

NATIONAL INFRASTRUCTURE ASSESSMENT |

Evidence Submission

Guildford, 10 February 2017

The Centre for the Understanding of Sustainable Prosperity (CUSP) is an ESRC-funded research programme concerned with sustainability and its implications, at all levels, from individuals' understandings of their own "prosperity" to global questions such as climate change. CUSP is based at the University of Surrey. Our work leads us to the following responses to the Commission's questions -

4. What is the maximum potential for demand management, recognising behavioural constraints and rebound effects?

(a) Joined up thinking

In the context of infrastructure, 'demand management' should not be defined too narrowly: we urge the commission to consider the demand management potential of the 'infrastructure of civic life' (Sandel, 2009). For example, infrastructure investment in schools and hospitals, community halls and theatres, museums and public libraries empowers us to live in less materialistic ways. That is, certain forms of infrastructure enable people to engage with the world in ways that emphasise community and nature rather than individual wants and material possessions (Jackson, 2016). This is desirable because materialistic lifestyles are associated with higher energy demand and material throughput in the economy. Likewise, materialism is linked to lower levels of physical and mental health (Kasser, 2016). Consequently, investment in infrastructure that is aimed at strengthening our communities and our social lives is likely to reduce the strain on energy and health infrastructures, by providing wider societal benefits.

Similarly, when considering demand management it is vital that the infrastructure of the UK is considered as an integrated system. This will include, for example: assessing travel needs alongside the siting of residential and non-residential buildings; making use of waste heat in district heating networks through careful placing of buildings; integrating disposal of waste in planning decisions, so that biogas emitted from anaerobic digestion of food waste can be easily and efficiently utilised.

b) The UK Building Stock

Assessment of UK building stock is key to demand management for energy. Buildings are responsible for a large proportion of UK (and global) energy use, and in the life cycle (construction, operation and demolition) of a building, approximately 80% of energy use occurs in the operation phase (Cabeza et al. 2014). Buildings must be assessed in order to ascertain which buildings are suitable for retrofit to provide greater energy efficiency, and which buildings should be demolished and replaced.

This should be applied to domestic and non-domestic buildings. Stringent, low carbon standards should be set for both refurbishment and new-build (Committee on Climate Change 2016). Energy efficiency refurbishment will include installation of, for example, loft insulation and cavity wall and solid wall insulation. Other options include low energy retrofit of LED lights and water efficiency measures such as rain water harvesting and grey water recycling, where appropriate. Likewise, low carbon options such as heat pumps should be considered where suitable. Smart controls are also important in demand management. Electrification of heat demand should also be considered. However, this will depend on the availability of renewable electricity. In summary there are many options for demand management during the lifetime of a building, and this can have a substantial impact on energy use.

This said, assessment of the UK building stock should be done on a life cycle thinking basis, in which all steps are taken into account¹. This is because although most energy use occurs in operation, energy is used in every stage of a building's lifecycle. Moreover, embodied energy (energy used in production of building materials) makes up 10-20% of energy used across the whole of a building's life, and there are substantial opportunities for reducing this. Studies suggest that use of low carbon or recycled building materials can reduce the embodied energy of a building by 30-50% (Cabeza et al. 2014). Such opportunities would be missed if a life cycle thinking perspective was not taken in the assessment phase.

c) Travel infrastructure

A transition from a private vehicle based transport system towards an integrated public mobility system should be considered. In particular, options for active travel, such as walking and cycling, should be encouraged, as these have been shown to enhance both physical and mental health. In this way, they have added benefits for wider Government spending programmes, such as the NHS. For example, in a review that assessed the evidence base concerning the economic assessment of investment in walking and cycling², Davis (2010) found that almost all of the studies reported highly significant economic benefits from walking and cycling interventions. In particular, for the UK studies reviewed, it was found that the benefits to costs ratio (BCR) median was 19:1 Davis (2010).

d) Incentives, taxation and subsidies - a clear message to encourage low carbon options

Government use of incentives, taxation and subsidies should be reformed in order to encourage low carbon options. Currently, government policy often increases the price of low carbon options and reduces the price of high carbon alternatives. A topical example is the current discussions around changing tax regimes for domestic and business rooftop solar installations while also excluding large scale solar from bidding for government contracts to sell energy to the grid at the lowest guaranteed price. This represents the use of taxation to increase the price of a low carbon option and simultaneously prevent it from accessing an (effective) government subsidy. These kinds of pricing issues must be eliminated wherever possible for two reasons. First, low prices directly encourage encouraging high carbon behaviours. Second, when high carbon options are subsidised by government (or vice versa) they give the impression that choosing low carbon options is not considered important by government.

e) Rebound effect

The rebound effect will occur, and so it is important to factor it into plans and targets. Typical rebound effects have been found to be modest (0-32%) for efficiency measures affecting domestic energy use by UK households, larger (25-65%) for measures affecting vehicle fuel use, and very large (66-106%) for measures that reduce food waste (Chitnis et al, 2014)³.

However, presence of the rebound effect does not mean that energy efficiency actions should not be taken (Druckman et al. 2011). Rebound effects of less than 100% do reduce anticipated energy savings but they do not eliminate savings altogether. On the other hand, backfire (rebound effects of more than 100%) should generally be avoided (Druckman et al. 2011, Chitnis et al. 2013).

That said, there are likely to be cases where substantial rebound effects occur but energy efficiency measures are justified by other concerns. For example, energy efficiency rebound effects are highest for low income households (see Chitnis *et al* (2014)), but it is important to take into account the wider benefits (such as to the residents' health and wellbeing) that also result from these energy efficiency actions. Consequently, the Commission should always consider rebound effects in their wider context.

Carrying out the assessment of the UK building stock (and following it up with appropriate actions) is the best way to minimize the rebound effect. This is because, in simple terms, the size of the rebound effect is related to the relative intensities (energy or greenhouse gas emissions per £ spent) of competing expenditure choices. Rebound occurs when money saved by an energy efficiency measure is spent on other goods and services (Druckman *et al.* 2011). If the money saved by an efficiency measure is spent on goods/services that are more intensive than the goods/services subject to the energy efficiency measure, then backfire will occur. Conversely, if the money saved by an energy efficiency measure is spent on goods that are less GHG intensive, then rebound effects will be less than 100% and carbon will be saved. As an illustration, Table 1 shows the GHG intensities of different types of expenditure.

An extreme example of bad practice with regards to the rebound effect was the promotion by a major supermarket that gave consumers 'air miles' when they purchased energy efficient light bulbs (Chitnis *et al.* 2013).

Conversely, encouraging energy efficiency actions is good practice with regards to the rebound effect. This is because direct energy use in buildings is one of the most GHG intensive forms of expenditure (see Table 1), and so energy efficiency actions will, generally speaking, result in a rebound effect of less than 100% (typically 0-32% as stated above).

In summary, while rebound effects are almost inevitable when enacting appropriate energy efficiency measures in the UK housing stock, they do not negate the usefulness of this type of demand management.

Description	GHG intensity (kgCO₂e/£)
Food & non-alcoholic beverages	1.05
Alcohol and tobacco	0.26
Clothing & footwear	0.54
Electricity	5.04
Gas	4.70
Other fuels	6.95
Other housing	0.28
Furnishings etc.	0.75
Health	0.35
Vehicle fuels and lubricants	2.61
Other transport	1.25
Communication	0.43
Recreation & culture	0.65
Education	0.25
Restaurants & hotels	0.59
Miscellaneous	0.52
Savings	0.57

Table 1. GHG intensities by category for an average household.

This shows that expenditure on electricity, gas, other fuels and vehicle fuels is approximately three times as GHG intensive as expenditure on the other categories and five times as intensive as the share-weighted mean. (Source: Table A.5 in Chitnis *et al*, 2014)

NOTES

1 For refurbishment: energy usage of building once refurbished for the remainder of its estimated lifetime; the embodied carbon in the materials used in refurbishment; environmental impacts of the demolition of the building at the end of its lifetime and end of life impacts of, for example, any materials sent to landfill (including the materials added in the refurbishment); any 'gains' that offset these through potential recycling.

For demolition and replacement: environmental impacts of the demolition of the building and end of life impacts of, for example, any materials sent to landfill; for life time impacts of the replacement building including all stages of it, from raw material extraction, processing and production of materials, transportation, use and end of life.

2 The evidence reviewed was from both peer reviewed and grey literature, and from both the UK and beyond.

3 Rebound effects reported here are in terms of greenhouse gases.

REFERENCES

- Cabeza, L., Rincon, L., Vilarino, V., Perez, G. and Castell, A. (2014) 'Life cycle assessment (LCA) and life cycle energy analysis (LCEA) of buildings and the building sector: A review', *Renewable and Sustainable Energy Reviews*, 29, 394-416.
- Chitnis, M., Sorrell, S., Druckman, A., Firth, S. K. and Jackson, T. (2013) 'Turning lights into flights: Estimating direct and indirect rebound effects for UK households', *Energy Policy*, 55, 234-250.
- Chitnis, M., Sorrell, S., Druckman, A., Firth, S. K. and Jackson, T. (2014) 'Who rebounds most? Estimating direct and indirect rebound effects for different UK socioeconomic groups', *Ecological Economics*, 106(0), 12-32.
- Committee on Climate Change (2016) *Next steps for UK heat policy*, London, UK: Committee on Climate Change <https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf> [accessed 24.10.17].
- Davis, A., 2010. *Value for money: an economic assessment of investment in walking and cycling*. United Kingdom: Department of Health, Government Office for the South West. http://healthandtransportgroup.co.uk/health_transport/ValueforMoneyAnEconomicAssessmentofInvestmentinW.pdf.
- Druckman, A., Chitnis, M., Sorrell, S. and Jackson, T. (2011) 'Missing carbon reductions? Exploring rebound and backfire effects in UK households', *Energy Policy*, 39, 3572-3581.
- Jackson, T. (2016) *Prosperity Without Growth: Foundations for the Economy of Tomorrow*. 2nd edn. Routledge, London.
- Kasser, T. (2016) 'Materialistic Values and Goals', *Annual Review of Psychology*, 67, pp. 489-514.
- Sandel, M., (2009) *A New Citizenship*, 2009 Reith Lectures, London: BBC. Available at: www.bbc.co.uk/programmes/b00kt7rg

11. How should infrastructure most effectively contribute to protecting and enhancing the natural environment?

Infrastructure planning should consider – in addition to the “fiscal envelope” – the implications of the Climate Change Act and the implications of the fixed total land area of the UK.

The Climate Change Act 2008 does not include specific provisions regarding infrastructure, and so the National Infrastructure Commission – which is already committed to developing its recommendations in line with the Act – will need to come to a view about the share of the UK carbon budget that can be taken up by infrastructure building and use (e.g. both road building and extra car miles travelled). It will then need to assess the carbon implications of each infrastructure option it considers, so that it can ensure that its whole package of recommendations is within the “**carbon envelope**”.

Similarly, the “land envelope” is also crucially important. Again, a view will need to be reached as to the amount of land that can reasonably be devoted to infrastructure, bearing in mind competing uses, such as housing, industry, agriculture, and green space. The total package of recommendations will then need to be within this total “**land envelope**”. This will require analysis of the land take implications of each infrastructure option.

For each option, it would then be possible to see (and this can be imagined as a table of figures): the total financial cost, the cost to government, the carbon emissions implied, and the land take implied.

28. What are the barriers to achieving a more circular economy? What would the costs and benefits (private and social) be?

The circular economy has the potential to reduce waste and hence help to solve waste infrastructure problems. CUSP research has explored the business responses to circular economy ideas through its *More Profit Less Stuff* programme, as well as research on challenges for smaller businesses with regard to investing in circular economy business models.

Better use of current infrastructure - At a local authority level, there is a range of household recycling approaches. Better regulation is needed to simplify the system, and avoid low quality recycling which contributes to the exporting of waste to developing countries where environmentally damaging recycling is more likely to occur – particularly with regards to waste electrical and electronic equipment (WEEE) (Perkins et al., 2014).

Attracting new entrants to provide innovative solutions – CUSP research on finance shows that there is a specific finance gap for green high-technology businesses as they seek funding for growth particularly as their commercialisation process is characterised by a longer time horizon investment. Government interventions like the UK Innovation Investment Fund have the potential to improve early stage private investment into recycling and advanced manufacturing sectors (Owen and North, 2015; Owen et al 2016).

Encouraging investment in the circular economy – Developing circular business models requires coordination from multiple supply chain actors. Businesses developing these new models recognise this and are calling for better regulation which aligns incentives between actors rather than seeking the removal of ‘red tape’. This will provide the confidence to invest in the forward and backward supply chains where they do not already exist and ensure that the dis-assembly and re-manufacturing processes are done to a satisfactory standard. Regulation is also needed to ensure manufacturers design products for ease of dis-assembly (Allwood & Cullen, 2012).

Full-cost accounting is required to ensure that business and government procurement take into consideration the negative environmental and social impact of waste (Jackson, 1996). There are also particular challenges facing the circular economy from the Brexit negotiations as many product components are assembled at different stages in different countries (for example cars). Thus future investment in the circular economy infrastructure needs to consider the likely regulation in the EU which will also affect the decisions of UK manufacturers seeking to continue to sell products in this market. This is particularly relevant to the UK automotive, aviation, heavy goods equipment and construction sectors where there are existing initiatives (e.g. Caterpillar ReManufacturing in Shrewsbury) and further opportunities for applying circular economy principles (Allwood & Cullen, 2012; Tennant, 2013; Brennan et al, 2015).

Research and development for the circular economy – CUSP researchers have been exploring the R&D and product design issues associated with the transition to a circular economy (Brennan et al, 2015). While high-value advanced manufacturing sectors (renewable energy technology, automotive and aerospace) are where there are the biggest opportunities for applying circular strategies, they are increasingly dependent on innovative composite materials which also represent a challenge. The production of advanced materials is increasingly outpacing our ability to re-use and recycle them safely, implying that extensive research and development is likely to be required (Yang et al, 2012).

This suggests that continuing to invest in the UK's currently world leading research on material science and biotechnology is critical in order to explore the potential of substitutable materials that are less toxic and safer to dis-assemble. Related to this is the need for research into the role of automated dis-assembly and the impact on jobs.

REFERENCES

- Allwood, J. M. & Cullen, J. M. 2012. Sustainable Materials - with Both Eyes Open: Future Buildings, Vehicles, Products and Equipment - Made Efficiently and Made with Less New Material.
- Brennan, G., Tennant, M. and Blomsma, F. (2015). Chapter 10. Business and production solutions: Closing Loops & the Circular Economy, in Kopnina, H. and Shoreman-Ouimet, E. (Eds). *Sustainability: Key Issues*. Routledge: EarthScan, pp.219-239.
- Jackson, T. (1996) *Material Concerns: Pollution, Profit, and Quality of Life*, Routledge, London.
- Owen R, Lyon F, Vickers I and Cowling M (2016) A Review of UK Government Interventions to assist SMEs to address Green Sustainable Investment. Paper to Institute of Small Business and Entrepreneurship conference, Paris, October 27-28th
- Owen (Baldock) R and North (2015) The Role of UK Government Hybrid Venture Capital Funds in Addressing the Finance Gap Facing Innovative SMEs in the Post 2007 Financial Crisis Era, in Ed. Scott J. and Hussain J.G. *International Research Handbook on Entrepreneurial Finance*, Edward Elgar
- Perkins, D.N., Brune Drisse, M-N., Nxele, T. and Sly, P.D. (2014) E-Waste: A Global Hazard. *Annals of Global Health*. Volume 80, Issue 4, July–August 2014, pp286–295.
- Tennant, M. (2013) Sustainability and Manufacturing. Future of Manufacturing Project. Evidence Paper 35. UK Government Foresight Office.
- Yang, Y. Boom, R., Irion, B., Van Heerden, D.-J., Kuiper, P. & De Wit, H. 2012. Recycling of composite materials. *Chemical Engineering and Processing: Process Intensification*, 51,53-68.