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The costs and benefits of mandatory greenhouse gas reporting

An independent analysis of the Defra Impact Assessment

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Executive Summary

The UK Government has recently published a consultation on options for mandatory greenhouse gas reporting for companies. The corresponding impact assessment (IA) analyses the costs and benefits for the four options that are set out in the consultation, including option 3 which would seek to introduce mandatory carbon reporting for all large UK companies. The IA estimates that the total cost (over a ten year timeframe) could be as much as £6,025m and the total benefits are a maximum of £1,355m.

The Aldersgate Group, WWF, The Co-operative Group and Christian Aid commissioned adelphi to undertake an independent analysis of the IA.

The commissioning parties instructed us, for the purposes of this analysis, to follow Defra's approach for analysing the costs and benefits of mandatory reporting. This was done to ensure consistency even though they believe that Defra's approach is too narrow. For example, there are significant benefits that will flow to businesses from wider behaviour change, product and service innovation and other strategic advantages. There are also considerable long term intangible benefits for businesses in relation to brand and international reputation. The commissioning parties recognise the wide uncertainties involved in assigning specific financial values to these benefits and therefore we do not attempt to do so in this analysis; however, the parties believe them to significantly outweigh the related costs.

The assessment finds that when analysing the impacts of mandatory greenhouse gas reporting for large companies (option 3), Defra overestimates the total costs by up to £4,600m and underestimates the benefits by up to £980m. This is due to omitting benefits, assuming disproportionate efforts required for complying with option 3 and disregarding temporal effects. Overall, Defra's IA has taken a fairly narrow focus when looking at benefits, rarely taking into account wider social and environmental benefits that arise.

One of the most pertinent examples of disregarding temporal effects is the assumption that after carbon reductions are realised through mandatory carbon reporting in the first year, there will be no additional reductions over the next nine years. This seems unlikely. If this really were the case, then it would be most cost-efficient to drop the reporting requirement after the first year. There are a number of reasons which suggest that it is more plausible that companies will realise additional emission reductions in the following years: once businesses experience cost savings in the first year, they will look for further opportunities to improve their bottom line. Companies can be motivated by innovative approaches and achievements regarding the emission reductions of their competitors. Furthermore, it seems likely that technological innovations will make some low carbon technologies cost-efficient in later years. This contributes to benefit estimates ranging from £771m to £2,338m (high to upper), compared to £332m to £1,357m in the Defra IA.

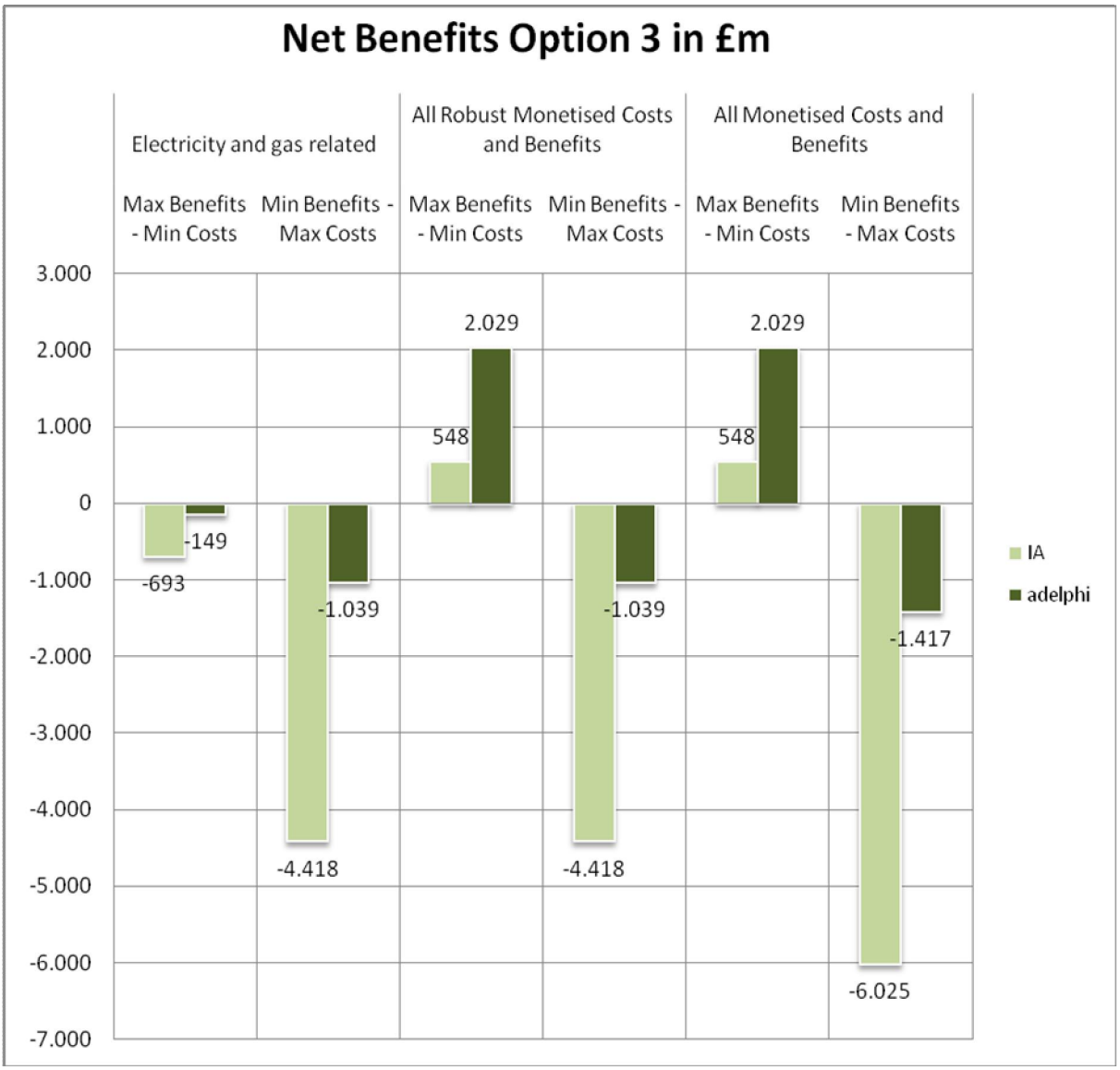
The adelphi analysis also challenges some of Defra's costs assumptions. For example, it suggests that one reason these are inflated is due to Defra using figures for carbon reporting from the CRC Energy Efficiency Scheme. By only taking into account the activities that would be required for mandatory carbon reporting (e.g. removing inputs regarding trading) and making widely differing day rates more consistent, this reduces associated annual costs for a large company to a range of £2,460 to £7,684 in year 0 (compared to £5,820 to £31,120 in the Defra IA).

In addition, aside from year 0, where one-off costs occur, the Defra IA assumes that the costs will stay constant over the next nine years. This seems unlikely, considering effects such as general increase in labour productivity, internal learning effects and technological innovations

in measuring and reporting. Accounting for these effects in the amended IA by assuming a reduction in required efforts by 2% every year yields final total cost estimates [present value (PV)] ranging from £310m to £1,417m (compared to £808m to £6,025m in the Defra IA).

Researchers at adelphi also found that due to its rather narrow focus, major benefits and costs have been omitted in the Defra IA. These relate to the measuring and reporting emissions from freight transport via rail, inland waterways, coastal shipping and aviation [which increases benefits by £113.04m and costs by £26.58m (PV)] as well as to health benefits from reduced consumption of diesel [leading to additional health benefits of £199.27m (PV)].

Incorporating all of the above mentioned changes and adjusting the amended IA by not using rounded figures and adhering to DECC energy price estimates yields the following results for benefits and costs of option 3:



Estimates for Option 3			Defra	adelphi
Benefits (GBP m)	Electricity and gas related	Upper	115.14	161.04
		High	10.69	31.79
		Lower	0	0
	Wider GHGs	Upper	2.88	4.15
		High	2.88	4.15
		Lower	0	0
	Transport	Upper	1,238.74	2,173.61
		High	318.28	734.63
		Lower	0	0
	Total	Upper	1,356.76	2,338.80
		High	331.85	770.57
		Lower	0	0
Costs (GBP m)	Electricity & gas related	High	4,418	1,039.24
		Lower	808	310
	Transport related	High	1,607	378
		Lower	0	0
	Total	High	6,025	1,417.47
		Lower	808	310
Net Benefits (GBP m)	Electricity and gas related	Maximum Benefits - Minimum Costs	-693	-149
		Minimum Benefits - Maximum Costs	-4,418	-1,039
	All Robust Monetised Costs and Benefits	Maximum Benefits - Minimum Costs	548	2,029
		Minimum Benefits - Maximum Costs	-4,418	-1,039
	All Monetised Costs and Benefits	Maximum Benefits - Minimum Costs	548	2,029
		Minimum Benefits - Maximum Costs	-6,025	-1,417

Overall, the amended IA shows that net benefits are significantly higher when compared to the Defra IA (see IA p. 9). Based on the alternative estimates it seems plausible that option 3 provides an opportunity rather than a burden for the UK economy. While the ranges between costs and benefits have been narrowed and benefits are shown to be higher, it is assumed that adelphi's figures remain conservative as, owing to the lack of reliable data, a number of expected benefits are still not included. Among them are costs and benefits of reporting international greenhouse gas emissions, health benefits resulting from reduced emissions of freight transport other than road, positive knock-on effects on companies that would not have to report under option 3 and general international competitive advantages for the UK on the path to a leading low carbon economy.

Having a brief look at measuring and reporting international emissions can illustrate what range of benefits and costs are still not included in the amended IA. Many of the large companies affected by option 3 have operations abroad in which they would have to measure and report on greenhouse gas emissions. Just looking at a small sample of the 24,000 companies – the FTSE 350 – and only taking into account the reduced social costs of carbon using global estimates would yield additional upper bound costs of £513m and benefits of £2,607m (all PVs). This does

not include monetary savings from reduced electricity and fuel consumption due to the difficulty of finding suitable prices.

Furthermore, costs and benefits are still only calculated for a time horizon of 10 years, in line with the assumptions of the Defra IA. This seems very short considering the persistence of GHGs in the atmosphere and the long term benefits of this policy option. The Defra IA states that the alteration of the time horizon does not significantly change the outcome. However, in the amended IA this is not the case anymore. Changing the time horizon from 10 to 20 years pushes the balance of costs and benefits significantly towards benefits. When looking at “all robust monetised costs and benefits” the value of (maximum benefits - minimum costs) increases by about 106% from £2,029m to £4,180m. At the same time, the value of (minimum benefits - maximum costs) only drops by 58% from -£1,039m to -£1,640m.

CONTENTS

Introduction

On 11th May 2011 the Department for Environment, Food and Rural Affairs (Defra) published a consultation on the measuring and reporting of greenhouse gas (GHG) emissions by UK companies, which incorporates four proposed reporting options. This was accompanied by an impact assessment that estimates benefits and costs of the different policy options, all of which seek to increase the number of companies which actively manage and report their GHG emissions in the UK. While pursuing the goal of increased reporting, the Defra Parliamentary Under Secretary Lord Henley made it clear that a balance needs to be struck to avoid any unnecessary burdens on businesses. The impact assessment (IA) and its detailed analysis of benefits and costs incurred by the different options sought to help inform the responses to the consultation provided by stakeholders, which included businesses, investors and civil society.

A central policy among the four options discussed in the IA is option 3, the introduction of mandatory annual greenhouse gas reporting for all large companies. This would affect around 24,000 companies.

This paper analyses the assumptions made and steps taken in the IA to arrive at the costs and benefits presented by Defra for option 3. If alternative assumptions or calculation steps were found to be more plausible, reasons for their plausibility are provided. Subsequently, the changes are incorporated into an alternative assessment of option 3 ("amended IA"). The following chapters discuss the estimated and omitted costs generally for all options and in detail for option 3. Subsequently, the benefits are debated in a similar fashion.

1. Costs

The following chapter provides an analysis of the costs presented in the IA, focusing mostly on those costs that are relevant for estimating the impacts of option 3. The structure of the analysis follows the train of thought on costs set out in the IA and its annexes (p. 20-24; p. 37-39; p. 61-62; p. 67-70). The authors hope that the points presented in the analysis can provide for a more holistic assessment of impacts.

When calculating costs for complying with mandatory reporting, the IA differentiates between measuring and reporting non-transport carbon emissions (i.e. electricity and gas related), wider GHG emissions and transport carbon emissions.

1.1. MEASURING AND REPORTING NON-TRANSPORT CARBON EMISSIONS

First, the Defra IA looks at the efforts required in an exemplary company to fulfil the reporting requirements regarding electricity and gas related carbon emissions. Different proxies are used to estimate costs incurred to the company (IA p. 20-22; p. 67-70).

1.1.1. Person-day input needed for measuring and reporting non-transport carbon emissions

1.1.1.1. Person-day input needed for measuring non-transport carbon emissions for large companies[1]

The upper bound person-day input needed for measuring non-transport carbon emissions for large companies in the Defra IA are taken from a past impact assessment of a related scheme, the CRC Energy Efficiency Scheme (IA p. 21). Although this approach might seem self-evident at first sight, closer examination shows that the cost components identified for the implementation of the CRC only apply to GHG measurement and reporting to a very limited degree. The following activities are required for the CRC and were therefore also included in the Defra IA for option 3; we argue that not all of them are needed to implement the requirements in a company:

1. Understanding the rules: In order to avoid double counting, this activity should be disregarded for the IA as the costs for reading and understanding are already covered as "one-off costs" under the overall costs for understandings the scheme and measuring and reporting non-transport emissions (IA p. 20, Table 2).

2. Developing a compliance strategy: This position holds little relevance for mandatory reporting. "Developing a compliance strategy" does not relate to measuring and reporting but to the reduction of GHGs. In Annex I when elaborating on the CRC, it is explained that the compliance strategy covers " 'make or buy' decisions" on whether to invest in energy savings and if so, at what level. "We assume that compliance strategies are only relevant for the fixed quantity type scheme [...]." (IA p. 69) As this is not relevant to reporting, the person-days associated with the activity should not be included in the IA.

3. Understand and take part in Auction: This position is not relevant. Auctioning of emission allowances is not part of measuring and reporting GHG and the costs should not be included here.

[1] The numbering of the headlines corresponds to the headlines of the respective underlying calculations given in the annex. The annex presents all calculations that were made to arrive at the amended IA.

4. Trading activities: This position is not relevant: Trading of allowances is not part of measuring and reporting GHG thus the costs should not be included here.

5. Submitting data to coordinator: This position is of little relevance as the costs for reporting are calculated separately in the third column of table 2 (IA p. 20). Including this position risks double counting the costs for the activity of reporting the data. Thus, in the amended IA the days for submitting data to coordinator are not included.

6. Verifying data (external costs): This should only relate to the internal costs. While an external verification might be of interest to increase the quality of the reports made, it is made clear in the IA that verification is not assessed in the analysis: "For the mandatory options in this IA, it is assumed that companies would only be required to perform internal verification and not seek third party assurance. Evidence to date suggests that the level of third party assurance gained by companies on their reports on GHG emissions is low." (IA p. 23) Therefore, "verifying data (external cost)" does not apply to option 3 and in our amended IA, it is replaced by internal verification cost. Internal days are estimated to be about 2/3 of the days of an external company because, first, internal staff knows the responsible personnel and is familiar with the company numbers and second, in most cases it is far more likely that it will be the same person conducting this activity every year, which would probably not be the case with external auditing companies.

While external verification and assurance is not part of the scope of the Defra IA, it should be seen as an essential part of effective mandatory reporting, especially as it lends credibility to the reported numbers for investors. One option for addressing the importance of verification would be to introduce external assurance after the phase-in of mandatory reporting has been carried out.

In summary, instead of 60 person-days, the amended IA estimates 28.7 days for the additional annual costs of measuring emissions.2 The assumption behind both the 60 and the 28.7 person-days figure is that each of the 24,000 large companies has 50 or more different sites that they operate. This seems improbably high, especially as the scope concerns only emissions from locations inside the UK. However, as the IA does not provide a list of companies or a sector breakdown of the companies affected by option 3, this assumption is difficult to verify. Further research is required to determine if all companies affected really do have 50+ sites each

1.1.1.2. Person-day input needed for understanding the scheme and measuring and reporting non-transport carbon emissions for all companies

The Defra IA does not offer explicit person-day input for all sizes of companies and all activities. But to analyse the cost given in table 2 on p. 20 of the IA, all available data in the IA was gathered and the implicit person-day input and corresponding day rates were estimated. Due to the changes described in 1.1.1.1, upper bound days for large companies are lower.

1.1.1.3. Implied rates for a person-day for different activities

In the IA, the day-rates applied for large companies are £200 or £229 (lower; upper) for reading and understanding the guidance as well as for reporting emissions and £500 (both lower and upper) for measuring emissions. It does not explain why the rate for measuring emissions should be 250% of the rate for understanding the guidance and reporting. In the absence of any reasons for the discrepancy, applying £500 seems disproportionate. The rates used here should

[2] IA numbers from CRC come from Nera/Enviros (April 2006). The discrepancies in the totals are explained by roundings in the person-days.

be internal rates and well below £500, especially because activity number 7 (verifying data) will be carried out internally by the companies themselves (see above). To establish consistency among the day rates applied for large companies in the IA for reading and understanding the guidance as well as with reporting, for the amended IA adelphi assumes an average rate of £200 (lower) and £229 (upper) for persons involved in measuring emissions.

Slight inconsistency: When deducing the day rates from the figures given on p. 21 and 22 it turns out that the lower day rates for small companies are higher than the upper day rates.

1.1.2. Overall costs for understandings the scheme and measuring and reporting non-transport emissions (see p. 20, Table 2)

Due to the changes to days and day-rates applied, the average additional annual cost of measuring emissions for medium and large companies are lower than in the Defra IA. Especially for large companies, costs are significantly lower than estimated in the IA:

Company Size	New / Adjust	One-off cost		Average additional annual cost of measuring emissions		Average additional annual cost of reporting emissions	
		Lower	Upper	Lower	Upper	Lower	Upper
large	New	£120	£120	£2,240	£6,565	£100	£1,000
	Adjust	£0	£0	£0	£0	£100	£1,000

Table 1: Amended IA: Overall costs for understanding the scheme and measuring and reporting non-transport emissions for large companies, year 0

1.1.3. Accounting for increases in labour productivity

The Defra IA assumes that aside from the additional one-off costs in the first year, the annual costs for measuring and reporting are constant over ten years. This seems unlikely for three reasons: general annual increases in labour productivity, learning effects inside the company over the years with regard to fulfilling the requirements and innovations pertaining to cost-effective tools for measuring and reporting GHG emissions. With financial accounting as an example, a reduction in costs for reporting GHG emissions over time seems very likely. In the past, the efforts required for increasingly complex financial accounting were drastically reduced by the introduction of software tools and automated processes for data gathering and analysis, which reduced costs drastically. Taking this into account, in the amended IA our cost estimate assumes that costs will be reduced by 2% every year. We take this reduction to be rather conservative as the long-term UK productivity growth per annum is around 2% already (see Lindsay 2004 or HM Treasury 2003: p. 25).

1.2. MEASURING AND REPORTING TRANSPORT CARBON DIOXIDE EMISSIONS

After estimating the costs for reporting electricity and gas related carbon emissions, the IA looks at the costs for reporting transport carbon emissions. The steps taken in the IA to arrive at the costs might appear complicated at first but seem unavoidable due to the lack of data on these issues (see Annex G, p. 61-62): first the present value (PV, over ten years) of reporting non-transport carbon emissions for all large companies is calculated (24,000 companies). Then, the cost for reporting one tonne of carbon dioxide is derived from this figure. Next, the resulting value is multiplied by the estimated amount of carbon emissions to be reported on under option 3. This yields the PV for reporting transport costs (for road freight).

1.2.1. Calculating PV of reporting non-transport carbon emissions for large companies

As the amended IA estimates different total annual costs of reporting non-transport emissions (including one-off costs), the upper and lower values differ from the Defra IA:

	Low(er)	Upper
total annual costs of reporting non-transport emissions (**including one-off costs**)	£59,040,000	£184,426,346
total annual costs of reporting non-transport emissions (**excluding one-off costs**)	£56,160,000	£181,551,850

Table 2: Amended IA: Costs of reporting non-transport CO_2 emissions for large companies

This of course will affect the overall PV value of reporting costs for non-transport CO_2.

In the Defra IA, for the purpose of deriving the costs for reporting transport emissions, when calculating the NPV of reporting non-transport carbon emissions, it seems that the annual costs used include the one-off costs *every* year (see IA p. 61 where total annual cost for upper is taken to be £747m). However, neither for reporting transport nor non-transport emissions does one need to read and understand the guidance every single year, so in the amended IA the one-off costs are only taken into account in year 0 when calculating the PV of reporting non-transport carbon emissions for large companies.

Accounting for the one-off costs only in the first year (year 0) approximates the actual costs more plausibly. It results in lowering the PV further below the value estimated in the Defra IA. The resulting PVs for the reporting cost for non-transport CO_2 are:

	Low(er)	Upper
PV of reporting cost for non-transport CO_2	£447,553,221	£1,440,396,681

Table 3: Amended IA: PV of reporting cost for non-transport CO_2

1.2.2. Estimating the relation between freight transport GHG emissions and electricity and gas emissions

Annex G of the Defra IA provides figures on the total freight transport related GHG emissions (52 $MtCO_2e$)[3] and the total electricity and gas related carbon dioxide emissions (213 $MtCO_2$) and states that the transport share is approximately one quarter. The calculations then proceed with a factor of 0.25.The exact factor however is 0.2441 and there seems to be no reason for preferring the rounded factor over the exact figure. Therefore, the amended IA proceeds with the non-rounded factor 0.2441.

[3] This includes all freight transport related emissions in the UK, not only road freight.

1.2.3. Deriving total costs for reporting freight transport emissions from costs of reporting electricity and gas emissions

Multiplying the PV of reporting cost for non-transport GHG with the share of transport emissions yield the following values for total costs of large companies for reporting transport related GHG emissions (over 10 years):

	Low(er)	Upper
Total costs for companies of reporting transport related GHG emissions (over 10 years)	£109,261,819	£351,646,138

Table 4: Amended IA: Total costs of reporting transport related GHG

The Defra IA leads to higher figures, partly also due to the rounding mentioned above: calculating with the rounded figure (IA p. 61) in the Defra IA leads to cost increases for companies reporting transport related GHG emissions by up to £37,512,994 (which is 2.4% of the total value). The central assumption underlying the IA PV for costs for reporting transport emissions is the following: "The transport cost estimates assume that the average cost of reporting transport related emissions (i.e. the cost per tonne of emissions reported), are the same as for reporting electricity and gas related emissions for large companies." (IA p. 22) This implies a linear relationship between reporting an additional tonne and the associated additional costs for reporting this tonne. This might seem questionable: measuring and reporting the first 100 tonnes of GHG emissions certainly results in higher costs (e.g. setting up the measuring and reporting system) than the 100,001st to 100,100th tonnes. However, lacking any better proxies, the amended IA follows this approach as well.

1.2.4. Adjusting total costs for reporting freight transport (road) emissions

The total costs for reporting road freight transport GHG emissions are derived from the corresponding value for all freight transport. The Defra IA only takes into account road freight transport emissions as these are taken to be the most significant and are "understood best" (IA, p. 26). Emissions from transport using other modes than road (i.e. rail, water and aviation) are not taken into consideration in the Defra IA.

1.2.4.1. Calculating the cost of reporting transport emissions per tonne of CO_2

The total costs (PV) for reporting all freight transport GHG emissions is divided by the annual estimated road freight transported related emissions (16.5mtCO_2) to arrive at the cost for reporting road transport emissions per tonne of CO_2. The estimated costs in the amended IA are significantly lower than in the Defra IA:

	Lower	Upper
Cost for reporting transport emissions per tonne of CO_2	£6.62	£21.31

Table 5: Amended IA: Cost for reporting transport emissions per tonne of CO_2

1.2.5. Estimated reporting costs for road freight transport emissions in all options (PV)

Multiplying this cost factor with the different road freight transport emissions (see IA p. 61) yields the following costs for reporting on (road) transport emissions (PV) in the amended IA:

		Option 1	Option 2	**Option 3**	Option 4
Transport costs	Upper	£2,131,188.72	£198,200,550.52	£351,646,138.03	£262,136,211.98
	Lower	0	0	0	0

Table 6: Amended IA: Costs for reporting on (road) transport emissions

1.2.6. Estimated reporting cost for non-road freight transport emissions in option 3 (PV)

Considering Defra and the Department of Energy and Climate Change (DECC) provide businesses with measurement of transport emissions and supply the data for non-road transport GHG emissions in the UK (e.g. McKinnon 2007a) it remains unclear why the analysis omits the cost and benefits of reporting non-road freight transport emissions. As the carbon savings in the transport sector can be considerable, in order to make the IA more holistic, we include the costs for reporting non-road emissions in the amended IA (as well as the benefits, see below). This is done by multiplying the tonnes of CO_2 in freight transport (excluding road) with the cost factor for measuring transport related emissions that was estimated in part 1.2.4.1, yielding the following results:

		Option 3
Transport costs (non-road)	Upper	£26,584,448.03
	Lower	0

Table 7: Amended IA: Costs for reporting on non-road transport emissions

1.3. TOTAL ANNUAL COST

1.3.1. Annual costs of mandatory reporting electricity and gas related carbon dioxide emissions

Based on the cost figures laid out above, the total annual costs for option 3 can be calculated, using the assumption that 16,300 companies are new reporters and 7,700 already report in some other form and just need to adjust to the new reporting requirements (IA p.37).

		Costs	**Number of Companies**	**One-off costs**	**Measuring emissions**	**Reporting emissions**	**Annual costs (excl. one-off)**
New reporters	**large**	upper	16,300	£1,952,262	£107,004,067	£16,299,898	£123,303,964.79
		lower	16,300	£1,956,000	£36,512,000	£1,630,000	£38,142,000.00
Adjustors	**large**	upper	7,700	£0	£0	£7,699,952	£7,699,951.88
		lower	7,700	£0	£0	£770,000	£770,000.00

Table 8: Amended IA: Annual costs of mandatory reporting electricity and gas carbon dioxide emissions (disregarding increase in labour productivity)

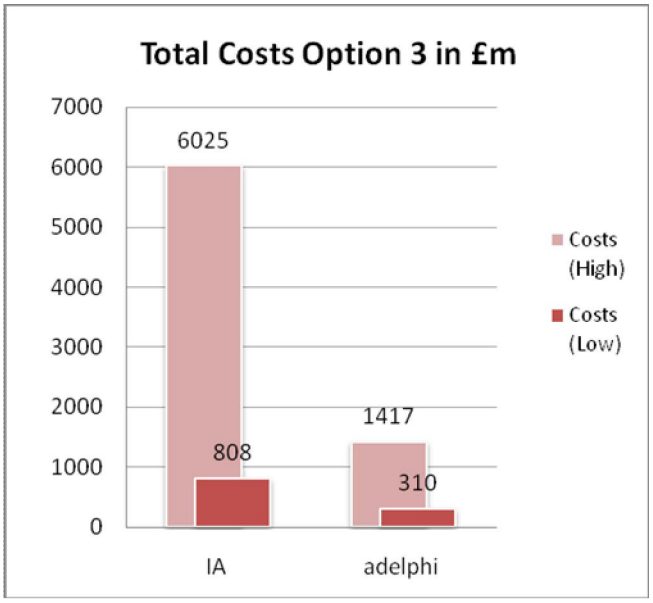
1.3.2. PV of mandatory reporting transport emissions

Costs for reporting transport emissions are estimated using the PV of cost for electricity and gas related emissions thereby arriving not at annual costs for transport but right at the PV for the time horizon of ten years which is thus provided here instead of the annual costs.

		Option 3
Transport costs (all freight transport modes)	Upper	£378,230,586.06
	Lower	0

Table 9: Amended IA: Transport costs (all freight transport modes)

To summarise, annual costs estimated in the amended IA are significantly lower for option 3 than in the initial assessment. The reduction in person-days required for reporting alone accounts for much cost reductions. Including costs for reporting on all freight transport emissions and taking into account productivity increases have contributed to making the assessment more holistic. The following figure presents the total costs for Option 3 of the Defra and the amended IA (adelphi).



2. Benefits

The benefits arising from option 3 pertain to each individual company under the reporting scheme as well as to the wider British economy and society. Apart from accounting for the reduced social costs of carbon however, the Defra IA does not monetise any of these wider benefits. This leaves the benefits of option 3 significantly undervalued as we attempt to show in the amended IA.

In the following sections it is analysed how benefits in the Defra IA were estimated and amendments are suggested for approximating the benefits more holistically. The analysis shows that in some aspects, the Defra IA overstates the included benefits; in other aspects it understates them. Subsequently, we present evidence on omitted benefits that were not accounted for in the Defra IA. Eventually, we take a look at the relevant positive impacts of option 3 that should be included in the amended IA but which, due to the lack of reliable data, could not be accounted for. Here, further research into possible benefits is identified in order to substantiate the IA on the benefit side.

The following points follow the line of thought of the Defra IA and offer suggestions for making the IA more holistic, mostly by arguing for the plausibility of alternative assumptions. Our analysis focuses on option 3 but many points apply to the estimates for the other options as well.

2.1. SUGGESTIONS CONCERNING THE HIGH AND THE UPPER SCENARIO

The following analysis pertains to the estimates of benefits in the high and the upper scenario as the Defra IA makes the general assumption that for the lower band, there are no benefits at all (this assumption itself is discussed in part 2.3 of this paper).

2.1.1. Value of emission reductions associated with electricity and gas

To calculate the value of emission reductions, the Defra IA uses DECC's 2009 approach. In the DECC publication, Annex 4 shows a table of traded and non-traded carbon values per tonne CO_2 over the years 2008 to 2050. The values are divided in low, central and high data. Regarding electricity and gas, the Defra IA estimates the high benefit values of emission reductions using the low value. To calculate the upper benefit values of emission reductions, the Defra IA uses the high data for electricity (traded) but for gas (non-traded) the low one is used again. Similar calculations have been made to value emission reductions of wider GHG reductions and from reductions in freight transport. Here for both benefit variations (high and upper) the central value, which is the average value, has been used.

Since the only difference between the high scenario and the upper scenario is that "the average cost to companies of reducing emissions is equal to the energy and fuel savings, related to these reduced emissions – hence only GHG reductions are valued" (IA p. 8), there seems to be no apparent reason to use different reduction values. Therefore, to increase the consistency in the assessment, when estimating the high and the upper benefit values of emission reductions in the amended IA, we use the central value for electricity as well as for gas. This yields the following values.

		Value of emission reductions in 2011
High	Associated with electricity	£547,248
	Associated with gas	£592,852
	Sum	£1,140,100
Upper	Associated with electricity	£1,231,308
	Associated with gas	£1,801,358
	Sum	£3,032,666

Table 10: Amended IA: Value of emission reductions in 2011

Additionally, it seems that for estimating the high benefit value of emission reductions associated with electricity for 2011 the Defra IA uses the 2012 value for traded carbon. Otherwise the value of emission reductions would not be £1.19m but £1.14m.

2.1.2. Range of potential emission reductions in wider GHG

It remains unclear how the range of potential emission reductions (5,992 tCO_2e) is calculated in the Defra IA. No explanation could be found. However, it does note that "wider GHG emissions account for an additional 8% of CO_2e" (IA p. 39). In consideration of this specification we use the value of 8% of 68,406 tCO_2 (the emission reductions associated to electricity and gas), which is 5,472 tCO_2e to calculate the value of electricity and gas related wider GHG reductions. This adjustment lowers the benefits associated with wider GHG emission reductions in the amended IA.

2.1.3. Results of the benefit calculation in freight transport

The benefits from the reduction in freight transport emissions presented on page 39 in the Defra IA beneath the table do not match with the corresponding data in the table.

2.1.4. Emission reductions triggered by mandatory reporting

One of the key assumptions of the Defra IA is that reporting carbon emissions triggers an emission reduction of up to 2% (electricity and gas) resp. 4% (fuel). These reductions were monetised and considered in the annual profile of monetised costs and benefits (IA, Annex J) using a discount rate of 3.5%.

This approach implies that the Defra IA expects only one single reduction triggered by the introduction of mandatory GHG reporting. One might imagine it like this: a company measures its footprint for the first time, as is required by the reporting scheme and thanks to the data from measuring and reporting, at one point – and just once – the company implements activities to reduce its footprint by 2%. In all the following years, the IA seems to imply, the company still measures and reports but these mandated tasks do not lead to any further

reductions. Following this logic, the most cost-efficient option for the scheme would be a new option 5: introducing mandatory reporting of GHG for all companies for just one year. According to the underlying logic of the IA, this would yield the same benefits as option 3 but only result in costs for year 0. This implied logic seems counterintuitive. It seems more likely that having to report annually would stimulate companies to improve their carbon footprint continually, harvesting the low-hanging fruits first but continuing to improve the footprint. A number of reasons may make this scenario more plausible than the approach described above:

- Once companies experience the first cost reductions brought about by 2% emission reductions they will look for further opportunities to reduce emissions in the years following year 0.

- Innovative approaches to GHG reductions displayed by other companies motivated by the scheme will inspire peers.

- Reduced emissions of competitors will motivate companies to improve their footprint as well (compare indications offered by Matsumura et al. 2011). Competition could increase for investors, customers/clients and business partners that would not arise without the mandatory reporting.

- Over the time span of the assessment, it can be expected that new or increasingly affordable low carbon technologies will become available for companies to reduce their GHG emissions (to illustrate: consider the availability, quality and price of energy-efficient lamps ten years ago). This might make emission reductions attractive in year 8 which were not yet financially or technically feasible in year 0 and would then be tapped because companies are still required to measure and report their emissions.

Therefore, in the amended IA we try to account for the expected further emissions reductions that go beyond 2% (or 4% regarding transport) in year 0. The approach is as follows: every two years after year 0, the reduced emission level is further decreased by a margin. The factor for reduction is (2%/2) in year 2, in year 4 it is (2%/4), in year 6 it is (2%/8) and in year 8 (2%/16), i.e. the reduction rate is halved every time to account for the fact that identifying reduction potentials will become more difficult the more emissions have been reduced already.

An example for illustration:

year	0	1	2	3	4
	2011	**2012**	**2013**	**2014**	**2015**
Benefits from reduced electricity and gas related carbon dioxide emissions					
Emission levels (tCO_2)	3,400,000	3,331,594	3,331,594	3,298,278	3,298,278
Reduction rate	ca. 0.02	0	0.01	0	0.005
Emission reduction (tCO_2):	**68,406**	**68,406**	**101,722**	**101,722**	**118,213**

Table 11: Amended IA: Calculation with further emission reductions

2.2. SUGGESTIONS CONCERNING THE UPPER SCENARIO

The upper scenario assumes that companies make energy and fuel savings, as well as GHG reductions, at no additional cost, thus reaping financial savings from the emission reductions, i.e. lower expenditure on electricity and fuels (IA, p.8).

2.2.1. Benefits from reduced electricity and gas related carbon dioxide emissions

2.2.1.1. Emission factors

For the estimation of the energy required to produce the emissions associated with electricity, the Defra IA uses the factor 0.43 $kgCO_2$ per kWh (IA p. 27), citing DECC's 2010 paper on 'Valuation of energy use and greenhouse gas emissions for appraisal and evaluation'. However, in table 1 of the DECC paper, the electricity emissions factor for 2011 is 0.49$kgCO_2$ per kWh (DECC 2010: table 1). As probably intended by the DECC guidelines, the amended IA uses the factor of 0.49 which is why further on we calculate that 93,069,387 kWh will produce 45,604 tCO_2.

Minor point: the factors for calculating the energy required associated with electricity and gas written on page 27 of the IA have misleading units. The correct unit is $kgCO_2$ per kWh (see DECC 2010: tables 1 and 2a) and not kWh per tCO_2.

2.2.1.2. Energy prices

The prices for electricity and gas (IA p. 27) are not consistent with the cited paper. As the Defra IA does not provide any reasons for deviating from the DECC guidelines, in our amended IA we adopt the DECC's energy prices. For electricity we use the average of commercial and industry prices, rising from 6.27 p in 2011 to 7.13 p in 2020. For gas, the commercial and the industrial prices are the same, rising from 2.14 p in 2011 to 2.38 p in 2020 (see DECC 2010: table 4-9).

2.2.2. Benefits from reduction in freight transport emissions

2.2.2.1. Emission factor of road transport

To calculate the amount of diesel required to produce 661,977 tCO_2, the Defra IA states that it uses an emission factor of 2.6413 $kgCO_2$. Nevertheless, the IA calculation seems to use a rounded factor of 2.6 $kgCO_2$ per litre. This overstates the value of diesel fuel savings by about £2,000,000. It might just be a small inaccuracy but as there are no apparent reasons for using a rounded figure, in the amended IA we use the full factor of 2.6413 $kgCO_2$ per litre.

Minor point: the unit of the emission factor in the text on page 27 is incorrect. It is not 2.6413gCO_2 per litre but 2.6413 $kgCO_2$ per litre (see Defra and DECC 2010: 8).

2.2.2.2. Diesel price for road transport

To monetise the fuel savings, the Defra IA estimates the resource cost of diesel at 42 p per litre. An increase in prices is not assumed although the benefits are modelled over the time horizon of ten years. Only in a footnote is it mentioned that fuel and carbon values would increase (16% resp. 11%), but these rates do not seem to be taken into consideration for the analysis as they "would not impact on the choice between options, or switch options from being, or not being, cost beneficial" (IA p. 18) and the calculation does not include a price rise. However, the price increases for petrol and oil for motor vehicles in the past would more than justify an inclusion of price increase regarding diesel in the IA, e.g. during 1999 and 2009 statistics show an increase of 50% over 10 years (Department for Transport Statistics 2011).

To account for this, we relate to DECC again and adopt their prices, rising from 38.49p in 2011 to 42.68p in 2020. This slightly decreases the benefits compared to the Defra IA on this point.

2.2.2.3. Additional transport modes

To calculate the benefits of emission reduction in transport, the Defra IA only takes road transport into consideration. Although road transport is responsible for by far the greatest part of emissions due to freight transport[4], there is no apparent reason for ignoring the other types of freight transport, especially if one takes into account that the average CO_2 emissions per tonne-km in aviation transport are substantially higher than in road transport (see McKinnon 2007: 28). McKinnon developed two scenarios to illustrate how much CO_2 emissions could be saved. One of these scenarios "suggests that total CO2 emissions in 2004 could be cut by 28% by 2015" (McKinnon 2007: 52).

Even if McKinnon does not take this to be realistic, limiting the possible emission reductions in the IA to 0-4% for transport related emissions seems slightly arbitrary when compared to these figures. Especially if one considers that there are a lot of possible reduction options in transport, not just by driving more efficiently but also by switching modes of transporting freight or managing the supply chain to reduce the miles that freight is on the road, on water, rail or in the air. The reason given in the IA for omitting the monetised benefits from emission reductions related to water transport, aviation and rail is that it would not have been proportionate as the corresponding costs for measuring and reporting these emissions have not been estimated (see IA p. 28). However, it remains unclear why the costs have not been estimated – as the approach for calculating the transport related emissions is fairly similar to the approach for electricity and gas. The approach for estimating the costs of these activities for the purpose of the IA is also not much different (see above, part 1.2.6).

Companies will not require much additional effort to report on transport related emissions as the processes are related to reporting electricity and gas and there are quite a number of supporting materials for carrying out this task: Defra and other organisations published a detailed "Guidance on measuring and reporting Greenhouse Gas (GHG) emissions from freight transport operation" including aviation, water transport and rail. The government-funded programme "Freight Best Practice" even offers free resources, tools and guides for calculation. The individual company's costs therefore would just increase slightly by the additional person-days required for measuring its transport-related emissions. Not including the costs and benefits arising from this would either bias the whole IA or assume that costs and benefits

[4] "Using what are considered the most reliable estimation methods, it is suggested that domestic freight transport in the UK generated 33.7 million tonnes of CO_2 in 2004, roughly 21% of emissions from the transport sector and 6% of total emissions from all sectors. Road transport accounted for 92% of these freight-related CO_2 emissions." (McKinnon 2007: 4)

would be fairly equal, therefore not substantial for the outcomes of the IA. The latter seems unlikely though, so in order not to bias the amended IA, we include estimates for other transport related emissions, namely rail, aviation and water transport (and associated costs and benefits).

The calculation of the benefits of the additional modes of transport is similar to the approach for road freight. From the Defra IA estimates on road freight, we adopt the assumptions that the firms affected by option 3 are responsible for 55% of the freight transport related CO_2 emissions and that the emission reduction will be 4% in the beginning. Thus, the only data needed to be included for other types of transport are transport mode specific CO_2 emissions, emission factors and fuel prices.

The emission factors can be found in the same paper as the emission factor for diesel (see Defra and DECC 2010: 8). They are 2.5218 $kgCO_2$ per litre for aviation turbine fuel and 2.7667 $kgCO_2$ per litre for gas oil, which "is used for stationary power generation and 'diesel' rail in the UK. Also use these emission factors for similar marine diesel oil and marine gas oil fuels" (Defra and DECC 2010: 9).

Information on fuel prices is taken from the same source as before. Again, we relate to DECC using an aviation fuel price rising from 33.99p in 2011 to 38.59p in 2020. The price of gas oil is the average price for commercial and industrial usage (similar to electricity and gas) being 29.36p in 2011 and 32.97p in 2020. (See DECC 2010: table 4-9)

Emission data on different freight transport modes are collected in a study by the Logistics Research Centre of Heriot-Watt University, Edinburgh (see McKinnon 2007b, summarised in McKinnon 2007a). Here, data on carbon dioxide emissions by rail freight, coastal shipping, transport on inland waterways and domestic air freight can be found. These are the transport modes included in the amended IA for the calculation of mandatory reporting benefits.

Overall, the additional benefits from reporting on non-road freight transport carbon dioxide emissions add up to £37.1m in the higher scenario and £113.04m in the upper scenario.

2.3. OMITTED BENEFITS

The amended IA takes into account two types of benefit of option 3 that are not included in the Defra IA: health benefits from the reduction in diesel emissions and benefits from GHG emission reduction of British companies realised in their operations abroad.

2.3.1. Health benefits

Diesel emissions from transport especially the particulate matter is proven to be responsible for creating serious health problems such as respiratory symptoms, heart disease and lung cancer. Option 3 will lead to a reduction in emissions from diesel which will result in health benefits. However, these benefits to the wider society are not accounted for in the Defra IA. As HM Treasury's guidance for conducting appraisal and evaluation in central government – the Green Book – states that "wider social and environmental costs and benefits for which there is no market price also need to be brought into any assessment" (HM Treasury 2003: p. 19), we include health benefits from reduced diesel consumption in the amended IA.

A study from the National Academy of Science (NAS 2010: p. 213) estimates the mean health and other non-climate damages per gallon for most fuels to range from 23 to 38 US cents (2005). Lacking a better proxy for the UK on health impacts of diesel, we take the average of these figures from the NAS report, account for inflation, the exchange rate (01.01.2011) and the

difference in volume units. This yields benefits (i.e. avoided costs) of 5.95p per reduced litre of diesel used. In the amended IA this results in additional benefits of £199.27m (present value) under transport benefits.

It is likely that this figure still understates the health benefits of option 3 as it only accounts for health benefits from reduced road transport. Lacking data on the health impacts of emissions from rail, inland and coastal waterway as well as aviation, these could not be accounted for. Thus, in case the UK health cost from diesel emissions should be lower than in the US, overall, due to not accounting for the other means of transport, the health benefits in the amended IA can be seen as very conservative.

2.3.2. International benefits

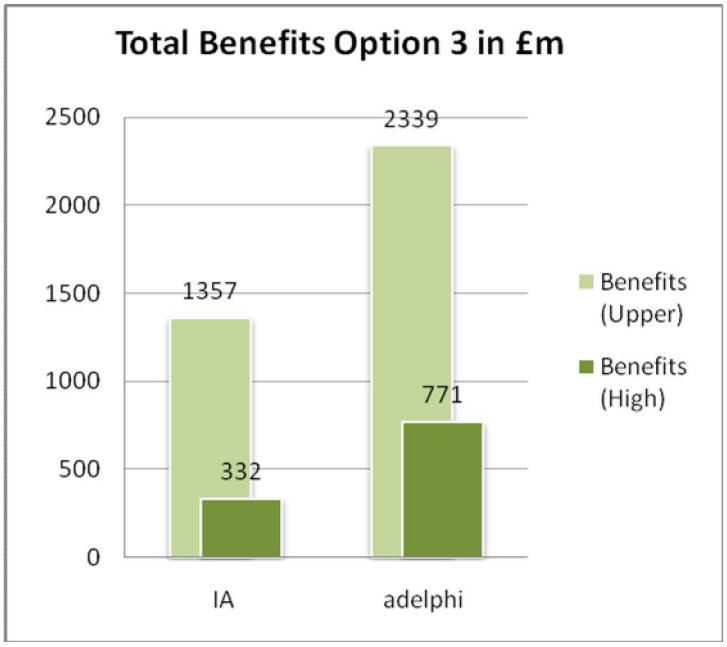
The Defra IA states that excluding international costs and benefits "is consistent with Green Book Guidance that states that only costs and benefits to the UK should be estimated" (IA, p. 27). However, there are two reasons why international benefits should still be accounted for: benefits to the non-UK operations and locations of UK firms still affect their bottom line and can therefore be seen as impacting on the UK (e.g. if FTSE 350 company realises significant energy savings in their offices and operations in Asia this will reduce the costs of the whole company). Furthermore, the Green Book states that "all impacts (including costs and benefits, both direct and indirect) on non-UK residents and firms should be identified and quantified separately where it is reasonable to do so, and if such impacts might affect the conclusions of the proposal (HM Treasury 2003, p.21, footnote 4). As emission reductions abroad can be significant, we therefore account for parts of the international benefits in the amended IA, based on the figures provided in Annex E of the Defra IA.

The Defra IA looks into the costs and benefits of international emissions reporting illustratively using just a small sample of the 24,000 companies affected by option 3, namely the FTSE 350. To show the wider benefits of option 3 and the importance of considering international reporting benefits in the IA, we follow the illustrative estimation in the following way: for the PV of costs we adopt the lower quartile of £168m (lower) and the upper quartile of £513m. A main reason for not including the international benefits in the Defra IA seems to be the fact that those benefits were estimated using UK values of carbon costs, electricity and fuel prices. To remedy this problem we make two changes for the amended IA: first, we adopt a global value for the social cost of carbon (Yohe et al. 2007: US$43 in 2005 per tonne of carbon, increasing by 3% p.a.) and second, we do not take into account any monetary savings realised by reducing electricity, gas and fuel consumption. The latter omission obviously leads to undervaluing the benefits; however, just using UK prices would most likely inflate the benefits. To provide a very conservative estimate of international benefits we thus disregard them. Still, using the estimated emissions of the FTSE 350 firms given in Annex E, the benefits account for £2,607.04m.[5] Again, this is likely to be a very conservative estimate as it only includes around 1.5% of the companies who would have to report under option 3.

Nevertheless, the amendments show that the international benefits are considerable and that it is in line with the Green Book to take them into account. However, as our knowledge of the 24,000 companies and their involvement abroad is limited, in the calculation of net benefits we do exclude international costs and benefits from "All Robust Monetised Costs and Benefits" and only include them under "All Monetised Costs and Benefits".

[5] For calculating the monetised benefits of international reporting, the Defra IA uses the estimated emissions of 891 MtCO2 of the FTSE 350, including transport. We assume that this does not include the UK emissions, otherwise the calculations on p.58 of the IA do not really add up. However, should it be the case that this value includes UK emissions, it is unlikely that the amended IA overvalues the international benefits as those are only the benefits accruing to the FTSE 350 who comprise around 1.5% of the 24,000 companies affected by option 3.

The following figure presents the total benefits for Option 3 of the IA and the amended IA.



2.4. DISCUSSION OF GENERAL ASSUMPTIONS REGARDING BENEFITS

A number of issues could not be addressed in the amended IA due to the lack of reliable data, but disregarding them completely can lead to an unbalanced IA. Therefore the following issues deserve additional attention to make the IA more holistic.

- The costs and benefits are calculated for a time horizon of 10 years. This seems very short considering the persistence of GHG in the atmosphere and the fact that the financial benefits from saved energy are realised every year. The Defra IA states that the alteration of the time horizon does not significantly change the outcome. However, in the amended IA this is not the case anymore. Changing the time horizon from 10 to 20 years in the amended IA pushes the balance of costs and benefits significantly towards benefits. When looking at "all robust monetised costs and benefits" the value of (maximum benefits – minimum costs) increases by about 106% from £2,029m to £4,180m. At the same time the value of (minimum benefits – maximum costs) only rises by 58% from £1,039m to £1,640m. When the selection of the time horizon influences the outcomes so significantly, the choice should be justified thoroughly. Doing different runs with changing time horizons would increase the transparency of the IA.

- The Defra IA assumes emission reductions due to mandatory GHG reporting up to 2% for electricity and up to 4% for transport. Evidence on these figures is hard to come by as the cited IEMA report does not provide any hints on the extent of emission reductions that is due to reporting. However, these values are central to whole IA. Here, more empirical evidence would be very beneficial. Alternatively, different assessments with changing reduction figures could increase the transparency of the assessment.

- In the lower scenario the benefits are always assumed to be zero. This assumes that a "mandatory reporting policy does not result in emission reductions by private firms" (IA p.27). However, this would imply that none of the companies reporting voluntarily have any attractive GHG emissions reduction options, i.e. they all work as efficiently as possible. Contrary to this, a great number report voluntarily already and have realised beneficial emissions reductions. Therefore, it seems very unlikely that none of the 16,300 companies

who would report for the first time under option 3 would realise any benefits from measuring and reporting. One might argue that the lowest likely benefits should be taken here to provide a wide range of benefits in the IA. However, this pessimism would have to be matched with more optimism on the upper end of the benefits, to have a wide range at both ends, in order not to bias the assessment one way. However, assumptions on the upper end, such as only 2% of emission reductions are by no means optimistic.

- There are more benefits, which are difficult to quantify. Some of them are listed in the IA, some of them have been taken into account in the amended IA. Additionally, there are benefits from…

  - …reporting international emissions, in addition to the benefits included here of the FTSE 350.

  - …a decreasing risk from climate change impacts (the more GHG emission reductions are stimulated the more the chance to limit climate change rises)

  - …a higher motivation of employees. Some surveys show that (voluntary) environmental management in companies leads to higher motivated workforce which increase its productivity.

  - …spill-over or knock-on effects to smaller companies that do not have to report mandatorily but are motivated due to the activities of larger competitors who have to report.

  - …knock-on effects to the employees and their private lives. If the company measures and manages its footprint, employees might be curious to do so as well – or as conscious consumers or investors demand such data from other companies not affected directly by the scheme as well.

  - …get the higher emitting companies to disclose by making reporting mandatory as voluntary disclosure correlates with superior environmental performance (see Matsumura et al. 2011: 29) and a mandatory reporting is therefore a necessary step to go.

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Annex

Defra			O1	O2	Option 3	O4
Benefits (GBP m)	Electricity and gas related	Upper			115.14	
		High			10.69	
		Lower			0	
	Wider GHGs	Upper			2.88	
		High			2.88	
		Lower			0	
	Transport	Upper			1,238.74	
		High			318.28	
		Lower			0	
	Total	Upper			1,356.76	
		High			331.85	
		Lower			0	
Costs (GBP m)	Electricity & gas related	High			4,418	
		Lower			808	
	Transport related	High			1,607	
		Lower			0	
	Total	High			6,025	
		Lower			808	
Net Benefits (GBP m)	Electricity and gas related	Maximum Benefits - Minimum Costs			-693	
		Minimum Benefits - Maximum Costs			-4,418	
	All Robust Monetised Costs and Benefits	Maximum Benefits - Minimum Costs			548	
		Minimum Benefits - Maximum Costs			-4,418	
	All Monetised Costs and Benefits	Maximum Benefits - Minimum Costs			548	
		Minimum Benefits - Maximum Costs			-6,025	

adelphi			O1	O2	Option 3	O4
Benefits (GBP m)	Electricity and gas related	Upper			161.04	
		High			31.79	
		Lower			0	
	Wider GHGs	Upper			4.15	
		High			4.15	
		Lower			0	
	Transport	Upper			2,173.61	
		High			734.63	
		Lower			0	
	Total	Upper			2,338.80	
		High			770.57	
		Lower			0	
Costs (GBP m)	Electricity & gas related	High			1,039.24	
		Lower			310	
	Transport related	High			378	
		Lower			0	
	Total	High			1,417.47	
		Lower			310	
Net Benefits (GBP m)	Electricity and gas related	Maximum Benefits - Minimum Costs			-149	
		Minimum Benefits - Maximum Costs			-1,039	
	All Robust Monetised Costs and Benefits	Maximum Benefits - Minimum Costs			2,029	
		Minimum Benefits - Maximum Costs			-1,039	
	All Monetised Costs and Benefits	Maximum Benefits - Minimum Costs			2,029	
		Minimum Benefits - Maximum Costs			-1,417	

adelphi

Policy Option 3

1. adelphi: Costs of GHG reporting by company

1.1 Measuring and reporting non-transport carbon emissions

1.1.1**. Person-day input** needed for measuring and report non-transport carbon emissions

1.1.1.1 Person-day input needed for measuring non-transport carbon emissions for large companies

Number of sites operated by organisation	**1**	**2**	**3**	**4**	**5**	**5-6**	**11-50**	**50+**
1. Understanding the rules								
2. Initial collection and analysis of energy data	3	3	4	4	4	4	7	13
3. Developing a compliance strategy								
4. Understand and take part in Auction								
5. Trading activities								
6. Submitting data to coordinator								
7. Verifying data (internal costs)	2.0	2.7	3.3	4.0	4.7	6.7	9.3	12.7
Total person-days	**5.0**	**5.7**	**7.3**	**8.0**	**8.7**	**10.7**	**16.3**	**25.7**
Days for wider GHGs								**3**
Total person-days								**28.7**
DAY RATE								
£500.00	£2,500.00	£2,833.33	£3,666.67	£4,000.00	£4,333.33	£5,333.33	£8,166.67	£14,333.33

1.1.1.2 Person-day input needed for understanding the scheme and measuring and reporting non-transport carbon emissions for all companies

Company Size	New / Adjust	Read and understand guidance		Average additional person-day of measuring emissions		Average additional person-day input for reporting		SUM of person-days p.a.	
	0	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**
small	**New**	0.25	0.5	8.68	8.93	0.25	0.5	9.18	9.93
	Adjust	0	0	0	0	0.25	0.5	0.25	0.5
medium	**New**	0.465	0.432	5.9	5.938	0.406	0.54	6.771	6.910
	Adjust	0	0	0	0	0.406	0.54	0.406	0.54
large	**New**	0.6	0.524	11.2	28.667	0.5	4.375	12.3	33.566
	Adjust	0	0	0	0	0.5	4.375	0.5	4.375

1.1.1.3 Implied rates for a person-day for different

Company Size	New / Adjust	day-rate for reading and understanding guidance		day-rate for measuring emissions		day-rate for reporting emissions	
		Lower	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**
small	**New**	£144	£140	£144	£140	£144	£140
	Adjust	£144	£140	£144	£140	£144	£140
medium	**New**	£172	£184	£172	£185	£172	£184
	Adjust	£172	£184	£172	£185	£172	£184
large	**New**	£200	£229	£200	£229	£200	£229
	Adjust	£200	£229	£200	£229	£200	£229

1.1.2. Overall costs for understandings the scheme and measuring and reporting non-transport emissions (see p. 20, Table 2)

Company Size	New / Adjust	One-off cost		Average additional annual cost of measuring emissions		Average additional annual cost of reporting emissions		SUM including one-off costs	
		Lower	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**
small	**New**	£36	£70	£1,250	£1,250	£36	£70	£1,322	£1,390
	Adjust	£0	£0	£0	£0	£36	£70	£36	£70
medium	**New**	£80	£80	£1,015	£1,095	£70	£100	£1,165	£1,275
	Adjust	£0	£0	£0	£0	£70	£100	£70	£100
large	**New**	£120	£120	£2,240	£6,565	£100	£1,000	£2,460	£7,684
	Adjust	£0	£0	£0	£0	£100	£1,000	£100	£1,000

1.1.3. Annual measuring and reporting costs per large company taking into account labor productivity

Annual Costs for large companies	year	0 **2011**	1 **2012**	2 **2013**	3 **2014**	4 **2015**
increase in labor productivity		-	0.02	0.02	0.02	0.02
costs (lower)	**New**	£2,460	£2,293	£2,247	£2,202	£2,158
	Adjust	£100	£98	£96	£94	£92
costs (upper)	**New**	£7,684	£7,413	£7,265	£7,120	£6,977
	Adjust	£1,000	£980	£960	£941	£922

Annual Costs for large companies	year	5 **2016**	6 **2017**	7 **2018**	8 **2019**	9 **2020**
increase in labor productivity		0.02	0.02	0.02	0.02	0.02
costs (lower)	**New**	2,115.17	2,072.87	2,031.41	1,990.79	1,950.97
	Adjust	90	89	87	85	83
costs (upper)	**New**	6,837.85	6,701.10	6,567.07	6,435.73	6,307.02
	Adjust	904	886	868	851	834

1.2 Measuring and reporting transport carbon emissions

1.2.1 Calculating NPV of reporting non-transport carbon emissions for large companies

Number of large companies	24,000
discount rate	3.5%
time horizon (years)	10

	Low(er)	Upper
total annual costs of reporting non-transport emissions (including one-off costs)	£59,040,000	£184,426,346
total annual costs of reporting non-transport emissions (excluding one-off costs)	£56,160,000	£181,551,850

Low(er)

year	cost each year	discounted flow	NPV value of reporting cost for non-transport GHG
0	£59,040,000	£59,040,000	
1	£55,036,800	£53,175,652	
2	£53,936,064	£50,349,893	
3	£52,857,343	£47,674,295	
4	£51,800,196	£45,140,878	
5	£50,764,192	£42,742,087	
6	£49,748,908	£40,470,769	
7	£48,753,930	£38,320,148	
8	£47,778,851	£36,283,812	
9	£46,823,274	£34,355,687	£447,553,221

Upper

year	cost each year	discounted flow	NPV value of reporting cost for non-transport GHG
0	£184,426,346	£184,426,346	
1	£177,920,813	£171,904,167	
2	£174,362,397	£162,769,163	
3	£170,875,149	£154,119,594	
4	£167,457,646	£145,929,664	
5	£164,108,493	£138,174,947	
6	£160,826,323	£130,832,317	
7	£157,609,797	£123,879,875	
8	£154,457,601	£117,296,887	
9	£151,368,449	£111,063,719	£1,440,396,681

1.2.2 Estimating the relation between freight transport GHG emissions and electricity and gas emissions

Total freight transport related GHG emissions in UK	52	MtCO2e
Total electricity and gas related GHG emissions in UK	213	MtCO2e
Size of transport to emissions relative to electricity and gas emissions	0.24	

1.2.3 Deriving total costs for reporting freight transport emissions from costs of reporting elec and gas emissions

	Low(er)	Upper
Total costs of companies for reporting transport related GHG emissions (over 10 years)	£109,261,819	£351,646,138

1.2.4 Adjusting total cost for reporting freight transport emissions for different options

1.2.4.1 Calculating the reporting cost of transport emissions per tonne of CO2

	Option 1	Option 2	Option 3	Option 4
Estimated (annual?) road freight transport related emissions (MtCO2)	0.1	9.3	16.5	12.3
Estimated (annual?) road freight transport related emissions (tCO2)	100,000	9,300,000	16,500,000	12,300,000

	Lower	Upper
Cost for reporting transport emissions per tonne of CO2	£6.62	£21.31

1.2.5 Estimated reporting costs for road freight transport emissions in different options (present value)

		Option 1	Option 2	Option 3	Option 4
Transport costs	**Upper**	£2,131,188.72	£198,200,550.52	£351,646,138.03	£262,136,211.98
	Lower	0	0	0	0

1.2. 6 Estimated reporting costs fo r non-road transport emissions in different options (present value)

tonnes of CO2 in freight transport (excluding road)	1,247,400

		Option 3
Transport costs non road	**Upper**	£26,584,448.03
	Lower	0

1.3. Total annual cost

Companies affected under Option 3

Total number of large UK companies	24,000
Estimate of large companies engaged in some form of monitoring or reporting	7,700
new reporters under option 3	16,300

1.3.1. Annual Costs of Mandatory Reporting Electricity and Gas Carbon Dioxide Emissions (disregarding increase in labour productivity)

		Costs	Number of Companies	One-off costs	Measuring emissions	reporting emissions	annual costs (excl. One-off)
New reporters	**large**	upper	16,300	£1,952,262	£107,004,067	£16,299,898	£123,303,964.79
		lower	16,300	£1,956,000	£36,512,000	£1,630,000	£38,142,000.00
Adjustors	**large**	upper	7,700	£0	£0	£7,699,952	£7,699,951.88
		lower	7,700	£0	£0	£770,000	£770,000.00
Overall including one-off costs (year 0)		upper					£131,003,916.67
		lower					£38,912,000.00

1.3.1.1. Annual Costs of Mandatory Reporting Electricity and Gas Carbon Dioxide Emissions (accounting for increase in labour productivity)

Annual Costs for large companies	year	0 **2011**	1 **2012**	2 **2013**	3 **2014**	4 **2015**
increase in labor productivity		-	0.02	0.02	0.02	0.02
New reporters	**upper**	£125,256,227	£120,837,885	£118,421,128	£116,052,705	£113,731,651
	lower	£40,098,000	£37,379,160	£36,631,577	£35,898,945	£35,180,966
Adjustors	**upper**	£7,699,952	£7,545,953	£7,395,034	£7,247,133	£7,102,190
	lower	£770,000	£754,600	£739,508	£724,718	£710,223

Annual Costs for large companies	year **0**	5 **2016**	6 **2017**	7 **2018**	8 **2019**	9 **2020**
increase in labor productivity	**0**	0.02	0.02	0.02	0.02	0.02
New reporters	**upper**		£109,227,878	£107,043,320	£104,902,454	£102,804,405
	lower	£34,477,347	£33,787,800	£33,112,044	£32,449,803	£31,800,807
Adjustors	**upper**	£6,960,147	£6,820,944	£6,684,525	£6,550,834	£6,419,818
	lower	£696,019	£682,099	£668,457	£655,088	£641,986

1.3.2. NPV of Mandatory Reporting Transport Emissions

		Option 3
Transport costs all	**Upper**	£378,230,586
	Lower	0

2 Benefits from GHG reporting in Option 3

2.1. Benefits from reduced electricity and gas related carbon dioxide emissions

Emission reduction:	68,406	tCO2	2% of 3.4 MtCO2 (IA p. 38)
associated with electricity	45,604	tCO2	2/3 (IA p. 25)
associated with gas	22,802	tCO2	1/3 (IA p. 25)

Value of emission reductions:

High	£547,248
	£592,852
	£1,140,100
Upper	£1,231,308
	£1,801,358
	£3,032,666

£/t	low	central	high
electricity: traded 2011	12	22	27
gas: non-traded 2011	26	52	79

(DECC 2009: Carbon Valuation in UK Policy Appraisal: A Revised Approach, Annex 4)

Value of electricity energy savings (Upper):

energy required to produce those emissions	93,069,388	kWh	0.49	kgCO2/kWh	
value of energy saved	£6,274,464		6.7	p	IA p. 27

ELECTRICITY - Variable element: commercial	p/KWh (2009)	6.97
ELECTRICITY - Variable element: industrial	p/KWh (2009)	6.52

Value of gas energy savings (Upper):

energy required to produce those emissions	123,923,913	kWh	0.184	kgCO2/kWh	
value of energy saved	£2,650,211		2.1	p	IA p. 27

GAS - Variable element: commercial	p/KWh (2009)	2.14
GAS - Variable element: industrial	p/KWh (2009)	2.14

Total savings:

High	Upper
£1,140,100	£11,957,340

	Lower	High	Upper
Range of Potential Emission Reductions (tCO2)	0	68,406	68,406
Value of emission reductions (£m) 2011	0	1.14	3.03
Value of electricity energy savings (£m) 2011	0	0	6.27
Value of gas energy savings (£m) 2011	0	0	2.65
Total savings (£m) 2011	0	1.14	11.96

2.2. Reduction in Wider GHG Emissions

electricity and gas related wider GHG reductions	5,472	tCO2e

	Lower	High	Upper
Range of Potential Emission Reductions (tCO2e)	0	5,472	5,472
Value of emission reductions (£m) 2011	0	0.28	0.28
Total savings (£m) 2011	0	0.28	0.28

2.3 Benefits from Reduction in Freight Transport Emissions

Emission reduction: 661,977 tCO2 4% of 16.5 MtCO2 (IA p. 39)

Value of diesel fuel savings:

energy required to produce those emissions	250,625,450	l	2.6413	kgCO2/l	
value of energy saved	£96,464,184		42.0	p	IA p. 27

ROAD TRANSPORT - Variable element: DERV	p/litre (2009)	38.49

	Lower	High	Upper
Range of Potential Emission Reductions (tCO2)	0	661,977	661,977
Value of emission reductions (£m) 2011	0	17.21	52.30
Value of diesel fuel savings (£m) 2011	0	0	96.46
Total Transport Benefits (£m) 2011	0	17.21	148.76

2.4 Total Annual Benefits

	Lower	High	Upper
Range of Potential Emission Reductions (tCO 2)	0	735,855	735,855
Value of emission reductions (£m) 2011	0	18.64	55.61
Value of energy and fuel savings (£m) 2011	0	0	105.67
Total savings (£m) 2011	0	18.64	161.29

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Annual costs
Policy Option 3

discount rate (%):	3.5

Upper/high

year	0	1	2	3	4	5	6	7	8	9	**Total**
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**costs**
Annual Costs											
Electricity and Gas Related Costs											
total costs (£m)	**132.96**	**128.38**	**125.82**	**123.30**	**120.83**	**118.42**	**116.05**	**113.73**	**111.45**	**109.22**	
discounted:	**132.95618**	**124.04236**	**117.45073**	**111.20939**	**105.29971**	**99.704075**	**94.405791**	**89.389058**	**84.638915**	**80.141195**	***1,039.24***
Road Transport Related Costs											
total costs (£m) - indicative											
discounted:											***351.65***
Total Annual Costs											***1,390.88***

Lower

year	0	1	2	3	4	5	6	7	8	9	**Total**
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**costs**
Annual Costs											
Electricity and Gas Related Costs											
total costs (£m)	**40.868**	**38.13376**	**37.371085**	**36.623663**	**35.89119**	**35.173366**	**34.469899**	**33.780501**	**33.104891**	**32.442793**	
discounted:	**40.868**	**36.844213**	**34.886308**	**33.032446**	**31.277098**	**29.61503**	**28.041285**	**26.551168**	**25.140237**	**23.804282**	***310.06***
Transport Related Costs											
total costs (£m) - indicative	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
discounted:											***0.00***
Total Annual Costs											***310.06***

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Additional costs
Policy Option 3

Reporting for non-road freight transport

	Lower	Upper
Cost for reporting transport emissions per tonne of CO2	£6.62	£21.31

tonnes of CO2 in freight transport (excluding road)	1,247,400

Estimated reporting costs for non-road transport emissions in different options (present value)

		Option 3
Transport costs (in m)	**Upper**	£26.58
	Lower	0

Reporting for international emissions FTSE350 - illustrative costs (see Defra IA: Annex E)

PV Costs (£m)	Lower Bound	84
	Lower Quartile	168
	Median	336
	Upper Quartile	513
	Upper Bound	1,765

Estimated Total Emission Related to FTSE 350 firms	891	MtCO2

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Annual benefits
Policy Option 3
High

year	0 **2011**	1 **2012**	2 **2013**	3 **2014**	4 **2015**	5 **2016**	6 **2017**	7 **2018**	8 **2019**	9 **2020**	**Total benefits**
Benefits from reduced electricity and gas related carbon dioxide emissions											
Emission levels (tCO2)	**3,400,000**	**3,331,594**	**3,331,594**	**3,298,278**	**3,298,278**	**3,281,787**	**3,281,787**	**3,273,582**	**3,273,582**	**3,269,490**	
Reduction rate	ca. 0.02	0	0.01	0	0.005	0	0.0025	0	0.00125	0	
Emission reduction (tCO2):	**68,406**	**68,406**	**101,722**	**101,722**	**118,213**	**118,213**	**126,418**	**126,418**	**130,510**	**130,510**	
associated with electricity (tCO2):	45,604	45,604	67,815	67,815	78,809	78,809	84,279	84,279	87,007	87,007	
associated with gas (tCO2):	22,802	22,802	33,907	33,907	39,404	39,404	42,139	42,139	43,503	43,503	
Value of emission reductions (£m):	**2.19**	**2.21**	**3.39**	**3.42**	**4.02**	**4.14**	**4.42**	**4.47**	**4.74**	**4.79**	
associated with electricity (£):	1,003,288	1,003,288	1,559,736	1,559,736	1,812,604	1,891,413	2,022,685	2,022,685	2,175,163	2,175,163	
associated with gas (£):	1,185,704	1,208,506	1,830,995	1,864,902	2,206,649	2,246,053	2,401,938	2,444,077	2,566,692	2,610,195	
Total savings (£m):	**2.19**	**2.21**	**3.39**	**3.42**	**4.02**	**4.14**	**4.42**	**4.47**	**4.74**	**4.79**	***37.79***
discounted:	**2.19**	**2.14**	**3.17**	**3.09**	**3.50**	**3.48**	**3.60**	**3.51**	**3.60**	**3.51**	***31.79***

year	0	1	2	3	4	5	6	7	8	9	Total
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	benefits
Reduction in Wider GHG Emissions											
Emission levels (tCO2)	**272,000**	**266,528**	**266,528**	**263,862**	**263,862**	**262,543**	**262,543**	**261,887**	**261,887**	**261,559**	
Reduction rate	ca. 0.02	0	0.01	0	0.005	0	0.0025	0	0.00125	0	
electricity and gas related wider GHG reductions (tCO2e):	**5,472**	**5,472**	**8,138**	**8,138**	**9,457**	**9,457**	**10,113**	**10,113**	**10,441**	**10,441**	
Value of emission reductions (£m):	**0.28**	**0.29**	**0.44**	**0.45**	**0.53**	**0.54**	**0.58**	**0.59**	**0.62**	**0.63**	
Total savings (£m):	**0.28**	**0.29**	**0.44**	**0.45**	**0.53**	**0.54**	**0.58**	**0.59**	**0.62**	**0.63**	***4.94***
discounted:	**0.28**	**0.28**	**0.41**	**0.40**	**0.46**	**0.45**	**0.47**	**0.46**	**0.47**	**0.46**	***4.15***
Benefits from Reduction in Road Freight Transport Emissions											
Emission levels (tCO2)	**16,500,000**	**15,838,023**	**15,838,023**	**15,521,263**	**15,521,263**	**15,366,050**	**15,366,050**	**15,289,220**	**15,289,220**	**15,250,997**	
Reduction rate	ca. 0.04	0	0.02	0	0.01	0	0.005	0	0.0025	0	
Emission reduction (tCO2):	**661,977**	**661,977**	**978,737**	**978,737**	**1,133,950**	**1,133,950**	**1,210,780**	**1,210,780**	**1,249,003**	**1,249,003**	
Value of emission reductions (£m):	**34.42**	**35.08**	**52.85**	**53.83**	**63.50**	**64.64**	**69.01**	**70.23**	**73.69**	**74.94**	
Total savings (£m):	**34.42**	**35.08**	**52.85**	**53.83**	**63.50**	**64.64**	**69.01**	**70.23**	**73.69**	**74.94**	***592.20***
discounted:	**34.42**	**33.90**	**49.34**	**48.55**	**55.34**	**54.42**	**56.14**	**55.20**	**55.96**	**54.99**	***498.26***
Total Annual Benefits											
Range of Potential Emission Reductions (tCO2):	**735,855**	**735,855**	**1,088,597**	**1,088,597**	**1,261,620**	**1,261,620**	**1,347,312**	**1,347,312**	**1,389,954**	**1,389,954**	
Value of emission reductions (£m):	**36.90**	**37.59**	**56.68**	**57.70**	**68.05**	**69.31**	**74.02**	**75.28**	**79.05**	**80.35**	
Total savings (£m):	**36.90**	**37.59**	**56.68**	**57.70**	**68.05**	**69.31**	**74.02**	**75.28**	**79.05**	**80.35**	***634.92***
discounted:	**36.90**	**36.32**	**52.91**	**52.04**	**59.30**	**58.36**	**60.21**	**59.17**	**60.03**	**58.96**	***534.20***
discount rate (%):	3.5										

Upper											
year	0	1	2	3	4	5	6	7	8	9	**Total**
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**benefits**
Benefits from reduced electricity and gas related carbon dioxide emissions											
Emission levels (tCO2)	**3,400,000**	**3,331,594**	**3,331,594**	**3,298,278**	**3,298,278**	**3,281,787**	**3,281,787**	**3,273,582**	**3,273,582**	**3,269,490**	
Reduction rate	ca. 0.02	0	0.01	0	0.005	0	0.0025	0	0.00125	0	
Emission reduction (tCO2):	**68,406**	**68,406**	**101,722**	**101,722**	**118,213**	**118,213**	**126,418**	**126,418**	**130,510**	**130,510**	
associated with electricity (tCO2):	45,604	45,604	67,815	67,815	78,809	78,809	84,279	84,279	87,007	87,007	
associated with gas (tCO2):	22,802	22,802	33,907	33,907	39,404	39,404	42,139	42,139	43,503	43,503	
Value of emission reductions (£m):	**2.19**	**2.21**	**3.39**	**3.42**	**4.02**	**4.14**	**4.42**	**4.47**	**4.74**	**4.79**	
associated with electricity (£):	1,003,288	1,003,288	1,559,736	1,559,736	1,812,604	1,891,413	2,022,685	2,022,685	2,175,163	2,175,163	
associated with gas (£):	1,185,704	1,208,506	1,830,995	1,864,902	2,206,649	2,246,053	2,401,938	2,444,077	2,566,692	2,610,195	
Value of electricity energy savings (£m):	**6.27**	**6.49**	**9.78**	**9.90**	**11.65**	**11.78**	**12.74**	**12.84**	**13.46**	**13.60**	
energy associated with the reduced emissions (kWh):	93,069,388	93,069,388	138,397,197	138,397,197	160,834,463	160,834,463	171,997,003	171,997,003	177,564,319	177,564,319	
emissions per kWh for electricity (kgCO2):	0.49										
price of electricity per kWh (p):	6.7	7.0	7.1	7.2	7.2	7.3	7.4	7.5	7.6	7.7	
Value of gas energy savings (£m):	**2.7**	**2.7**	**4.0**	**4.1**	**4.8**	**4.9**	**5.3**	**5.3**	**5.6**	**5.6**	
energy associated with the reduced emissions (kWh):	124,207,430	124,207,430	184,700,476	184,700,476	214,644,533	214,644,533	229,541,702	229,541,702	236,971,665	236,971,665	
emissions per kWh for gas (kgCO2):	0.184										
price of gas per kWh (p):	2.1	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.4	2.4	
Total savings (£m):	**11.12**	**11.39**	**17.22**	**17.43**	**20.49**	**20.80**	**22.44**	**22.65**	**23.78**	**24.03**	***191.35***
discounted:	**11.12**	**11.00**	**16.07**	**15.72**	**17.86**	**17.51**	**18.26**	**17.81**	**18.06**	**17.63**	***161.04***

year	0	1	2	3	4	5	6	7	8	9	**Total**
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**benefits**
Reduction in Wider GHG Emissions											
Emission levels (tCO2e)	272,000	266,528	266,528	263,862	263,862	262,543	262,543	261,887	261,887	261,559	
Reduction rate	ca. 0.02	0	0.01	0	0.005	0	0.0025	0	0.00125	0	
electricity and gas related wider GHG reductions (tCO2e):	**5,472**	**5,472**	**8,138**	**8,138**	**9,457**	**9,457**	**10,113**	**10,113**	**10,441**	**10,441**	
Value of emission reductions (£m):	**0.28**	**0.29**	**0.44**	**0.45**	**0.53**	**0.54**	**0.58**	**0.59**	**0.62**	**0.63**	
Total savings (£m):	**0.28**	**0.29**	**0.44**	**0.45**	**0.53**	**0.54**	**0.58**	**0.59**	**0.62**	**0.63**	***4.94***
discounted:	**0.28**	**0.28**	**0.41**	**0.40**	**0.46**	**0.45**	**0.47**	**0.46**	**0.47**	**0.46**	***4.15***

Benefits from Reduction in Freight Transport Emissions (road)											
Emission levels (tCO2)	16,500,000	15,838,023	15,838,023	15,521,263	15,521,263	15,366,050	15,366,050	15,289,220	15,289,220	15,250,997	
Reduction rate	ca. 0.04	0	0.02	0	0.01	0	0.005	0	0.0025	0	
Emission reduction (tCO2):	**661,977**	**661,977**	**978,737**	**978,737**	**1,133,950**	**1,133,950**	**1,210,780**	**1,210,780**	**1,249,003**	**1,249,003**	
Value of emission reductions (£m):	**34.42**	**35.08**	**52.85**	**53.83**	**63.50**	**64.64**	**69.01**	**70.23**	**73.69**	**74.94**	
Value of diesel fuel savings (£m):	**96.46**	**97.63**	**146.07**	**147.80**	**173.24**	**175.24**	**189.25**	**191.38**	**199.63**	**201.83**	
energy associated with the reduced emissions (l):	250,625,450	250,625,450	370,551,418	370,551,418	429,315,142	429,315,142	458,403,186	458,403,186	472,874,488	472,874,488	
emissions per l for diesel (kgCO2):	2.6413										
price of diesel per l (p):	38.49	38.96	39.42	39.89	40.35	40.82	41.28	41.75	42.22	42.68	
Total savings (£m):	**130.89**	**132.72**	**198.93**	**201.63**	**236.74**	**239.87**	**258.26**	**261.61**	**273.32**	**276.77**	***2,210.73***
discounted:	**130.89**	**128.23**	**185.70**	**181.86**	**206.31**	**201.97**	**210.10**	**205.62**	**207.56**	**203.07**	***1,861.30***

year	0	1	2	3	4	5	6	7	8	9	**Total**
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**benefits**
Total Annual Benefits											
Range of Potential Emission Reductions (tCO2):	**735,855**	**735,855**	**1,088,597**	**1,088,597**	**1,261,620**	**1,261,620**	**1,347,312**	**1,347,312**	**1,389,954**	**1,389,954**	
Value of emission reductions (£m):	**36.90**	**37.59**	**56.68**	**57.70**	**68.05**	**69.31**	**74.02**	**75.28**	**79.05**	**80.35**	
Value of energy and fuel savings (£m):	**105.39**	**106.81**	**159.90**	**161.80**	**189.71**	**191.90**	**207.27**	**209.57**	**218.67**	**221.07**	
Total savings (£m):	**142.29**	**144.39**	**216.58**	**219.51**	**257.76**	**261.21**	**281.28**	**284.85**	**297.72**	**301.42**	***2,407.02***
discounted:	**142.29**	**139.51**	**202.18**	**197.98**	**224.63**	**219.93**	**228.82**	**223.89**	**226.09**	**221.16**	***2,026.49***

discount rate (%):	3.5

adelphi

Additional benefits
Policy Option 3

High

year	0 **2011**	1 **2012**	2 **2013**	3 **2014**	4 **2015**	5 **2016**	6 **2017**	7 **2018**	8 **2019**	9 **2020**	**Total savings**
rail (diesel) freight											
Reduction rate	0.04	0	0.02	0	0.01	0	0.005	0	0.0025	0	
Emission reduction (tCO2):	**9,240**	**9,240**	**13,675**	**13,675**	**15,848**	**15,848**	**16,924**	**16,924**	**17,459**	**17,459**	
Value of emission reductions (£m):	0.48	0.49	0.74	0.75	0.89	0.90	0.96	0.98	1.03	1.05	
inland waterways freight											
Reduction rate	0.04	0	0.02	0	0.01	0	0.005	0	0.0025	0	
Emission reduction (tCO2):	**1,166**	**1,166**	**1,726**	**1,726**	**2,000**	**2,000**	**2,136**	**2,136**	**2,203**	**2,203**	
Value of emission reductions (£m):	0.06	0.06	0.09	0.09	0.11	0.11	0.12	0.12	0.13	0.13	
costal shipping freight											
Reduction rate	0.04	0	0.02	0	0.01	0	0.005	0	0.0025	0	
Emission reduction (tCO2):	**38,280**	**38,280**	**56,654**	**56,654**	**65,658**	**65,658**	**70,115**	**70,115**	**72,332**	**72,332**	
Value of emission reductions (£m):	1.99	2.03	3.06	3.12	3.68	3.74	4.00	4.07	4.27	4.34	
aviation freight											
Reduction rate	0.04	0	0.02	0	0.01	0	0.005	0	0.0025	0	
Emission reduction (tCO2):	**1,210**	**1,210**	**1,791**	**1,791**	**2,075**	**2,075**	**2,216**	**2,216**	**2,286**	**2,286**	
Value of emission reductions (£m):	0.06	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	
Total savings (£m):	**2.59**	**2.61**	**3.93**	**4.00**	**4.72**	**4.81**	**5.14**	**5.23**	**5.48**	**5.58**	
discounted:	**2.59**	**2.52**	**3.67**	**3.61**	**4.12**	**4.05**	**4.18**	**4.11**	**4.17**	**4.09**	***37.10***

Upper											
year	0	1	2	3	4	5	6	7	8	9	**Total**
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**savings**
rail (diesel) freight											
Overall emissions (tCO2):	**420,000**										
Emission levels (tCO2 mid-point 55%)	231,000	221,760	221,760	217,325	217,325	215,152	215,152	214,076	214,076	213,541	
Reduction rate	0.04	0	0.02	0	0.01	0	0.005	0	0.0025	0	
Emission reduction (tCO2):	**9,240**	**9,240**	**13,675**	**13,675**	**15,848**	**15,848**	**16,924**	**16,924**	**17,459**	**17,459**	
Value of emission reductions (£m):	**0.48**	**0.49**	**0.74**	**0.75**	**0.89**	**0.90**	**0.96**	**0.98**	**1.03**	**1.05**	
Value of diesel fuel savings (£m):	**0.98**	**0.99**	**1.49**	**1.51**	**1.77**	**1.80**	**1.94**	**1.97**	**2.06**	**2.08**	
energy associated with the reduced emissions (l):	3,339,719	3,339,719	4,942,784	4,942,784	5,728,286	5,728,286	6,117,109	6,117,109	6,310,549	6,310,549	
emissions per l for gas oil (kgCO2):	2.7667										
price of gas oil per l (p):	29.36	29.76	30.16	30.56	30.96	31.37	31.77	32.17	32.57	32.97	
Total savings (£m):	**1.46**	**1.48**	**2.23**	**2.26**	**2.66**	**2.70**	**2.91**	**2.95**	**3.09**	**3.13**	
discounted:	**1.46**	**1.43**	**2.08**	**2.04**	**2.32**	**2.27**	**2.37**	**2.32**	**2.34**	**2.30**	***20.93***

year	0	1	2	3	4	5	6	7	8	9	**Total**
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**savings**
inland waterways freight											
Overall emissions (tCO2):	**53,000**										
Emission levels (tCO2 mid-point 55%)	29,150	27,984	27,984	27,424	27,424	27,150	27,150	27,014	27,014	26,947	
Reduction rate	0.04	0	0.02	0	0.01	0	0.005	0	0.0025	0	
Emission reduction (tCO2):	**1,166**	**1,166**	**1,726**	**1,726**	**2,000**	**2,000**	**2,136**	**2,136**	**2,203**	**2,203**	
Value of emission reductions (£m):	**0.06**	**0.06**	**0.09**	**0.09**	**0.11**	**0.11**	**0.12**	**0.12**	**0.13**	**0.13**	
Value of diesel fuel savings (£m):	**0.12**	**0.13**	**0.19**	**0.19**	**0.22**	**0.23**	**0.25**	**0.25**	**0.26**	**0.26**	
energy associated with the reduced emissions (l):	421,441	421,441	623,732	623,732	722,855	722,855	771,921	771,921	796,331	796,331	
emissions per l (kgCO2):	2.7667										
price of gas oil per l (p):	29.36	29.76	30.16	30.56	30.96	31.37	31.77	32.17	32.57	32.97	
Total savings (£m):	**0.18**	**0.19**	**0.28**	**0.29**	**0.34**	**0.34**	**0.37**	**0.37**	**0.39**	**0.39**	
discounted:	**0.18**	**0.18**	**0.26**	**0.26**	**0.29**	**0.29**	**0.30**	**0.29**	**0.30**	**0.29**	***2.64***

costal shipping freight											
Overall emissions (tCO2):	**1,740,000**										
Emission levels (tCO2 mid-point 55%)	957,000	918,720	918,720	900,346	900,346	891,342	891,342	886,885	886,885	884,668	
Reduction rate	0.04	0	0.02	0	0.01	0	0.005	0	0.0025	0	
Emission reduction (tCO2):	**38,280**	**38,280**	**56,654**	**56,654**	**65,658**	**65,658**	**70,115**	**70,115**	**72,332**	**72,332**	
Value of emission reductions (£m):	**1.99**	**2.03**	**3.06**	**3.12**	**3.68**	**3.74**	**4.00**	**4.07**	**4.27**	**4.34**	
Value of diesel fuel savings (£m):	**4.06**	**4.12**	**6.18**	**6.26**	**7.35**	**7.44**	**8.05**	**8.15**	**8.51**	**8.62**	
energy associated with the reduced emissions (l):	13,835,978	13,835,978	20,477,247	20,477,247	23,731,469	23,731,469	25,342,309	25,342,309	26,143,702	26,143,702	
emissions per l (kgCO2):	2.7667										
price of gas oil per l (p):	29.36	29.76	30.16	30.56	30.96	31.37	31.77	32.17	32.57	32.97	
Total savings (£m):	**6.05**	**6.15**	**9.24**	**9.37**	**11.03**	**11.19**	**12.05**	**12.22**	**12.78**	**12.96**	
discounted:	**6.05**	**5.94**	**8.62**	**8.46**	**9.61**	**9.42**	**9.80**	**9.60**	**9.71**	**9.51**	***86.71***

year	0	1	2	3	4	5	6	7	8	9	**Total**
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**savings**
aviation freight											
Overall emissions (tCO2):	**55,000**										
Emission levels (tCO2 mid-point 55%)	30,250	29,040	29,040	28,459	28,459	28,175	28,175	28,034	28,034	27,964	
Reduction rate	0.04	0	0.02	0	0.01	0	0.005	0	0.0025	0	
Emission reduction (tCO2):	**1,210**	**1,210**	**1,791**	**1,791**	**2,075**	**2,075**	**2,216**	**2,216**	**2,286**	**2,286**	
Value of emission reductions (£m):	**0.06**	**0.03**	**0.04**	**0.04**	**0.05**	**0.05**	**0.05**	**0.05**	**0.06**	**0.06**	
Value of diesel fuel savings (£m):	**0.16**	**0.17**	**0.25**	**0.25**	**0.30**	**0.30**	**0.33**	**0.33**	**0.35**	**0.35**	
energy associated with the reduced emissions (l):	479,816	479,816	710,128	710,128	822,980	822,980	878,843	878,843	906,634	906,634	
emissions per l (kgCO2):	2.5218										
price of aviation fuel per l (p):	33.99	34.50	35.01	35.53	36.04	36.55	37.06	37.57	38.08	38.59	
Total savings (£m):	**0.23**	**0.19**	**0.29**	**0.29**	**0.34**	**0.35**	**0.38**	**0.38**	**0.40**	**0.41**	
discounted:	**0.23**	**0.19**	**0.27**	**0.26**	**0.30**	**0.30**	**0.31**	**0.30**	**0.31**	**0.30**	***2.76***

total (£m): ***113.04***

year	0	1	2	3	4	5	6	7	8	9	**Total**
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**savings**
health benefits from reduced diesel											
energy associated with the reduced emissions (l):	250,625,450	250,625,450	370,551,418	370,551,418	429,315,142	429,315,142	458,403,186	458,403,186	472,874,488	472,874,488	
health benefit per reduced litre in £	0.0595238	0.0595238	0.0595238	0.0595238	0.0595238	0.0595238	0.0595238	0.0595238	0.0595238	0.0595238	
Total savings (£m):	**14.92**	**14.92**	**22.06**	**22.06**	**25.55**	**25.55**	**27.29**	**27.29**	**28.15**	**28.15**	
discounted:	**14.92**	**14.41**	**20.59**	**19.89**	**22.27**	**21.52**	**22.20**	**21.45**	**21.38**	**20.65**	***199.27***

	0 **2011**	1 **2012**	2 **2013**	3 **2014**	4 **2015**	5 **2016**	6 **2017**	7 **2018**	8 **2019**	9 **2020**	**Total savings**
benefits from international reporting											
Global social cost of carbon per ton of carbon	£34.40	£35.43	£36.49	£37.59	£38.72	£39.88	£41.08	£42.31	£43.58	£44.88	
Estimated total emission level related to FTSE 350 firms (MtCO2)	891	873	873	864	864	860	860	858	858	857	
Reduction rate	0.02	0	0.01	0	0.005	0	0.0025	0	0.00125	0	
Emission reduction (MtCO2):	**18**	**18**	**27**	**27**	**31**	**31**	**33**	**33**	**34**	**34**	
Carbon content of reductions (in Mt)	**5**	**5**	**7**	**7**	**8**	**8**	**9**	**9**	**9**	**9**	
Value of emission reductions (£m):	**167.18**	**172.20**	**264.27**	**272.20**	**326.01**	**335.79**	**369.95**	**381.05**	**405.23**	**417.38**	
discounted:	**167.18**	**166.38**	**246.70**	**245.51**	**284.10**	**282.73**	**300.96**	**299.50**	**307.73**	**306.25**	***2,607.04***

THE COSTS AND BENEFITS OF MANDATORY GREENHOUSE GAS REPORTING JULY 2011

UK