What is the significance of the UK’s 80% territorial reduction target for GHG emissions from a consumption-based perspective?

Kate Scott and John Barrett

Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds, LS2 9JT.

The scenarios were devised in collaboration with the UK Committee on Climate Change (CCC, 2013).

Abstract

The UK has one of the highest net emission transfers questioning whether the current territorial approach to target setting is appropriate and whether enough policy effort is devoted to consumption measures. This paper investigates the relevance of the UK’s 80 percent territorial emission reduction target from a consumption-based perspective. A time series of consumption-based accounts is developed for 1993 to 2010 to show trends in the UK’s carbon footprint. A series of scenarios compatible with the climate objective of a two degree future are developed for the UK and seven trading regions (including China, India and OECD-Europe). UK consumption emissions are analysed in a world where a two degree future is realised, and compared to a world where international actions don’t go beyond pledges made in the Copenhagen Accord. Scenarios incorporate changes in UK production emissions and carbon intensities, UK final demand, UK trade relations and emission intensities in other countries. The consumption scenarios show that the UK’s carbon footprint is likely to fall over time as declining emission intensities offset any increase in demand from imports. However, the gap between production and consumption emissions remains, and widens more significantly under less ambitious international pathways and higher import demand assumptions. The paper concludes that the current territorial and end-point-based target does not reflect emissions driven by UK consumption and potentially overestimates success when compared to consumption-based cumulative emissions. Demand-side policies informed by consumption-based accounts can lead to greater and potentially more immediate reduction potential.

# Introduction

Internationally there is global agreement on the need to limit warming to no more than 2 degrees (UNFCCC, 2010). However, without a global cap on emissions linked to a reasonable probability of limiting global temperature to two degrees combined with a mitigation framework, it is difficult to assign responsibility that links to this global total. Even if fulfilled the CO2 impact of existing climate commitments and pledges within the UNFCCC fall far short of levels needed for a two degree future (IEA, 2013). The UK has taken unilateral action and adopted its own national target committing itself to reducing territorial greenhouse gas emissions by 80% by 2050 relative to a 1990 baseline (Crown, 2008). The reduction target is defined on a territorial basis in accordance with greenhouse gas emissions reporting obligations under the UNFCCC. Cumulative carbon budgets are set at five year intervals, four budget periods in advance, to ensure the UK is on trajectory to meet the overall target. However the UK is a net emissions importer where through demand for imported products the UK generates an equivalent volume of CO2 emissions abroad (Barrett et al., 2013).

Whilst the UK’s production emissions have been on a downward trajectory, its consumption-based emissions have risen. Consumption accounting allocates emissions to countries on the basis of their consumption of goods and services, irrespective of where they were produced along the supply chain (Munksguaard and Pederson, 2001 and Peters, 2008). In a truly globalised world defining responsibility for emissions becomes increasingly irrelevant from a territorial perspective. Countries that have reduced their manufacturing base will have a considerably lower carbon intensity of production, despite not consuming fewer products. This raises the questions of whether current territorial approach to target setting is appropriate and whether enough policy effort is devoted to consumption measures. Such analysis requires looking at the UK in the global context as evidently UK emissions are not limited to within its territory.

Between 1993 and 2010 CO2 emissions produced in the UK fell by 9%. In contrast, over the same period CO2 emissions associated with the UK’s consumption of goods and services - including imported emissions - are estimated to have risen by around 15%. If continued, these differential trends may have implications for UK climate change policy. However, the evidence base for this is weak: whilst projections of future production emissions are well researched (for example Davis et al., 2010; Usher and Strachan, 2010, Anandarajah and Strachan, 2010 and Mander et al., 2007), projections of future consumption emissions have been largely lacking. In particular, there have been no long-term projections of UK consumption emissions consistent with a carbon-constrained world.

This paper considers the relevance of an 80% territorial reduction target for CO2 emissions from a consumption-based perspective. The UK House of Commons Energy and Climate Change Committee (ECC) produced a report on consumption-based accounting advising the Committee on Climate Change, an independent body to inform UK climate policy, to explore the implications that consumption-based emissions accounting may have for the UK’s carbon budgets (House of Commons Energy and Climate Change Committee, 2012). This analysis forms part of the Committees investigation (CCC, 2013). This paper provides the first consumption-based emission scenarios for the UK, taking account the mitigation potential of its major trading partners. UK consumption emissions are analysed in a world where a two degree future is realised, and compared to a world where international actions don’t go beyond current targets pledged in the Copenhagen Accord. The analysis provides an insight into the possible trajectory of the UK’s consumption-based emissions. In addition it presents a scenario where key mitigation scenarios such as CCS play an insignificant role in future mitigation strategies. It discusses the need for consumption-based emissions accounting in national climate mitigation policy.

# Method: consumption-based emission accounting

Multi-region input-output analysis (MRIOA) is the most appropriate tool to estimate consumption-based emissions accounts at the national and supra-national level (Peters et al., 2012; Wiedmann, 2009 and Peters, 2010). MRIOA reallocates territorial emissions, point source emissions from industry within a country’s territory, through complex international trade flows to the destination country of the final consumer using Leontief’s standard input-output calculus. We use Eora, a multi-region input-output database developed at the University of Sydney (Lenzen et al. 2013 and Lenzen et al. 2012) to calculate a time series of consumption-based CO2 accounts for the UK from 1993 to 2010. The model represents 110 UK sectors consistent with UK National Accounts and 26 homogenous sectors for countries outside the UK. The 187 country coverage is aggregated into the UK and 7 trade regions: OECD Europe (excluding UK), non-European OECD, Russia, China, India, Rest of Asia and Rest of World.

In order to project UK consumption emissions, which include emissions released overseas in the production of goods consumed by UK residents, to 2050 we developed scenarios for both emissions produced domestically and imported emissions. Emissions are determined by the volume and pattern of UK final consumer spending (on both domestic and imported goods and services), multiplied by the CO2 intensity of products measured as CO2/ £ [output]. Carbon intensities are the emissions produced per unit of output in the UK and in its trading partners along the full supply chain of products and they reflect differences in regional production intensities, enabled by using a MRIO model. Given uncertainty over the range of future variables involved, we test the sensitivity of results to different scenarios for UK import demand and global emissions.

The 2010 input-output table from Eora is used as the baseline for scenarios. 2010 input-output variables are projected at 5 year intervals as a percentage change from 2010 to 2050 according to the assumptions described for each scenario in the following sub-section. Assumptions on global emissions, global economic growth, global carbon intensities, and UK final demand for domestic and imported goods are projected to explore regional and sectoral contributions to UK mitigation targets defined by consumption.

Two main scenarios explore the implications of existing high-level global emissions pathways for the UK’s consumption-based emissions trajectory:

* **2 degree future (CO2):** All regions reduce emissions to meet a 2050 target compatible with the 2 degree climate objective. A variation of this scenario is run where CCS is not successfully deployed thus requiring more deployment of renewable and nuclear, electrification in industry, and full decarbonisation of transport in the UK. In other regions emissions become higher without the availability of CCS.
* **4 degree future (CO2):** The UK meets its 2050 target but rest of the world emissions don’t go beyond those pledged under the Copenhagen Accord, consistent with a 4 degree future.

## Scenario assumptions

The scenarios are informed by historic trends and long-term emission pathways developed by the CCC and IEA (CCC, 2013 and IEA, 2012). Eora has a time series from 1993 to 2009 which allows us to extract, alongside the calculation of consumption-based CO2 emissions, changing rates of regional carbon intensities, trade structures, demand levels and consumption patterns experienced over the time period. It is assumed that the UK meets its 80% reduction target in line with its five year carbon budgets. The CCC demonstrated a range of technically feasible options for achieving the target against projected increases in population and economic growth. This was achieved by low carbon energy sources alongside improved energy efficiency and behaviour change across all sectors. They illustrated how the target could be met if barriers such as consumer resistance and the absence of key technologies like CCS prevailed.

Table 1 outlines the scenario assumptions taken. The transactions matrix representing trade between 292 sectors[[1]](#footnote-1) is kept constant. Baiocchi and Minx (2010) show that production structure changes have driven marginal changes in the UK’s carbon footprint compared to changes driven by increased final demand and carbon intensity improvements.

Table 1: Scenario assumptions

|  |  |  |
| --- | --- | --- |
| **IO variable** | **2DS scenario** | **4DS scenario** |
| UK sectoral emissions | UK production emissions are reduced 80% from 1990 levels by 2050 as defined by the Committee on Climate Change emission scenario “Barriers to industry” (pg. 46: CCC, 2012). | Same as 2DS |
| Global sectoral emissions | Global emissions reduce by 60% from 2010 to 2050 to 16 Gt CO2 in line with the 2 degrees climate objective informed by the IEA (2012)*[[2]](#footnote-2)*. A variation where CCS is not successfully deployed is run, in which global CO2 emissions reduce by 55%. | Current emission reductions pledged under the Copenhagen Accord are implemented, with global energy-related emissions in 2050 at 40 Gt CO2, similar to global emissions in 2010. |
| Economic growth | Office for Budget Responsibility (OBR) projections were used to project UK annual economic growth rates and IMF and other sources were used to project economic output in the seven trading regions. China and India are anticipated to have strong annual growth nearing 10% by 2020, reducing gradually thereafter. UK and OECD Europe are anticipated to experience more steady growth, reaching their highest (2.7% and 2.8%) in 2021-2025. Proportional analysis projects economic growth by sector i.e. the sectoral distribution of output in 2050 is the same as 2010. | Same as 2DS |
| Carbon intensities | Sectoral emissions are divided by sectoral output | Sectoral emissions are divided by sectoral output |
| UK final demand | Three demand sub-scenarios are modelled:   * Low demand: demand for imported products is assumed to increase in line with average long-run GDP growth (2.25%) and demand for domestic products just less at 2.2 percent. Imports would represent a similar share of UK GDP in 2050 compared to today. * Central demand: demand for imported products is expected to increase at the average annual growth rate of the past 20 years (2.75%) and growth in domestic demand is reduced to 1.9 percent. The import share of GDP would increase to 40 percent by 2050. * High demand: growth rates for imported products are anticipated to increase to 3.25 percent, the longer-term rate since 1975 reflecting a period of strong growth in trade and resulting in half UK GDP stemming from imports by 2050. Adjusting for historic rates in net trade demand for domestic products would reduce to 1.6 percent per annum. | Same as 2DS |
| Regional and sectoral demand | Demand for imports increasingly shifts to emerging economies, from representing a 29% share of UK imports in 1990 to 50% in 2050, and away from fossil fuels and associated products. | Same as 2DS |

# Results

The change in UK consumption-based accounts from 1993 to 2010 are shown followed by the presentation of results for UK consumption-based emissions to 2050. A regional and sectoral analysis identify in which country and sector the emissions are generated to meet UK final consumer demands. Results in 2050 are compared to the 2010 baseline data.

## Trends in the UK’s consumption-based emissions

UK consumption-based emissions increased 16% from 1993 to 2010 (Figure 1). All the growth in emissions was emitted outside the UK. Overall, imported emissions rose nearly 60% and were marginally offset by an 8% reduction in domestic emissions. In 1993 the share of imported emissions in the UK’s account was a third compared to 45% in 2010. Emissions released in all regions except European OECD countries have increase in the production of goods to satisfy UK demand. The most significant rise in emissions from UK demand is in China, overtaking European OECD countries combined, where an additional 60Mt CO2 became embodied in products destined for the UK in 2010. This is 2.5 times higher than 1993.

Figure 1: UK consumption-based emissions by source region in 1993 compared to 2010[[3]](#footnote-3)

**-8%**

**0%**

**290%**

16% increase

**144%**

**16%**

**-19%**

**83%**

240%%

## UK consumption emissions in 2050

In 2010 UK production and consumption emissions were 536 Mt CO2 and 775 Mt CO2 respectively. The UK is a net importer of emissions with UK consumption emissions being in the region of 50% higher than its production account. Figure 2 shows results for the two and four degrees scenarios for UK domestic and imported CO2 emissions to 2050. Under both a two and four degree future UK consumption emissions are likely to reduce as global carbon intensities fall at greater rates than the increase in UK demand. Under a central demand scenario where the UK achieves an 80 percent reduction in its production emissions by 2050 and global emission fall in line with the climate objective of 2 degrees, UK consumption emissions are estimated to fall almost 80% from 775 Mt CO2 in 2010 to 180 Mt CO2 in 2050. Under a less ambitious global emissions pathway where countries outside the UK don’t go beyond current climate mitigation pledges, consumption emissions are estimated to be 384 Mt CO2, a 50% reduction from 2010. In this situation the gap between production and consumption widens and consumption emissions are estimated to be almost three and a half times greater than those generated from its production. A sensitivity on the 2DS scenario without CCS technology shows a footprint that is just over 20 MtCO2 or 12% higher than the 2DS scenario due to higher industrial emissions intensities in the absence of CCS.

A low and high demand variant tested the sensitivity of the two degree scenario. Approximately 10 Mt CO2 was reduced and added to the UK footprint, making the carbon footprint results about 5% lower or higher than the central assumption. In the high demand scenario the share of imported emissions was in the region of 5% higher reflecting increasing levels of demand being met by imports.

Figure 2: UK consumption-based emission scenario results

## Regional distribution of emissions

In 2010 domestic emissions accounted for a 55% share of UK consumption emissions. Figure 3 compares this to domestic and imported shares in the scenarios. Comparing scenarios under the central demand assumption the domestic emissions share reduces to 28% and 13% under the two degree and four degree scenarios respectively. Imported emissions become increasingly significant if the climate objective is not met. The share of emissions from OECD countries increases in both cases as emission intensities in less developed countries become comparatively similar to those in developed countries. Therefore the footprint is more reflective of the physical trade pattern.

Figure 3: Domestic and import shares of projected UK consumption emissions

## Sector emissions

In 2010 over a third of imported emissions were emitted in the power sector (125 Mt CO2), with approximately a fifth each attributed to transport and the manufacture of petroleum, chemical and non-metallic mineral products (76 and 72 Mt CO2 respectively). Figure 4 shows the (aggregated) sector in which emissions were generated abroad for final consumption in the UK. If global policy is successful by 2050 there is a switch between the top emitting sectors abroad. Strong international decarbonisation in the power sector reduces imported emissions by more than 80% to less than 20 Mt CO2. Transport replaces electricity as the most polluting sector where limited decarbonisation options have resulted in a 40% reduction, with an estimated 44 Mt CO2 being generated in 2050 to meet UK demand. Emission reductions in other sectors such as agriculture, construction and services are less, yet there contribution to absolute emissions is lower. In 2050 they are expected to account for a 30% share of UK imported emissions.

Figure 4: Projected UK imported emissions by sector of origin

# Discussion and considerations for UK climate policy

Based on the scenarios described, where UK climate mitigation policies are played out in a world with strong and weaker climate action, this section discusses the significance of the UK’s 80% reduction on UK territorial emissions compared to its consumption emissions. Already implicit is the success of the UK to achieve the targets set under the Climate Change Act by means described in the UK carbon Plan and supported by the CCC (2012). This in itself has been the subject of many emissions scenarios and debate.

## The UK’s offshore account

It is clear from the results than even if a global deal is made to reduce emissions to levels that limit global warming to no more than two degrees, imported emissions matter to the UK’s carbon footprint. Under this scenario, UK consumption emissions would be almost twice its production emissions in 2050 and imports would account for more than a 70% share. However without a global deal, if countries reduced emissions in accordance with current pledges, the UK’s carbon footprint would end up more than twice as high and assuming the same pattern of trade the imported share would be nearly as much as 90%. If the UK is not able to meet its reduction target this would also have the effect of increasing its footprint, yet with upward trends in trade and imported emissions already accounting for nearly half the emissions, neglecting these is by no means insignificant.

The question then becomes both a political and technical feasibility one. Firstly, under current convention can a global deal be reached where countries are required to reduce their territorial emissions, and secondly are the rates of reduction (a) technically feasible and (b) technically feasible with territorial emissions as the main policy driver? Attributing the global budget to countries based on a consumption basis may be a mechanism for involving industrialising countries in reduction targets. Yet if the former is agreed then there is no reason why the UK needs to reduce its imported emissions as these will be covered under the convention. However if international efforts fall short of ambition the implications for global emissions and the UK’s footprint are stark. Therefore consumption accounts should be required as a measure of progress.

The CCC and IEA scenarios are heavily reliant on decarbonisation and technology solutions. The IEA suggests global carbon intensities need to reduce by 4% a year to 2050, rates unprecedented in history. This is greater than three times the current global average of 1.2% a year from 1990 to 2011[[4]](#footnote-4) (IEA, 2012). On average, carbon intensity improvements have been greatest in emerging economies over this time period, improving at 2.8% per year since 1990. Even if strong decarbonisation has occurred it has not been sustained. For example the UK achieved its greatest reduction in the carbon intensity of its energy supply in the 1990s with the privatisation of the electricity sector and the consequent switch from coal to gas, which has a relatively lower carbon output. Additionally its carbon intensive manufacturing base has declined, matched by increasing imports from more carbon intensive economies, leading to a reduction in CO2 relative to its GDP.

Additionally, a UK service economy is not necessarily a low carbon one as service sectors are significant drivers of manufacturing activities abroad (Scott and Barrett, 2013 and Suh, 2006). With the UK’s shift to a service-based economy it is likely to remain to be a net importer of emissions, relying on manufacturing activities overseas. Increased trade means increased transportation and increased emissions. Limited decarbonisation options in the transport sector means transport overtakes energy becoming the highest emitting sector. Whilst some traded and transport emissions are captured within the EU ETS the majority of emissions fall outside the EU’s control as trade with emerging economies like China and India rise, and the inclusion of emissions from international transportation remains a contentious issue.

## A foundation for consumption-based emission accounting

The UNFCCC has defined the accounting framework for emissions on a territorial basis. This however can lead to a biased view by hiding emissions generated in production activities abroad for imported products. Consumption-based emission accounting differs by its geographical allocation by attributing emissions to the consumer, not the producer. At the national level multi-region input-output analysis is regarded as an appropriate tool for consumption-based accounting. Production emissions are reallocated through economic trade flows to the final consumer. It is supported by an increasing research community committed to developing and updating multi-regional input-output databases.

In 2011 Defra (UK Department for Environment, Food and Rural Affairs) commissioned the University of Leeds to provide annual consumption-based accounts. They have since been supported by the Energy and Climate Select Committee who have requested that DECC (UK Department for Energy and Climate Change) consider it when devising climate policy (House of Commons Energy and Climate Change Committee, 2013). The uncertainty of estimates has been questioned (CCC, 2013) however arguably presents an excuse for inaction. Continuously the government bases climate policy comparing the future costs of climate change with the monetary value of the future benefits, a cost-benefit analysis (Ackerman, 2008). An obvious example is the widely publicised Stern Review on the Economics of Climate Change (Stern, 2007). In simple terms the cost of emission abatement technologies need to be offset by the cost of their benefits to human life and ecosystems, fundamentally non-monetary values. In this sense governments are pricing the priceless, clearly with a huge dose of uncertainty about the damages of climate change, and trading them against each other.

However, with concern to consumption-based accounts, Peters et al. (2012) found that consumption-based emissions accounts are broadly consistent despite some differences in the model compilation, and that the difference didn’t necessarily translate into uncertainity but were a result of several data sources and definitions of consumption (see Table 1). Variation in the territrial emissions accounts, and the attribution of these emissions to countries and sectors, was found to be much larger than the variation in economc and trade input data. Transport and energy intensive sectors exhibit the most variation in results along with small trade dependant countries and countries with poor data quality. When calculting consumption-based estimates differences in the territorial emissions will propgate through the model explaining the most significant variation in consumption-based emission accounts. Therefore, the relative uncertainty is less for consumption accounts.

Table : Average percentage variation between consumption-based emission accounts

|  |  |
| --- | --- |
| Input data/ assumptions | Average percentage variation |
| Territorial emission accounting source | 30% (between countries) |
| Definition of consumption | 21% |
| Economic and trade input data | 5% |

## Meeting carbon budgets

When referring to the UK’s 80% emission reduction target, the target is still defined by an end-point basis as opposed to a cumulative budget, even though the science of climate change is clear on the cumulative impact of emissions (Anderson and Bows, 2011). Global temperature rises are approximately proportional to an increase in cumulative emissions, but not end-point targets where emission pathways to reach a 2050 reduction target can differ (Gillet et al., 2013). Whilst the UK carbon budgets are only on five year timescales and not directly related to a corresponding cumulative budget, they do ensure the UK is on a downward trajectory to meet its 80% target and therefore mitigation efforts cannot be delayed. Carbon budgets determine a ceiling on cumulative emissions over five year periods and have been set up to 2027.

By extrapolating the emission results between the five year periods, cumulative emissions for the different consumption-based scenarios are calculated and compared to the UK carbon budgets (Figure 2). Whilst domestically the carbon budgets will be surpassed, even if global mitigation efforts are aligned with limiting warming to two degrees, the emissions more than double those produced domestically. The level of carbon budgets in 2023 to 2027 fall a third short of UK consumer driven emissions. From this perspective, that the UK is responsible for increased emissions in countries that have contributed less to cumulative global emissions and have less capacity to mitigate, the level of budgets is arguably too low.

Figure 5: Cumulative UK consumption-based emissions aligned with defined carbon budgets

Additionally, cumulative emissions (Figure 3) expose progress to be weaker than shown from an end-point target basis and shift some emphasis back towards domestic emissions. According to progress towards the 80% target, 54% of emissions will be saved if a global deal is reached compared to current reduction pledges. Domestic emissions would represent a 28% share. From a cumulative basis savings are only 18%, and progress in the UK is less favourable with domestic emissions making up a 50% share. An 80% end-point reduction does not translate to an equivalent reduction in cumulative terms.

Figure 6: UK consumption emissions from 2010 to 2050 from a cumulative basis

## Increasing mitigation opportunities

Demand levels in the UK are ultimately what drive the UK’s global carbon footprint, offsetting carbon reductions from improved efficiency. However, production emissions are the main policy lever in UK and global mitigation policy. From a global perspective this makes sense as the scope for individual countries to implement emission reduction policies outside their political boundary is limited. Yet within a country, consumption-based emissions provide a mechanism to increase the scope for emission reductions through demand-side measures (Scott and Barrett, 2013 and Barrett and Scott, 2012).

UK production emissions are the direct emissions released by UK sectors to produce both products for domestic consumption and exports. This identifies the power sector, energy-intensive industries (e.g. petroleum, mineral and metal manufacturing sectors) and transport as the dominant source of emissions. UK consumption emissions reveals the role of products (Barrett et al., 2013), attributing the majority of emissions to the service sector (Scott and Barrett, 2013). Whilst service industries emit less carbon directly from their premises than heavy industries, they themselves are drivers of manufacturing activity as the provision of services is heavily reliant on manufactured products (Suh, 2006). Products used by the UK service industry are not confined to national production with more than 50% of emissions originating outside the UK, and largely outside the European Union (Barrett et al., 2011).

By changing the focus of policy new opportunities for reduction strategies are introduced. For example Barrett and Scott (2012) explore the potential for demand-side measures to reduce product throughput in the economy. Strategies such as product lifetime extension, product-service systems and dietary changes can contribute to reduced material and product use contributing to emission reductions. This exerts influence on emissions outside the UKs political boundary increasing the scope for reductions whilst not imposing its policies on other countries. In the UK context WRAP already exists with a wide and increasing evidence base to provide advice on opportunities for product policy.

# Conclusions

Internationally, the UK has one if the highest net emission transfers questioning whether the current territorial approach to target setting is appropriate and whether enough policy effort is devoted to consumption measures. If a global deal is reached whereby countries sign up to reducing emissions within their territory, the UK’s 80% emission reduction target provides an appropriate mechanism for mitigation policy. However, this conventional approach warrants caution as it relies on strong international collaboration and immediate and unprecedented reductions in carbon intensities. In terms of reaching a global deal, consumption-based accounting could facilitate international agreement on the grounds that it allocates emission reductions on a more equitable basis. Industrialised countries such as the UK would be responsible for reducing a larger share of global emissions on the premise that it is their high level of demand driving global production activities.

Whilst the UK is on track to meet its 80% target and exceed its first four carbon budgets, the same cannot be said when all the emissions released to satisfy its final demand are considered. The carbon budgets fall about a third short. Moreover, the UK’s end-point 80% reduction target is not attached to a global carbon budget aligned with limiting temperature to two degrees, let alone a cumulative budget for the UK. The end-point nature of the target primarily needs to be reframed to a cumulative target aligned with a global budget as every tonne emitted is linearly correlated to temperature rise. Under this approach, consumption-based reductions under strong mitigation are not much better than those if only current mitigation pledges globally were met, potentially overestimating success. This would improve if mitigations options were implemented earlier, reducing total emissions in the atmosphere. The share of domestic emissions rise, of which the UK has greater control, however, half the emissions remain outside UK territory.

Even if consumption-based accounting is deemed politically infeasible, at the national level it provides a mechanism to benchmark progress against global efforts and to increase the scope of its emissions outside its political control. Used as a complementary tool for devising climate mitigation policy it increases the levers available to policy makers with the potential to provide shorter-term measures whilst waiting for the wide deployment of low carbon technologies. This need is ever more apparent from a cumulative perspective. Given the increasing share of imported emissions in the UK’s account, and the political and technological uncertainty, making consumption-based accounting mandatory gives us the greatest chance to be armed with responses faced with the increasing danger of climate change.

# References

Ackerman, F. (2008) Critique of Cost-Benefit Analysis, and Alternative Approaches to Decision-Making, A report to Friends of the Earth England, Wales and Northern Ireland

Anandarajah, G. and Strachan, N. (2010) Interactions and implications of renewable and climate change policy on UK energy scenarios, *Energy* *Policy,* 38(11): 6724-6735.

Anderson K and Bows A (2011) A new paradigm for climate change. *Nature Climate Change* 2: 639 – 640

Baiocchi, G. and Minx, J.C. (2010) Understanding Changes in the UK’s CO2 Emissions: A Global Perspective, *Environ. Sci. Technol.*, 44(4): 1177 – 1184

Barrett J., Owen A., Sakai M. (2011) UK Consumption Emissions by Sector and Origin, Report to the UK Department for Environment, Food and Rural Affairs by University of Leeds

Barrett , J., Peters , G., Wiedmann, T., Scott , K., Lenzen , M., Roelich, K. & Le Quéré, C. (2013) Consumption-based GHG emission accounting: a UK case study, *Climate Policy*, 13(4), 451-470, DOI:10.1080/14693062.2013.788858

Barrett, J. and Scott, K. (2012) Link between climate change and resource efficiency, *Global Environmental Change*, 22, 299-307

CCC (2013) Reducing the UK’s carbon footprint, UK, London

Crown (2008) Climate Change Act, http://www.legislation.gov.uk/ukpga/2008/27/contents

Davis S.J., Caldeira K. and Matthews, H.D. (2010) Future CO2 Emissions and Climate Change from Existing Energy Infrastructure, *Science*, 329.

DEFRA (2013) *UK’s Carbon Footprint – 1997 to 2011*, Statistical Release, UK, London

Gillett, N. P., V. K. Arora, D. Matthews, and M. R. Allen, 2013: Constraining the ratio of global warming to cumulative CO2 emissions using CMIP5 simulations. *Journal of Climate*, doi:10.1175/JCLI-D-12-00476.1.

House of Commons Energy and Climate Change Committee (2012) Consumption-Based Emissions Reporting, Twelfth Report of Session 2010–12, Volume I, UK, London

IEA (2013) Redrawing the energy-climate map, World Energy Outlook Special Report, International Energy Agency, Paris, France

IEA (2012) CO2 Emissions from Fuel Combustion (2012 Edition), IEA, Paris.

IEA (2012) *Energy Technology Perspectives: Pathways to a Clean Energy System*

Lenzen, M., Kanemoto, K., Moran, D., Geschke, A. Mapping the Structure of the World Economy (2012). *Env. Sci. Tech*. 46(15) pp 8374-8381. [DOI:10.1021/es300171x](http://dx.doi.org/10.1021/es300171x)

Lenzen, M., Moran, D., Kanemoto, K., Geschke, A. (2013) Building Eora: A Global Multi-regional Input-Output Database at High Country and Sector Reso lution, *Economic Systems Research*, 25:1, 20-49, [DOI:10.1080/09535314.2013.769 938](http://dx.doi.org/10.1080/09535314.2013.769938)

Manders, S., Bows, A., Anderson, K., Shackley, S., Agnolucci, P. and Ekins, P. (2007) Uncertainty and the Tyndall decarbonisation scenarios, *Global Environmental Change,* 17, 25 – 36

Munksgaard, J. and Pedersen, K.A. (2001) CO2 accounts for open economies: producer or consumer responsibility?, Energy Policy, 29, 327-334.

Peters, G.P. (2010) Carbon footprints and embodied carbon at multiple scales, *Current Opinion in Environmental Sustainability*, 2: 245 – 250, DOI 10.1016/j.cosust.2010.05.004

Peters GP (2008) From production-based to consumption-based national emission inventories. *Ecological Economics* 65(1): 13–23

Peters, G.P., Davis, S.J., and Andrew, R.M. (2012) A synthesis of carbon in international trade, *Biogeosciences Discussions*, 9, 3949 – 4023, doi:10.5194/bgd-9-3949-2012

Scott, K. and Barrett, J. (2013) Investigation into the greenhouse gas emissions of the UK services industries, Report to the UK Department for Environment, Food and Rural Affairs by the University of Leeds.

Stern, N. (2007) *The Economics of Climate Change: The Stern Review*, Cambridge and New York: Cambridge University Press

Suh, S. (2006) Are services better for climate change, *Environmental Science and Technology*, 40 (21), 6555

UNFCCC (2010) Report of the Conference of the Parties on its fifteenth session, held in Copenhagen from 7 to 19 December 2009, United Nations Office at Geneva, Geneva, Switzerland

Usher, W. and Strachan, N. 2010 ‘UK MARKAL Modelling - Examining Decarbonisation Pathways in the 2020s on the Way to Meeting the 2050 Emissions Target’, Final Report for the Committee on Climate Change (CCC), November, UCL Energy Institute, University College London

Wiedmann, T. (2009) A review of recent multi-region input–output models used for consumption-based emission and resource accounting, *Ecological Economics*, 69, 211 – 222, doi:10.1016/j.ecolecon.2009.08.026

1. UK 110 sectors and 7 trading regions represented by 26 sectors each [↑](#footnote-ref-1)
2. UK emissions from the CCC scenario are subtracted from the IEA global emissions [↑](#footnote-ref-2)
3. Emissions released directly by UK households (mainly from gas heating and petrol for car use) are separated from domestic industry emissions from intermediate production [↑](#footnote-ref-3)
4. GDP is calculated using purchasing power parities, not exchange rates. The average rate is less than 1% using exchange rates [↑](#footnote-ref-4)