

The Carbon Footprint and Ecological Footprint of the Scottish Parliament



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Cover picture: Photo of the Scottish Parliament Building
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Summary of key findings

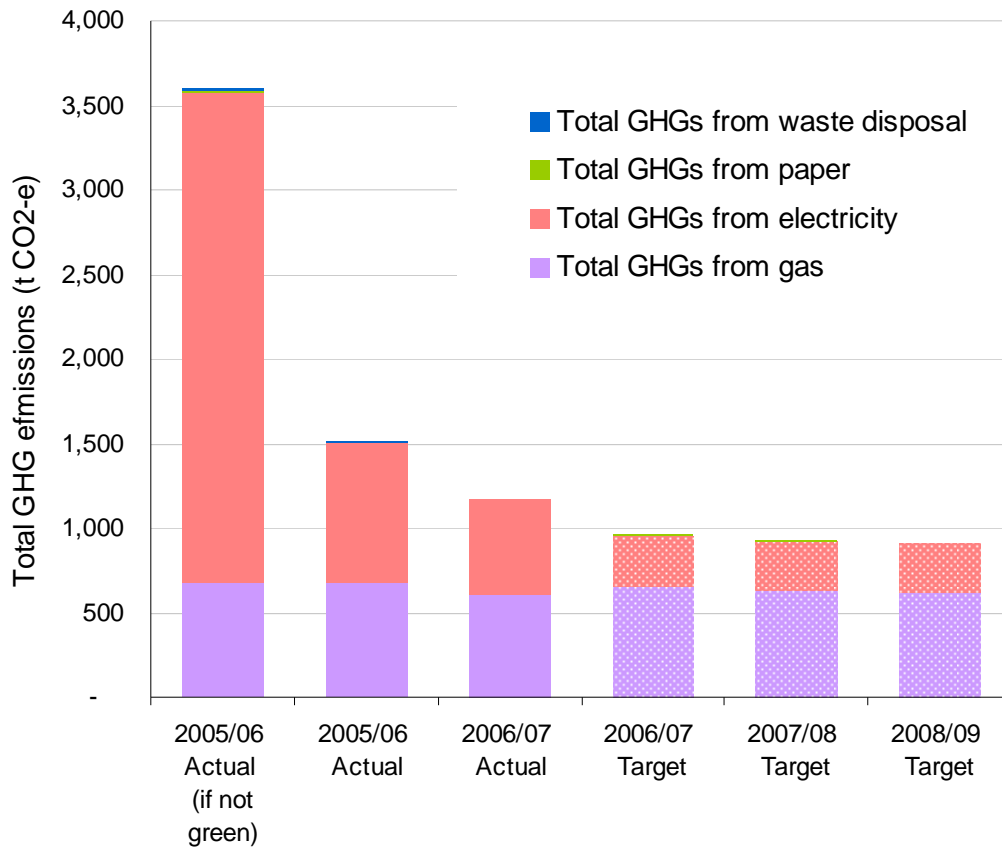
The **carbon footprint** and **Ecological Footprint** of the Scottish Parliament in the three areas **energy**, **paper** and **waste** was calculated for the financial years 2005/06 and 2006/07, as well as for targets set until 2008/09. The carbon footprint includes direct (on-site) as well as indirect (from suppliers and other sectors in the economy) emissions of carbon dioxide, methane and nitrous oxide. The Ecological Footprint includes direct and indirect impacts for the land types fossil fuel energy land, nuclear energy land, cropland, pasture, forest, built-up area and sea area. The results are presented in the tables and graphs below together with highlights of findings.

Overview

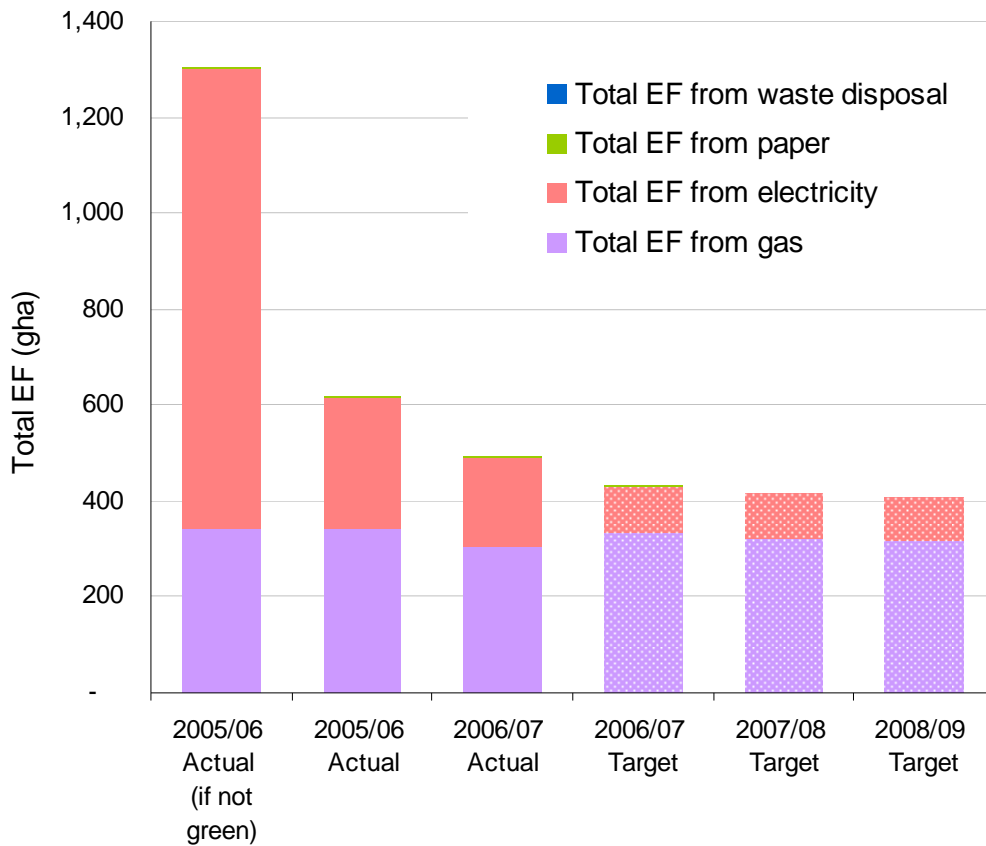
	Impact in 2005/06 if no green purchasing	Impact in 2005/06	Impact in 2006/07	Impact of target for 2006/07	Impact of target for 2007/08	Impact of target for 2008/09	
Year	2005/06 Actual (if not green)	2005/06 Actual	2006/07 Actual	2006/07 Target	2007/08 Target	2008/09 Target	Unit
Total GHGs from gas	677	677	604	657	636	623	t CO ₂ -e
Total GHGs from electricity	2,901	826	565	298	289	283	t CO ₂ -e
Total GHGs from paper	10.4	5.3	5.3	5.0	4.9	4.7	t CO ₂ -e
Total GHGs from waste disposal	4.2	4.2	2.5	4.0	2.7	2.1	t CO ₂ -e
Total carbon footprint	3,593	1,513	1,177	964	933	912	t CO₂-e
Total EF from gas	343	343	306	333	323	316	gha
Total EF from electricity	958	271	184	96	93	91	gha
Total EF from paper	3.8	1.7	1.7	1.6	1.6	1.5	gha
Total EF from waste disposal	0.3	0.3	0.2	0.3	0.2	0.2	gha
Total Ecological Footprint	1,305	616	492	431	417	408	gha

- The total carbon footprint (CF) of energy, paper and waste together was 1,513 t CO₂-e in 2005/06 and 1,177 t CO₂-e in 2006/07.
- The total Ecological Footprint (EF) of energy, paper and waste together was 616 global hectares (gha) in 2005/06 and 492 gha in 2006/07.
- Around half of the impacts in both indicators come from electricity and gas consumption, respectively. The CF and EF of waste disposal and paper use are much smaller.
- Large reductions in both CF and EF have already been achieved through a switch to green electricity supply in 2005 (80% renewable electricity from April 2005; 100% from October 2006). If all the electricity had come from non-renewable sources (average UK mix) the total CF and EF would have been more than twice that high in 2005/06 (see first column in table and graphs).
- The Scottish Parliament is on track to achieve its targets for the years up to 2008/09 (see below).

Total carbon footprint (GHGs)



Total Ecological Footprint

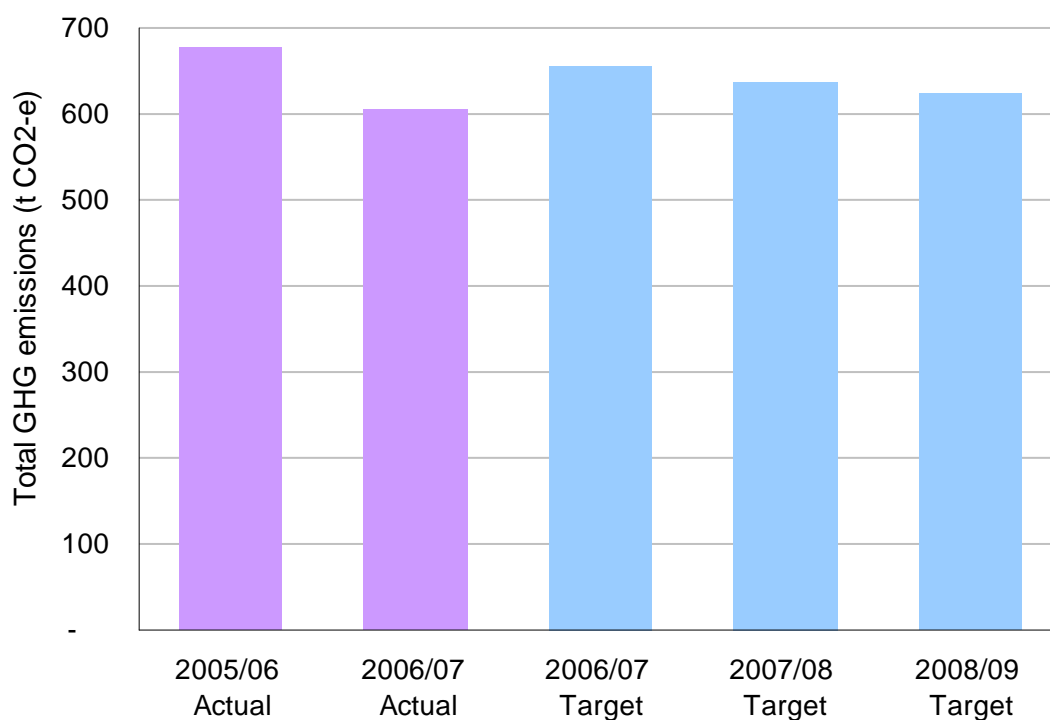


Gas consumption

Note: The following graphs show results for the carbon footprint only. Ecological Footprint results and graphs look very similar.

NATURAL GAS CONSUMPTION	Gas consumption in 2005/06	Gas consumption in 2006/07	Target (2006/07): -3%	Target (2007/08): -6%	Target (2008/09): -8%	Unit
	2005/06 Actual	2006/07 Actual	2006/07 Target	2007/08 Target	2008/09 Target	
Amount of gas consumed	3,349,164	2,987,137	3,248,689	3,148,214	3,081,231	kWh
Total greenhouse gases	677	604	657	636	623	t CO₂-e
Total Ecological Footprint	343	306	333	323	316	gha

Gas carbon footprint (GHGs)

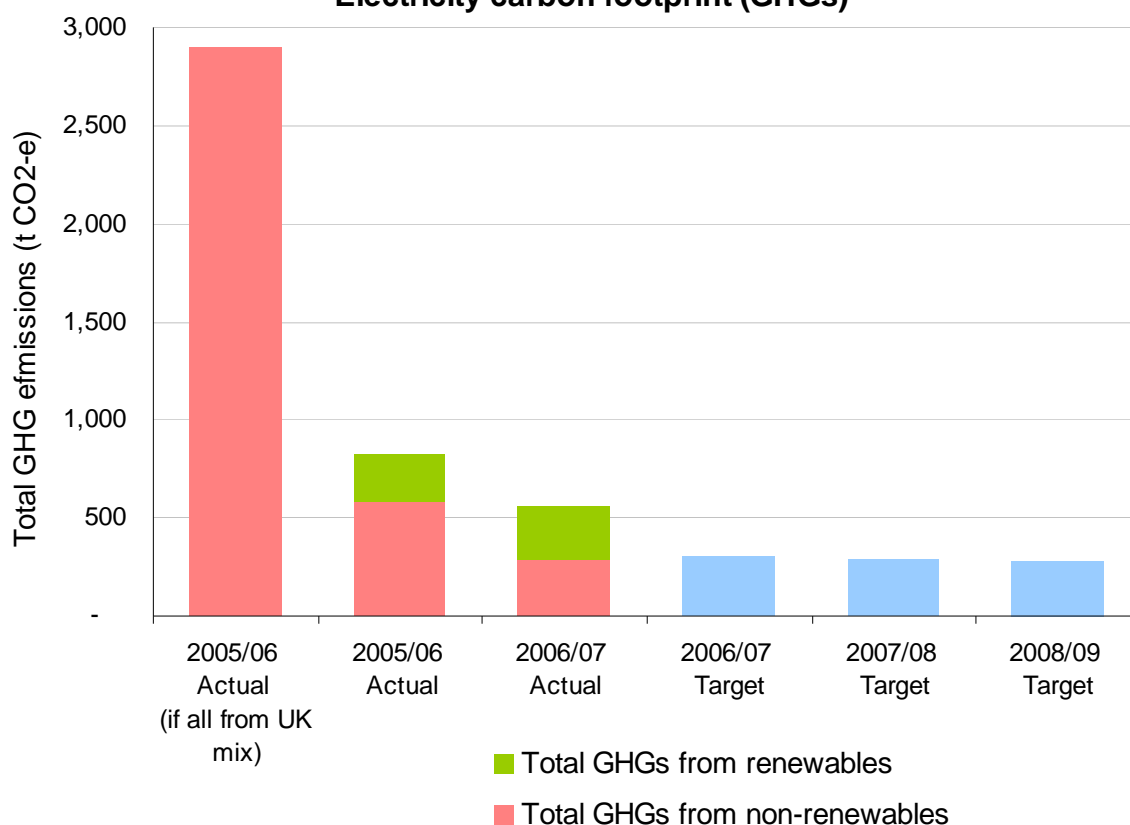


- The consumption of natural gas in 2006/07 was actually lower than the target set for this year (and all years up to 2008/09). Between 2005/06 and 2006/07 a reduction in gas consumption of 11% was achieved.
- However, the consumption of natural gas for heating is now the highest contributor to the total CF (604 t CO₂-e) and EF (306 gha) and further reductions are more difficult to achieve than for other areas, e.g. electricity.

Electricity consumption

ELECTRICITY CONSUMPTION	Electricity consumption in 2005/06 (if all had come from average UK mix)	Electricity consumption in 2005/06	Electricity consumption in 2006/07	100% Renewable Electricity + Target (2006/07): - 3%	100% Renewable Electricity + Target (2007/08): - 6%	100% Renewable Electricity + Target (2008/09): - 8%	
Year	2005/06 Actual (if all from UK mix)	2005/06 Actual	2006/07 Actual	2006/07 Target	2007/08 Target	2008/09 Target	Unit
Electricity from non-renewables	6,606,490	1,321,298	660,925	-	-	-	kWh
Electricity from renewables	-	5,285,192	5,914,476	6,408,295	6,210,101	6,077,971	kWh
Total GHGs from non-renewables	2,901	580	290	-	-	-	t CO₂-e
Total GHGs from renewables	-	246	275	298	289	283	t CO₂-e
Total EF from non-renewables	958	192	96	-	-	-	gha
Total EF from renewables	-	79	88	96	93	91	gha

Electricity carbon footprint (GHGs)

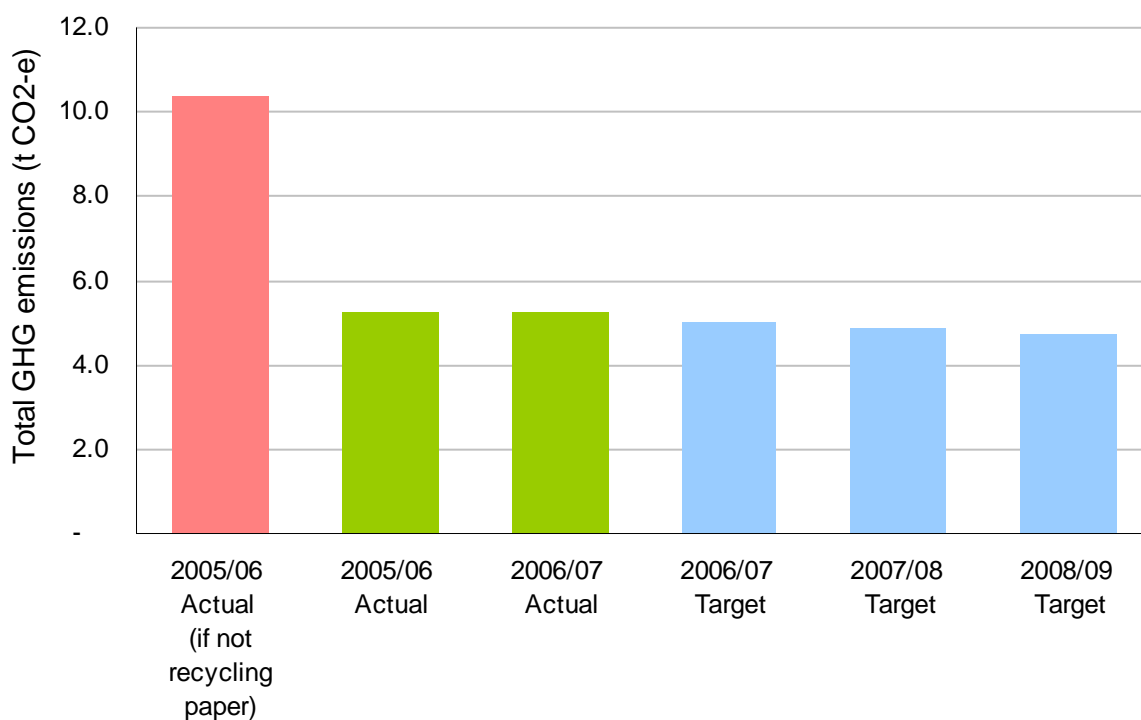


- Large CF and EF reductions have already been achieved by switching to green electricity.
- From 1 October 2006, the Scottish Parliament uses 100% electricity from renewable resources. However, the carbon footprint and Ecological Footprint will not be reduced to zero because there are still indirect emissions associated with the provision of green electricity, located higher up in the supply chain (e.g. emissions for manufacturing, transporting, installing wind turbines, hydro dams, etc). The achievable CF of around 300 t CO₂-e in the coming years is depicted above. This is around half the CF coming from gas consumption.
- Therefore, further reductions in the CF and EF of electricity can only be made through savings and further improved efficiency of appliances, lighting etc.

Paper consumption

PAPER CONSUMPTION	Paper use in 2005/06 (if not recycling paper)	Paper use in 2005/06 (recycling paper)	Paper use in 2006/07 (recycling paper)	Interim targets: Reduce office paper used by 5% by March 2007	Interim targets: Reduce office paper used by 7.5% by March 2008	PAPER OBJECTIVE: Reduce office paper used by 10% by March 2009	
Year	2005/06 Actual (if not recycling paper)	2005/06 Actual	2006/07 Actual	2006/07 Target	2007/08 Target	2008/09 Target	Unit
Amount of paper	26.6	26.6	26.6	25.3	24.6	23.9	tonnes
Total greenhouse gases	10.4	5.3	5.3	5.0	4.9	4.7	t CO₂-e
Total Ecological Footprint	3.8	1.7	1.7	1.6	1.6	1.5	gha

Paper carbon footprint (GHGs)

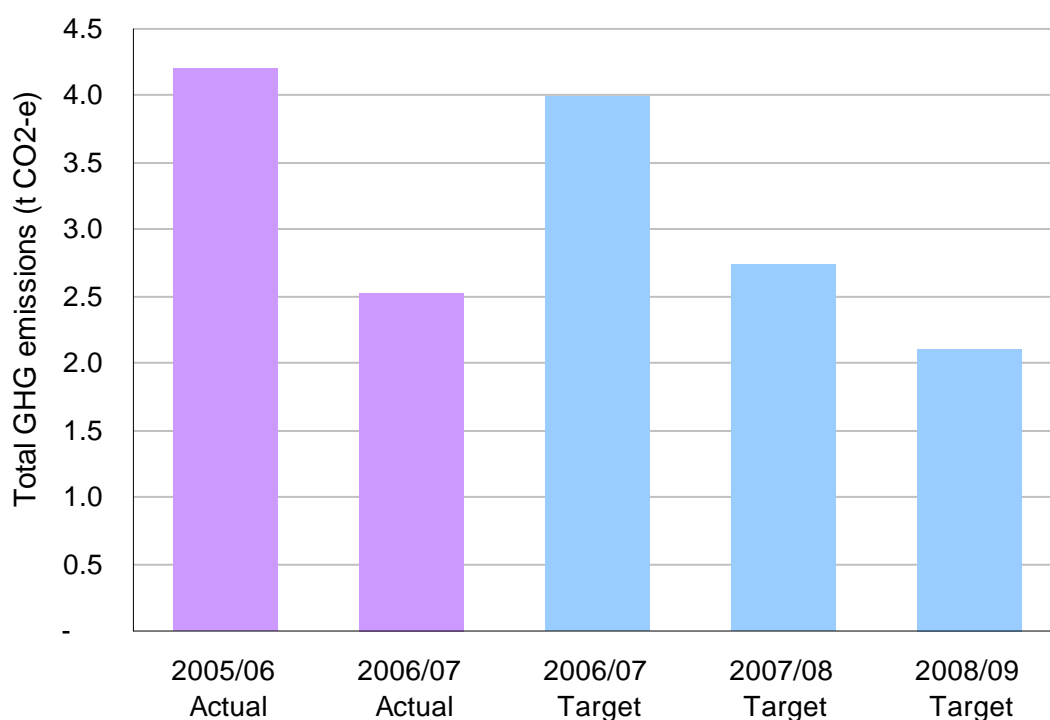


- The CF and EF of paper consumption has already been reduced by around 50% by the decision to use 100% recycled paper (the first column in the graph above shows the impact in 2005/06 if the paper used had not been made from recycled paper).
- Paper use remained unchanged between 2005/06 and 2006/07. Further reductions in the CF and EF of paper use can only be achieved through less use, e.g. through less printing and copying and by using more electronic resources instead. The impact of the targets set are depicted above.

Waste

WASTE ARISING	Waste to landfill in 2005/06	Waste to landfill in 2006/07	Target for 2006/07: -5% waste to landfill	Target for 2007/08: -35% waste to landfill	Target for 2008/09: -50% waste to landfill	
Year	2005/06 Actual	2006/07 Actual	2006/07 Target	2007/08 Target	2008/09 Target	Unit
Amount of waste in tonnes:	153.7	92.3	146	100	77	tonnes
Total greenhouse gases	4.2	2.5	4.0	2.7	2.1	t CO₂-e
Total Ecological Footprint	0.3	0.2	0.3	0.2	0.2	gha

Waste disposal carbon footprint (GHGs)



- The disposal of waste leads to emissions from landfill sites and incineration. Diverting waste streams away from end-of-life processes through the collection of recyclables and compostable waste avoids these emissions and saves landfill space and therefore reduces both CF and EF.
- The Scottish Parliament has reduced the amount of waste to landfill from 154 tonnes to 92 tonnes in just one year and thus has already more than achieved the target for 2007/08.

Outlook

This study has looked at three areas: energy use, paper consumption and waste arisings. Of these, clearly the use of electricity and natural gas are the big hitters, both in terms of carbon footprint as well as Ecological Footprint. Compared to energy, the impacts of paper and waste are small.

Other areas, however, can also significantly contribute to indirect impacts captured by footprint accounting. As more comprehensive studies show, equipment, materials and even services can be associated with considerable amounts of embodied energy and footprint. Examples are furniture, computers and office equipment, construction materials and service activities such as cleaning or repair and maintenance. A future footprint study could include these categories and would allow a more comprehensive monitoring of the total footprint of the Scottish Parliament.

Methodology

Definitions

The **carbon footprint** of an organisation is a measure of the total amount of carbon dioxide emissions that can be attributed exclusively to the full life-cycle impacts of the organisation's activities (see also Wiedmann & Minx, 2008). In this analysis we have also included two other main greenhouse gases in the analysis, methane and nitrous oxide ('climate footprint'). The unit is 'tonnes of carbon dioxide equivalents' (t CO₂-e).

The **Ecological Footprint** of an organisation is a measure of the land and sea area required to provide continuously all the natural (biological) resources and services to sustain the activities of the organisation. This land and sea area might be located anywhere on earth. The Ecological Footprint is measured in 'global hectares' (gha), an area unit adjusted to world average bioproductivity.

Requirements

Calculating the total resource use impacts (the "Footprint" in short) of an organisation has to fulfil certain requirements. It must take into account the 'on-site' impacts such as direct emissions from heating premises, for example (cf. Scope 1 of the Greenhouse Gas Protocol; WBCSD and WRI, 2004). And it must also take account of indirect impacts that are embodied in the products and services purchased by the organisation, for example paper (Scope 2 and Scope 3 of the Greenhouse Gas Protocol). The approach that we have applied in this project has proved to fulfil both requirements in numerous studies.

Introduction

The methodology we have employed in this project is a **Hybrid Life-Cycle-Analysis** (Hybrid-LCA). This is the combination of two approaches with life-cycle perspective: a bottom-up process analysis (PA) and a top-down environmental input-output (EIO) analysis. While EIO analysis is

superior for the establishment of comprehensive footprints in macro and meso systems, process analysis has advantages when looking at micro systems: a particular process, an individual (e.g. 'green') product or a relatively small group of products. The comprehensive nature of EIO means that the whole (UK) economy, including imports and exports, are the system boundary, which is a major advantage to a PA-based LCA where only on-site, most first-order, and some second-order impacts are considered. This truncation of the system boundary in PA-based LCA can lead to a significant underestimation of the true impact (boundary problem). Using input-output analysis, the error caused by this truncation can be avoided. Process analysis on the other hand is more specific to individual products or services, a level of detail which is not easily achievable with the top-down approach of input-output analysis.

The appropriate solution for the assessment of micro-systems such as individual products (e.g. recycled paper) is a Hybrid-LCA, where PA is combined with EIO. In this approach, on-site, first- and second-order process data on environmental impacts is collected for the product or service system under study, while higher-order requirements are covered by input-output analysis. In the following we briefly describe our approach to both EIO and PA.

Our approach to Environmental Input-Output (EIO) analysis

The calculation model used in this project is based on environmentally extended input-output analysis on the national (UK) level, using official data from the ONS National (economic) Accounts and ONS Environmental Accounts. This means that all results are fully consistent with standard accounting and fully comparable amongst each other. The sophisticated methodology is based on year-long scientific research, has been field-tested over five years, has been published in numerous journal articles, and has recently been incorporated into a software tool named Bottomline³ (www.bottomline3.co.uk).

Bottomline³ was developed at the University of Sydney and has been adapted to the UK economy by ISA^{UK} **Research and Consulting**. This tool is based on a static, single-region, open, basic-price, 76-sector industry-by-industry input-output model of the UK economy, augmented with a database of environmental, social and economic indicators. Bottomline³ provides total (**direct + indirect**) impact quantification, sector benchmarking, supply chain analysis, production layer decomposition and quantification of 'shared responsibility' for over 100 economic, social and environmental indicators. Most importantly, a direct and valid comparison is possible between company/organisation, sector and national economy performance.

Our approach to Process Analysis (PA)

ISA^{UK} has a database of bottom-up, processed-based Ecological Footprints and carbon footprints of around 4000 raw materials and products which we can use to further refine the results of the Bottomline³ analysis to account for specific procurement and management practices. This enables us to understand the effect of very specific procurement, such as buying recycled paper, green electricity, organic food etc. Most of this PA-based LCA data is derived from a very recent study (Huijbregts et al., in press) which in turn is based on the comprehensive 'ecoinvent' database, containing consistent and quality-controlled life-cycle information for products and services consumed in western economies (Frischknecht et al., 2005). Raw materials carbon intensities are derived from the Stockholm Environment Institute's database of embodied energies.

We also use external data from various electricity providers, Energy Efficiency Advice Centres, the Energy Saving Trust and similar sources to calculate footprint savings for green procurement options or to run 'low carbon scenarios'.

Combining EIO and PA into a Hybrid-LCA

A comprehensive footprint analysis needs to be based on an all-encompassing approach (such as the environmental input-output analysis implemented in Bottomline³). This is for two reasons:

- a) it is the only way to capture all indirect impacts; no other method can achieve this and the analysis might well come up with some impacts that have not been thought about before (e.g. what is the footprint of services, such as banking, legal advice, accounting, conference organising, design etc.?) and
- b) it is useful to answer the question "what would be the footprint performance of our organisation if our purchasing was just average, i.e. if we did not buy green electricity etc.?" This is certainly a useful benchmark to compare with.

After performing an EIO with we adjust on-site, first- and second-order results on environmental impacts with process-based data that are specific to the activities of the organisation under investigation, e.g. the use of electricity from renewable sources or the purchasing of recycled paper. This is also called a **tiered Hybrid-LCA** (see Minx et al., 2007).¹

As an example, the calculations for paper are presented below. At the finest level of detail of the Bottomline³ analysis – in the results from the **structural path analysis (SPA)** – corrections for green procurement are made. The SPA result tables itemise all production and supply processes that are important for one particular indicator, e.g. CO₂ emissions. Using data from Process Analysis, corrections are made for specific processes or supplies that are relevant for the green product (e.g. less energy and no wood products for recycled paper). Other paths remain unchanged as inputs for average and recycled paper would be the same or very similar, e.g. transport and distribution. Consider the following example:

Rank	Path Description	Average paper	Recycled paper	Unit
1	Pulp and paper > Paper	305.9	140.7 a)	kg CO ₂ / t
2	Pulp and paper > Pulp and paper > Paper	30.34	13.95 a)	kg CO ₂ / t
3	Electricity > Pulp and paper > Paper	11.63	4.85 b)	kg CO ₂ / t
4	Pulp and paper > Pulp and paper > Pulp and paper > Paper	3.01	3.01	kg CO ₂ / t
5	Road transport > Pulp and paper > Paper	2.57	2.57	kg CO ₂ / t
6	Wood and wood products > Pulp and paper > Paper	2.46	- c)	kg CO ₂ / t
7	Electricity > Electricity > Pulp and paper > Paper	2.26	0.94 b)	kg CO ₂ / t
8	Paints, varnishes, printing ink etc > Pulp and paper > Paper	2.05	2.05	kg CO ₂ / t
9	Inorganic chemicals > Pulp and paper > Paper	1.29	1.29	kg CO ₂ / t
10	Wholesale distribution > Paper	1.22	1.22	kg CO ₂ / t
11	Plastic products > Pulp and paper > Paper	1.20	1.20	kg CO ₂ / t

¹ Whatever method is used to calculate Ecological and carbon footprints it is important to avoid double-counting along supply chains or life cycles. This is not least because there are significant implications on the practices of carbon trading and carbon offsetting. The Bottomline³ software avoids double-counting by automatically splitting impacts between agents in a supply chain.

12	Electricity > Pulp and paper > Pulp and paper > Paper	1.15	1.15	kg CO ₂ / t
13	Mechanical machinery and equipment > Pulp and paper > Paper	0.93	0.93	kg CO ₂ / t
14	Retail distribution > Paper	0.88	0.88	kg CO ₂ / t
15	Plastics & Synthetic resins etc > Pulp and paper > Paper	0.69	0.69	kg CO ₂ / t
16	Road transport > Wholesale distribution > Paper	0.68	0.68	kg CO ₂ / t
17	Furniture and miscellaneous manufacturing > Pulp and paper > Paper	0.57	0.57	kg CO ₂ / t
18	Electricity > Electricity > Electricity > Pulp and paper > Paper	0.44	0.44	kg CO ₂ / t
19	Electricity > Retail distribution > Paper	0.43	0.43	kg CO ₂ / t
20	Motor vehicle distribution and repair, automotive fuel retail > Paper	0.35	0.35	kg CO ₂ / t
>20	All other paths	16.4	16.4	kg CO ₂ / t
	Total	386	194	kg CO₂ / t

- LCA (PA) studies show that manufacturing recycled paper causes 46% less CO₂ emissions compared to average paper.
- LCA (PA) studies show that manufacturing recycled paper requires 42% less electricity compared to average paper.
- No wood and wood products are needed for the production of recycled paper.

The Footprint of waste ('end-of-life' impacts)

When calculating the (carbon or Ecological) Footprint of waste, we are looking for an answer to the question: what impact is created by products that have reached the end of their 'life' and are not used any longer? In other words, we need to look into the Footprint impacts of end-of-life processes, such as landfill, incineration, reclamation, recycling and even export and processes occurring in other countries.

In this project we have calculated the Footprint of three different types of waste that represent the three main disposal methods for the Scottish Parliament: waste sent to landfill, composting and recycling (more precisely collection for recycling, see below). The sector 'Refuse Services' provides the basis for the calculation of impacts from landfill and composting. The Footprint factors for landfill have been directly derived by using EIO and structural path analysis whereas the impacts of composting have been calculated by employing the Hybrid-LCA method as described above. The main reason for the lower impact of composting is a smaller amount of greenhouse gas emissions.

Materials that are collected for recycling do not contribute to the Footprint of waste disposal. This is because they do not enter the waste disposal stream at all. Rather they are collected and brought to reclamation sites where they are sorted and merged into the stream of virgin materials for the production of new goods. For example, paper and aluminium cans collected for recycling are brought to paper mills and aluminium smelters where they are turned into new paper and aluminium products. The Footprint of *producing* recycled paper or recycled aluminium however must not be attributed to the category 'waste disposal' but has to be attributed to the production process of the recycled products. In the calculations for the Scottish Parliament in this project we have accounted for the impacts of paper recycling in the *purchasing* of *recycled* paper.

A small Footprint, however, is associated with the collection, transport and sorting of recyclables as this is a process that takes part before the materials enter the actual recycling process. This is taken into account in our methodology. Again, we use the results from the structural path analysis and attribute pro rata the impacts of transport in the 'Refuse Services' sector to the amount of materials collected for recycling.

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