/21
Communications	6,012	2,628	2,975	409	0	0	0	0	0
Energy	63,184	12,038	11,439	10,116	9,057	7,795	3,697	3,367	5,676
Flood	579	228	132	76	45	25	21	18	34
Science and Research	547	208	212	107	11	6	3	0	0
Transport	31,067	8,359	7,037	5,048	4,470	3,537	1,259	1,341	15
Waste	850	415	308	120	7	0	0	0	0
Water	1,980	1,980	0	0	0	0	0	0	0
Total	104,219	25,856	22,103	15,876	13,589	11,363	4,980	4,726	5,726