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Travel exhaustion

Kate Fewson and **Adrian Leaman** examine eight British office buildings to see how they compare in terms of CO_2 contributions made by journeys-to-work

So-called green buildings may or may not achieve their energy targets (most don't), and may or may not be liked by their occupants (although many are), but what about the carbon dioxide (CO_2) emissions resulting from journeys made to and from those buildings?

The authors have carried out a preliminary study of existing data in order to establish some yardsticks and to get some idea of the orders of difference.

The study buildings are a subset from Building Use Studies' (BUS) UK database.[3] These have had building-user surveys carried out on them which include a journey-to-work section. The journey-to-work analysis was originally introduced when it became clear that many buildings were increasingly dependent on recruiting staff to service them, many of whom travel longer distances to work because they could not afford to live close by.

The approach was originally developed by Kate Fewson on three study buildings[4], then extended by a further five buildings for this article. Altogether, there are data for 21 offices, 11 higher education buildings and 11 schools: but here we are only looking at eight of the offices. These are described, anonymously, in Table 1.

The offices were selected to cover a mixture of types and locations, ranging from large city-centre offices to smaller buildings in semi-rural and urban fringe/ring-road settings in England and Wales. Some of them have green building credentials, and some are occupied by organisations with an avowedly green agenda.

Note that the sample is not big enough to allow robust comparisons between these types and locations. At this stage we need to understand orders of difference and magnitude.

The BUS survey asks people how they get to the study building, whether by their own car, a shared car, a bus, train, or bicycle and so on. People know quite accurately their best and normal journey times, and especially recall the worst cases.

As the BUS questionnaire asks for respondents' home postcodes, and the postcode of the study building is known, Google maps can be used to obtain approximate travel distances to and from the study buildings. The task is laborious, but less so than other methods,

Table 1: The eight buildings that formed the study in carbon dioxide emissions from journeys to work. Advanced natural ventilation describes buildings with innovative, usually automated ventilation devices controlled by both occupiers and a building management system, the latter for night cooling and rain protection.

Building	Ventilation type	Type and location	Green credentials	Occupier has environmental agenda
A	Air-conditioned	Urban business park office, city outskirts		
B	Naturally ventilated	Studio units in a multi-tenanted, city-centre office		
C	Advanced naturally ventilated	Office, centrally located small town in rural setting	Yes	Yes
D	Advanced naturally ventilated	Large office in business park in medium-sized town	Yes	Yes
E	Advanced naturally ventilated/Air-conditioned	Academic offices in city centre	Yes	
F	Naturally ventilated/Advanced naturally ventilated	Business park, city outskirts	Yes	Yes
G	Air-conditioned	Large office, west London		
H	Air-conditioned	Large office, suburban fringe		

Table 2: The results summary for the eight study buildings. Direct comparison is difficult for buildings in very different contexts.

Building	Estimated CO_2 emissions contributed by building occupants' journeys (kg CO_2 per employee per annum)	Rank order (1=lowest emissions contribution)	Actual energy and CO_2 emissions by base building and occupiers' end use (all figures per annum)	Observations
A	1504	8	Not known	86% drive to work
B	985	4	Electricity: 107 kWh/m^2 Carbon dioxide: 60 kg CO_2/m^2	Mixed commuting pattern to city-centre location constrained by parking
C	620	2	Electricity: 39 kWh/m^2 Gas: 42 kWh/m^2 Carbon dioxide: 30 kg CO_2/m^2	Building emissions reasonably low, but 30% car use in 'green' organisation
D	1304	6	Carbon dioxide: 75 kg CO_2/m^2	Car-sharing and provided buses, bringing down car use to 50%. Otherwise it would have been over 90%
E	241	1	Not known	80% walk or cycle
F	1129	5	Electricity: 53 kWh/m^2 Biomass: 71 kWh/m^2 Carbon dioxide: 25 kg CO_2/m^2	The most efficient building in the study, but over 80% car use cancels out much of this
G	854	3	Carbon dioxide: 173 kg CO_2/m^2	Typical London commuting with 54% travelling by train/underground
H	1467	7	Not known	86% travel by car

including that of asking the respondents themselves, who tend to be very poor at estimating distances.

Knowing the journey mode and the distance travelled enables the use of published carbon dioxide coefficients to estimate emissions.[5] For example, for cars (as make, model, age and fuel type is not part of the BUS survey) a published (2005) ratio[6] of 82:18 petrol:diesel is used for the consumption of cars in the UK cars, along with 0·348 kg carbon dioxide per mile for petrol and 0·295 kg CO_2 per mile for diesel. This gives an estimate of 0·338 kg CO_2 per mile, with assumed average consumptions of 30 and 40 miles per gallon respectively.

Obviously, it would be better to use exact figures derived from detailed observations and monitoring of journeys, congestion, fuel use and other variables, so that the estimations could be improved, but we do not have that information. In its absence, we have to be as clear as possible about the assumptions, so that the reader can judge our estimates for themselves. To this end the summary of our assumptions are available from the Usable Buildings Trust website.[7]

Table 2 shows a summary of the results. The most striking things include a six-fold difference between the lowest CO_2 contribution (Building E, with over 80 percent walking or cycling) and the highest (Buildings A and H, both with over 85 percent car-based commuting).

City-centre buildings (B and G, with higher proportions of train and bus travel, 52 percent and 63 percent respectively) have about half the carbon dioxide contribution of car-dependent buildings.

Buildings occupied by organisations with an explicit environmental agenda (C and D) do better despite locational disadvantages. Staff in Building C make more of an effort. Where the organisation has introduced green travel plans (as in building D), car use has been cut down from a possible 90 percent to an actual 50 percent, of which 17 percent are car shares.

Figures 1 and 2 overleaf are journey-to-work plots for buildings E and D by journey mode and distance. Building E is the best performing in this study, with an unusually high proportion of people walking and cycling. Building D has introduced green travel plans, with enforced car sharing and buses to help cut down car-borne emissions. In spite of this, one employee commuted weekly by air.

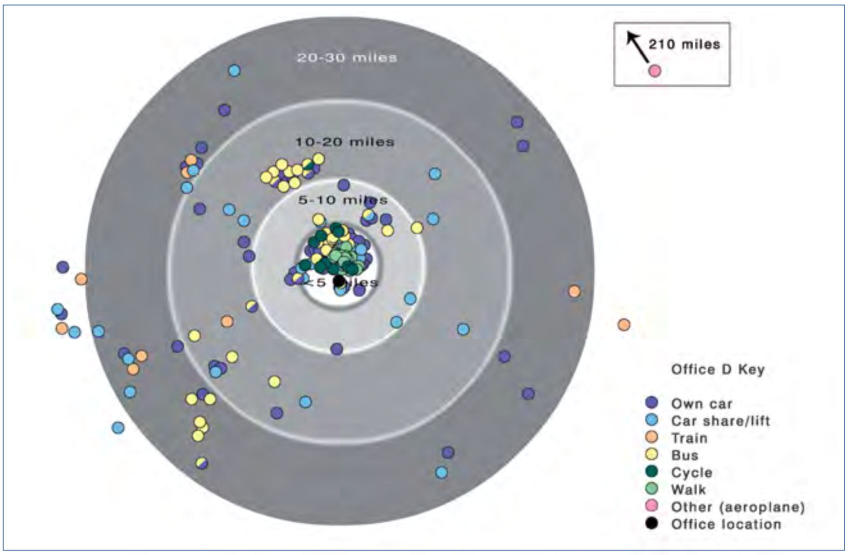
Table 3 overleaf has average normal journey-to-work times (one-way) for the study buildings. The lowest (20 minutes) is again building D. As might be expected, Building G, the London case, has the highest average, 55 minutes: this equates to nearly two hours commuting on a normal

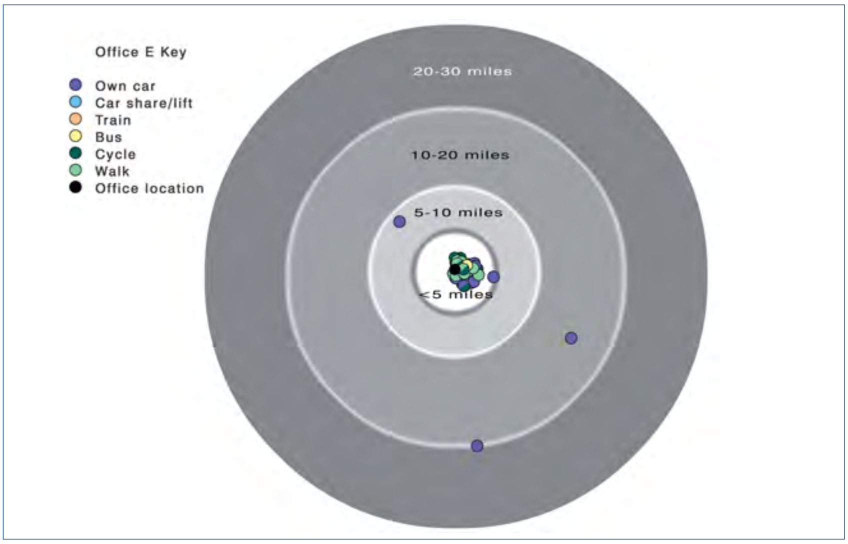
SUSTAINABLE TRAINS

North America often gets bad press where sustainable living is concerned. But some States are deeply committed to reducing carbon dioxide emissions and traffic pollution.

In California, Caltrain railcars, *above*, have been adapted to take 32 bikes, in four stacks of four deep on each side. There is a system of tags which encourages people to stack bikes in blocks for the same destinations. The Caltrain line runs from San Francisco down Silicon Valley to San Jose.

In an effort to increase railcar passenger carrying capacity and accommodate bicycles, the San Francisco Bay Area Rapid Transit District (BART) is modifying railcars by removing and/or changing seating configurations. Twenty out of 80 railcars have been completed as of May 2008. Two additional cars are expected to be retrofitted each month until all 80 cars are completed.





Top, Figure 1 (Building D) and ***below, Figure 2*** (Building E) showing journey-to-work plots by journey mode and distance. Note that some train and car outliers have been omitted from the Building D plot for ease of presentation. The full data is available from www.usablebuildings.co.uk/Pages/UBPublications/UBPubsTransportCO2.html

Below, Table 3: Average normal journey to work times for the study buildings.

Building	Average normal journey to work time (minutes)	Main mode of journey to work, percent							
		Car or motorcycle		*Train*	*Bus*	*Walk*	*Cycle*	*Other*	*Total*
		Own	*Shared*						
A	37	83	3	0	6	0	8		100
B	20	24	10	33	19	10	5		100
C	23	32	9	5	5	23	27		100
D	41	33	17	7	19	18	5	1	100
E	22	17	0	0	3	27	53		100
F	26	76	8	0	5	8	1		100
G	55	14	2	54	9	7	10	2	100
H	28	78	8	4	0	10	0	4	100

day, taking into account journeys both ways. Congestion and delays can make this much worse.

The average worse case journey time for building G is 93 minutes (not shown in table 3). If this is divided into the average best case time (47 minutes), this gives a congestion index for the building: a score of 1·97. If all the journey times were the same every day, the index would be 1, the best possible case. The congestion index for building D with its low contribution is 29/19, a score of 1·53.

What it all means

So what does this tell us? It shows that the study buildings with over 80 percent of people commuting to work by car are up to six times worse for commuting-related carbon dioxide emissions than those where 80 percent walk or cycle. It also tells us that buildings with occupiers with a committed green agenda are likely to get commuting-related emissions down by a half, even if they have locational problems, such as being located on an out-of-town business park with relatively poor public transport where the temptation to drive is overwhelming.

However, the study is only based on eight cases, so it important that these results should be seen only as a first stab at understanding orders of magnitude and difference. The next step is compare commuting emissions alongside building emissions, to look at their relative contributions. There is little point in being painstaking about reducing building emissions through better design and management if these are cancelled out or swamped by emissions from travel and the downsides of congestion.

If long commuting times mean that it becomes even harder to recruit staff to run buildings efficiently, especially in city centres, then this is a further nail in the carbon coffin.

References

[1] Kate Fewson is with Design Group 3 Architects.
[2] Adrian Leaman is with Building Use Studies and The Usable Buildings Trust.
[3] Further details about the Building Use Studies survey method may be accessed on www.usablebuildings.co.uk/WebGuideOSM/index.html.
[4] MSc Architecture, Advanced Environmental and Energy Studies, Centre for Alternative Technology, Machynlleth
[5] Hampton, D. (2006) The Edge Pledge: Carbon Audit Excel Spreadsheet. www.at-the-edge.org.uk/edgepledge/edgepledge.htm Accessed 31 May 2007 and 27 April 2008
Hampton, D. (2007) MSN Carbon Emissions Calculator: Assumptions and calculations. news.uk.msn.com/carbon_calculator_assumptions.aspx. Accessed 11 June 2007 (Thanks to Dave Hampton.)
[6] A further useful source on carbon calculators is Botterill C, *Internet-based tools for behaviour change*, Paper presented at sEuropean Council for Energy Efficient Economies. Summer Study 2007 Dynamics of Consumption Session 9.
[7] www.usablebuildings.co.uk/Pages/UBPublications/UBPubsTransportCO2.html.