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Consumption based Greenhouse Gas Emissions for London

(2008 to 2010)

Commissioned by the Greater London Authority

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Contents

1. Introduction

This report documents the Consumption-based Greenhouse Gas Emissions Accounts (CBA) for London for the period of 2008 to 2010. CBA offers a different perspective from the standard approach for assigning GHG emissions to a territory. Instead of purely considering the emissions that are released in the territory of London, CBA considers the emissions that occur due to the consumption activities of London residents, including all the emissions associated with the production of goods and services throughout their complete supply chain (more detailed definitions are provided below).

University of Leeds is responsible for producing the CBA for the UK Government providing national level figures. The same methodology has been applied to calculate the CBA for London. The predominant methodology is an “Environmentally Extended – Multi Regional Input Output” model (EE-MRIO). A European project (Wiedmann et al. 2009) identified Environmentally Extended Multi-Region Input-Output (EE-MRIO) Analysis as a favourable approach for the assessment of environmental impacts of trade. EE-MRIO is emerging as a comprehensive, versatile and compatible approach for consumption-based accounting of greenhouse gas emissions and has already become the norm (Davis and Caldeira, 2010; Peters and Hertwich, 2008; Peters et al., 2011; Wiedmann, 2009; Wiedmann et al, 2011). Strengths and weaknesses of the EE-MRIO approach were assessed in the European EIPOT project (Wiedmann et al., 2009).

The UK has adopted consumption-based emissions as an official government indicator and has undertaken numerous reports that employ the approach to evaluate the effectiveness of climate mitigation measures beyond technological solutions. These include an assessment of the role of resource efficiency in climate change mitigation policy, the role of services and an understanding of drivers of GHG emissions between 1992 and 2004 (Barrett and Scott, 2012; Minx et al, 2009; Baiocchi and Minx, 2010).

In summary, employing the EE-MRIO methodology and ensuring consistency with the national accounting, this report provides consumption based emissions for London from 2008 to 2010, for both carbon dioxide and Greenhouse Gases (GHGs) providing figures in absolute, household and per capita emissions.

2. Definitions

GHG emissions can be allocated to countries and cities in different ways. Three different methods of allocating emissions are now in common use: 1) territorial-based, 2) production-based, and 3) consumption-based.

1) The United Nations Framework Convention on Climate Change (UNFCCC) requires countries to submit annual National Emission Inventories. The UNFCCC follows the Intergovernmental Panel on Climate Change's guidelines in term of the allocation of GHG emissions which is, "emissions and removals taking place within national (including administered) territories and offshore areas over which the country has jurisdiction" (IPCC, 1996, pp.5). According to this definition, however, GHG emissions emitted in international territory, international aviation and shipping, are only reported as a memo and not allocated to individual countries. We call these "territorial-based emission inventories".

2) Some countries and cities also report GHG emissions using the same system boundary as the System of National Accounts (SNA), such as are already done with Gross Domestic Product (GDP). This allocation is necessary to make the emission statistics consistent with economic data used in economic modelling. These inventories are often called "National Accounting Matrices including Environmental Accounts (NAMEAs)". In the EU, NAMEAs are reported to Eurostat, though most other developed countries develop NAMEAs but do not report them internationally. The main difference between NAMEAs and the UNFCCC territorial emissions is the allocation of emissions occurring in international territory, and the allocation of tourist activities. In the SNA, international aviation and shipping are typically allocated to countries based on the operator of the vessel, likewise, international tourists are allocated emissions based on where they are resident and not where they are travelling. We call the NAMEAs "production-based emission inventories".

3) Consumption-based emissions allocate emissions to the consumers in each country or city, usually based on final consumption as in the SNA but also as trade-adjusted emissions (Peters, 2008). Conceptually, consumption-based inventories can be thought of as consumption equals production-based emissions minus the emissions from the production of exports plus the emissions from the production of imports (Consumption = Production – Exports + Imports). We call these "consumption-based emission inventories".

3. Methodology

3.1 EE-MRIO

EE-MRIO is a peer-reviewed method having applications in the calculation and reporting of consumption-based emissions accounts and in climate change policy (Minx et al., 2009; Wiedmann and Barrett, 2013).

Input-output models (IOM) make the link between the environmental impacts associated with production processes and the consumers of products. The IOM is constructed from observed economic data and shows the monetary transactions between industrial sectors (intermediate consumers) and final consumers[1]. Economic sectors purchase goods and services from other sectors; pay wages; pay taxes and potentially receive subsidies in the process of making their own product. Final consumers demand goods and services such as food, energy, transport, domestic appliances, leisure activities and so forth. Government sectors are recognised as both a final consumer with an annual budget to spend, and an intermediate sector providing public services (e.g. health care and education). Figure 1 illustrates the structure of an IOM.

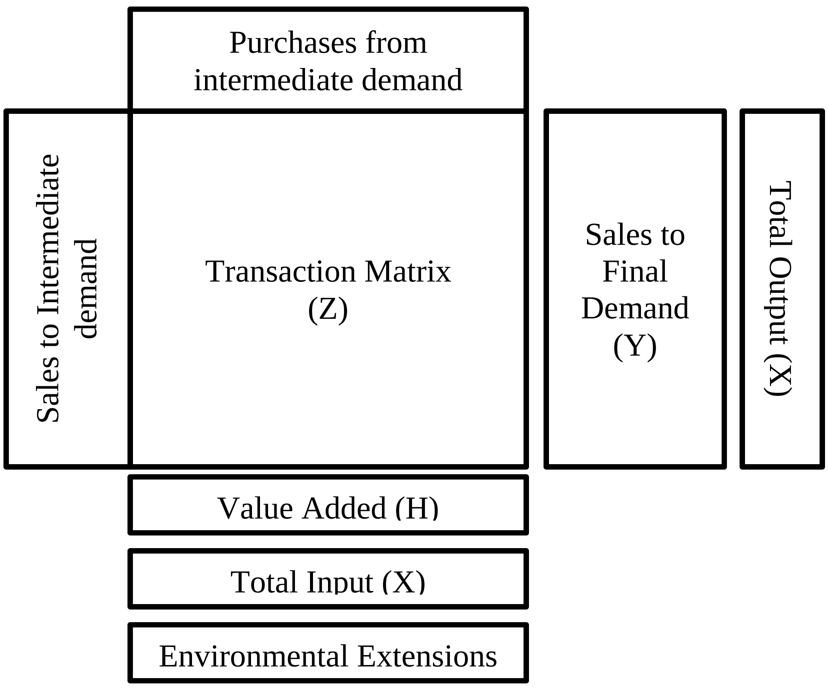

Figure 1: Basic structure of an IOM

[1] Represented as Households, Government, Non-Profit Institutions and Capital Investment in IO tables

EE-MRIO allows analysts to consider the impact of traded goods. Essentially, an MRIO model for *n* countries each with *m* sectors generates a matrix of dimensions '*m x n*' rows by '*m x n*' columns and rather than considering a single nations' economy it treats the entire global economy as a single system. The MRIO table is constructed by placing the domestic IO tables from every region along the diagonal of a large composite matrix and filling in the off diagonal matrices to show the sectoral requirements from non-domestic regions in the production of domestic products. This assumes IO tables are available for all nations, there is a degree of harmonisation in sectors described and trade linked data can be determined.

The methodology employed in this study is consistent with the approach adopted by both the UK and Scottish Government that employs an EE-MRIO model. For more details on the model please refer to Barrett et al (2013).

3.1 National to sub-national accounts

The methodology described above allows national consumption-based accounts to be produced. Additional steps are required to produce CBA at the sub-national level (London for example).

We use a hierarchical hybrid methodology for estimating final consumption of London (Minx et al, 2013). This approach integrates data from multiple sources and prioritizes the most robust information. Our methodology also prefers physical over monetary data, as far as possible, to avoid quantity estimates being biased by inhomogeneous or volatile prices (Weisz and Duchin 2004).

At the local level we update household spending on domestic energy consumption with data measured in energy units (kWh) and further adjust local consumer expenditure matrices by matching them with regional spending estimates derived from the expenditure survey across all consumption activities, in this case the Family Spending Survey produced by the Office of National Statistics. Accordingly, we match the sum of all regional matrices with national level data.

Household consumption contributes 70% of the UK's carbon footprint (Minx, Wiedmann et al. 2009). The remainder is attributable to government services and capital investments. We downscale the national accounts for those to the local level on an equal per capita basis. This means we assume that every citizen in the UK enjoys the benefits from government expenditures and capital investments in the same way. In summary, the proposed approach goes beyond mere geo-demographics and adjusts consumption patterns according to local conditions (Minx et al, 2013).

4. Results

Figure 1 and 2 show the consumption-based CO2 and GHG emissions for London. Both the CO2 and GHG emissions are lower on a per capita basis for London in comparison to the UK, across all three years. In 2010, the GHG emissions associated with the average London resident, in relation to household consumption, were 7% lower than the national average.

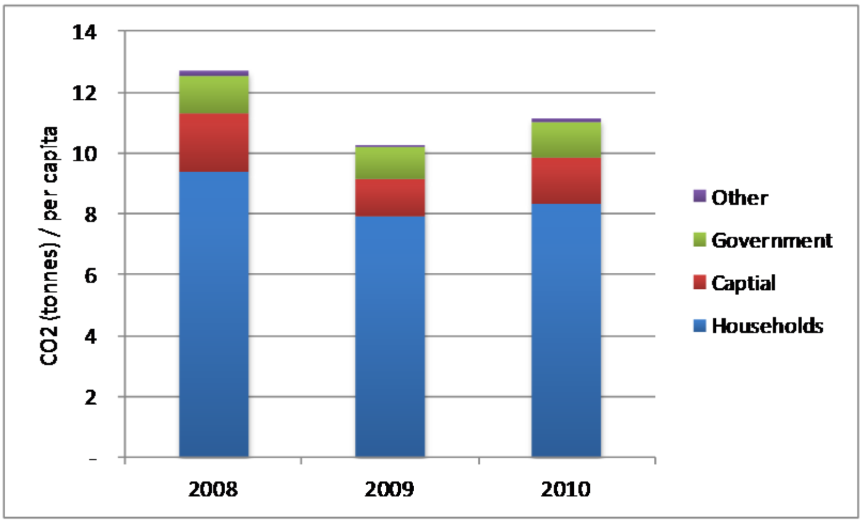

Figure 1: Consumption based CO2 Emissions for London (2008 – 2010) organised by households, capital, government and other

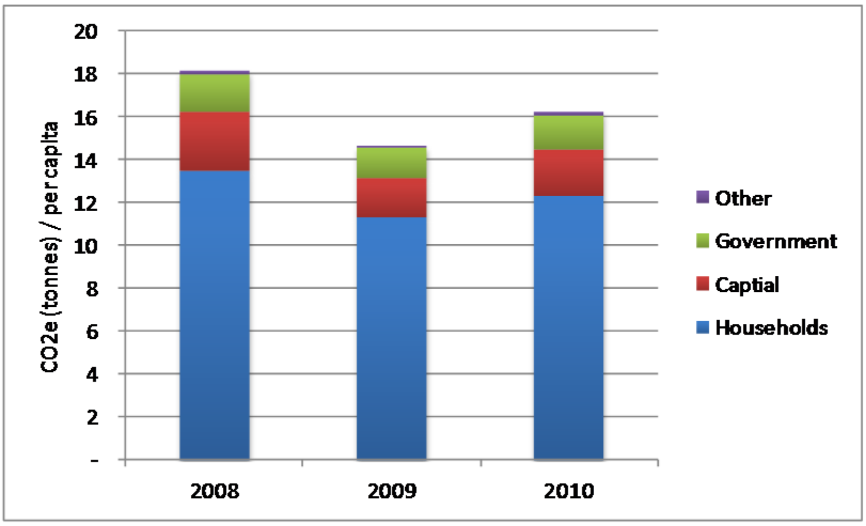

Figure 2: Consumption based GHG Emissions for London (2008 – 2010) organised by households, capital, government and other

In 2010, the CO2 consumption-based emissions for London were 11.1 tonnes per person. This was 12% lower than 2008 but an increase of 8% compared to 2009. The emissions in 2009 were significantly lower and analysis for the UK Government undertaken by the University of Leeds suggests that the majority of this decline relates to the global recession and the associated reduction in household expenditure and capital investment. The emissions for GHG emissions follow a very similar pattern. The GHG emissions per person in 2010 were 15 tonnes per person, a 15% decline compared to 2008 and a 7% increase compared to 2009.

The category "other" refers to a number of miscellaneous expenditure items that are difficult to assign to one of the main categories. These include expenditure by "Not for profit" institutions serving households (NPISH) such as charities and museums. In addition this category includes changes in stock within capital items.

75% of the GHG emissions relate to household consumption, a figure consistent over the three years. 14% of the emissions relate to capital investment and 10% relate to government expenditure.

The fact that London's GHG emissions are lower than the UK's emissions hides the fact that there is a more significant variation between consumption categories with some categories above and below the UK average. London's consumption has a unique structure compared to the rest of the country.

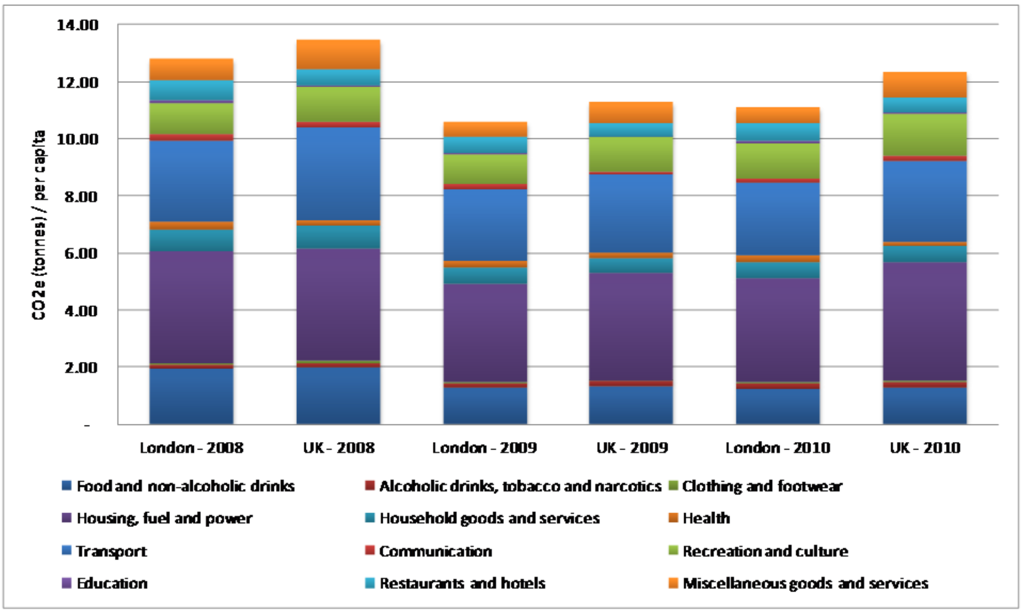

Figure 3: GHG Consumption based emissions for London and UK by consumption categories (tonnes / capita)

The key issues for the variation in the emissions between London and the UK have been provided below for individual consumption categories.

- Food – London residents have consistently lower emissions than the national average. There is less expenditure on food purchased for home cooking. The key variable that determines the emissions of food is the level of meat and dairy consumption. London residents were lower on both these categories in terms of expenditure. Another factor could relate to eating out. Eating out is categorised as a service and therefore not including in these category but spread over the service categories.

- Housing, including fuel and power – The GHG emissions were 6% below the national average. One key factor relates to the level of household occupancy. In London this is considerably higher than the national average meaning greater efficiency in terms of heating and use of power. In terms of gas use, London residents have marginally higher emissions and lower for electricity consumption.

- Travel – This category had the most significant difference between UK and London residents in relation to road transport. Distance travelled by private vehicles was considerably lower for London residents resulting in emissions being around 30% lower than the national average. Some of these reductions are lost due to higher than average use of aviation.

- Goods and services – For categories such as household goods, clothing, hotels and restaurants and other services, London residents have consistency higher GHG emissions than the national average (in the region of 10% more). This relates to higher expenditure on all these categories.

Finally, the results have been organised by the categories documented in the GHG Protocol. The GHG Protocol considers three scopes. These being:

- Scope 1 which includes GHG emissions directly occurring from sources within the location.
- Scope 2 emissions physically occur at the facility where electricity is generated.
- Scope 3 includes all other indirect GHG emissions that are a consequence of the expenditure activities of London residents

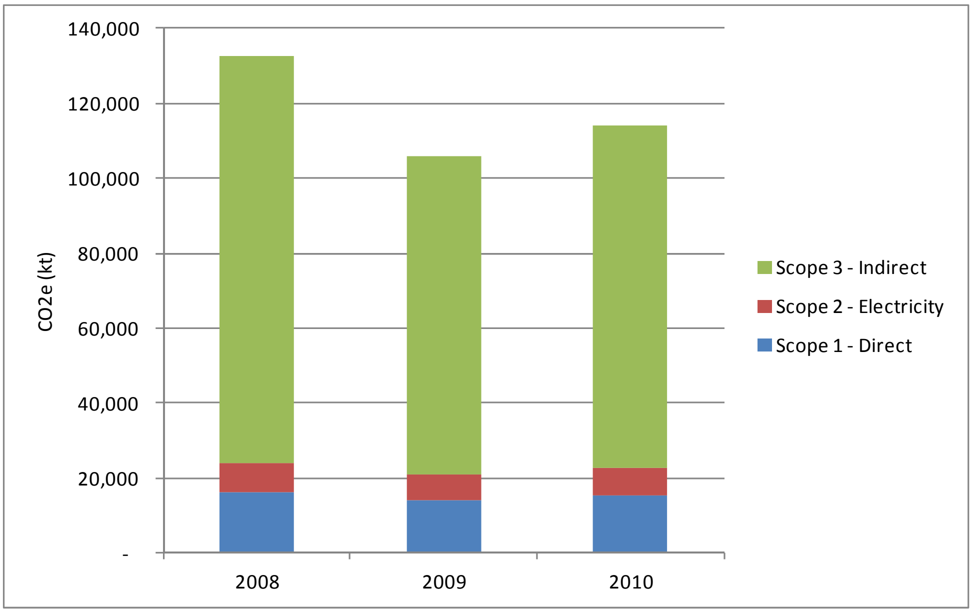

Figure 4: Total GHG Emissions within the Scopes defined in the GHG Protocol

The vast majority of GHG emissions associated with householders in London are scope 3 (80%). These emissions could occur in any location to deliver the goods and services consumed by London residents.

5. References

Baiocchi, G. and Minx J. (2010) "Understanding Changes in the UK ' s CO2 Emissions : A Global Perspective." *Environmental Science & Technology* 44 (4): 1177-1184.

Barrett J. and Scott K. (2012) Link between Climate Change Mitigation and Resource Efficiency: A UK Case Study, Global Environment Change, Volume 22, Issue 1, February 2012, Pages 299-307.

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

Davis, S. and Caldeira K. (2010) "Consumption-based accounting of CO2 emissions." *Middle East* 2010: 2-7. doi:10.1073/pnas.0906974107.

Intergovernmental Panel on Climate Change (1996) *IPCC Guidelines for National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html*

Minx, J. C., Wiedmann, T., Wood, R., Peters, G. P., Lenzen, M., Owen, A., Scott, K., Barrett, J., Hubacek, K., Baiocchi, G., Paul, A., Dawkins, E., Briggs, J., Guan, D., Suh, S., Ackerman, F. (2009) Input-Output Analysis and Carbon Footprinting: An overview of applications. *Economic Systems Research* 21(3) Pages: 187-216.

Peters G. and Hertwich E. (2008) "CO2 Embodied in International Trade with Implications for Global Climate Policy." *Environmental Science & Technology* 42 (5) (March): 1401-1407. doi:10.1021/es072023k. http://pubs.acs.org/doi/abs/10.1021/es072023k.

Wiedmann, T., H. Wilting, S. Lutter, V. Palm, S. Giljum, A. Wadeskog, and D. Nijdam. (2009) *Development of a methodology for the assessment of global environmental impacts of traded goods and services*. Environment Agency publication SCHO1009BRAM-E-P. Environment Agency UK and SKEP Network. http://www.eipot.eu.

Wiedmann T. & Barrett J. (2013) Policy-Relevant Applications of Environmentally Extended MRIO Databases – Experiences from the UK, Economic Systems Research, 25:1, 143-156.