The Economic Impact of Climate Change Adaptation/ Mitigation in the East Midlands: Stage 2: Sector Case Studies

Sector case studies prepared for *emda*

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CASE STUDY 1: TRANSPORT EQUIPMENT SECTOR

Introduction

The Manufacture of Transport Equipment is one of four “priority sectors” identified in the Regional Economic Strategy (RES) (emda, 2006). Economic growth in this sector was identified in Stage 1 of this study as one of the East Midland’s nine broader policy priorities. However, the sector is at risk from climate change, largely through UK and international legislation which seeks to limit the emissions of greenhouse gases (GHGs).

This case study assesses the ‘regulatory risk’ to the sector posed by polices and measures that aim to mitigate GHG emissions, and in doing so, internalise the cost of such emissions in business operations. Risks arise from a number of direct and indirect sources, including the consumption of energy (gas, oil, electricity from non-renewable sources) at manufacturing sites in the sector, and the carbon embodied in inputs to production manufactured in other sectors.

Mitigation policies likely to affect the Manufacture of Transport Equipment sector include:

- the EU Emissions Trading Scheme (EU ETS);
- the Climate Change Levy (CCL);
- the Carbon Reduction Commitment (CRC);
- the Climate Change Bill; and
- Voluntary agreements made as part of the UK Climate Change Programme.

EU Emissions Trading Scheme (EU ETS)

The EU ETS aims to reduce carbon dioxide (CO_2) emissions cost-effectively by facilitating the trading of allowances between installations covered by the scheme, such that allowances flow to their highest valued use. Combustion plants with an output of 20MW or more are covered by the scheme resulting in a number of sites in the sector being included – e.g. the Toyota and Rolls Royce factories in Derbyshire are both covered. Installations emitting more CO_2 during a compliance period than is covered by their allocation of allowances have to buy allowances from firms who have emitted less than their allocation, and who therefore have surplus allowances for sale. The EU ETS essentially places a price on the use of carbon, making the emission of a unit of CO_2 akin to the use of any other input to production. This, in turn, will increase production costs.

Since inception of the EU ETS the EU has revised its target for reducing greenhouse gas emissions. This target, endorsed by the March 2007 European Council, calls for a reduction in EU emissions of at least 20% by 2020 compared with 1990 levels, and by 30% provided that other industrialised countries commit to comparable efforts in the framework of a global agreement to combat climate change post-2012. Following the updated targets, proposals to amend the EU ETS have been put forward including:

- Introduction of an EU-wide cap on the number of emission allowances instead of 27 national caps.
- Auctioning a larger share of allowances instead of allocating them free of charge.
- Introduction of harmonised rules governing free allocation.
- Inclusion of a number of new industries (e.g. aluminum and ammonia producers) and two further gases (nitrous oxide and perfluorocarbons).

The European Commission proposed including aviation in the EU ETS from 2012 to pertain to all flights starting and landing in the EU and this was passed in the European Parliament. The inclusion of aviation in the EU ETS represents a risk, not only to aircraft operators but to the aerospace industry more widely.

Climate Change Levy (CCL)

The Climate Change Levy (CCL) is a levy on business use of non-renewable energy.

Discounts of up to 80% on the full rate of levy are available to energy-intensive industries that agree to energy efficiency or emission reduction targets (known as Climate Change Agreements (CCAs)). Revenue generated by the levy is returned to the non-domestic sector in the form of support for energy efficiency measures. The aim of the levy is to encourage users to improve energy efficiency and reduce emissions of greenhouse gases. The motor industry is covered by an umbrella CCA, which includes the Toyota Burnaston plant. The aerospace sector is also covered by an umbrella CCA, which includes three Rolls Royce facilities in Derbyshire.

The CCL only represents a significant material risk if the CCA targets are challenging enough to present the risk of non-compliance. However, the CCA targets are set at a level which means the majority of organisations can meet them through incremental efficiency require. The CCL can be avoided if firms use electricity generated from renewable sources of good quality CHP.

Carbon Reduction Commitment

The CRC is a mandatory cap and trade system that aims to reduce CO_2 emissions associated with electricity use in large non-energy intensive businesses and public sector organizations in the UK. The CRC was formerly known as the Energy Performance Commitment (EPC).

The CRC targets businesses that have annual electricity consumption from mandatory half hourly meters in excess of 6,000 megawatt-hours (MWh). This threshold is likely to include a number of transport equipment manufacturers in the East Midlands. Participants will be required to purchase sufficient allowances to cover their annual energy use CO2 emissions. They will monitor their emissions throughout the compliance period and, at the end of that period, surrender allowances corresponding to their annual energy use emissions. Emissions that are covered under CCAs and direct emissions included in the EU ETS will not be covered by CRC.

Climate Change Bill

The proposed Climate Change Bill in the UK will put into statute the UK's targets to reduce carbon dioxide emissions through domestic and international action by 60% (relative to 1990 levels) by 2050. In the medium term it proposes a target of a 26-32% reduction by 2020. The Bill proposes a system of carbon budgeting based on five year periods. The carbon budget will set a limit on emissions within a five year period. The Bill would place a legal duty on the Government to ensure that the UK meets its targets and stays within the limits of its carbon budgets. Whilst the Climate Change Bill is unlikely to directly affect the transport equipment sector, mandatory targets will strengthen the policy driver for greenhouse gas emissions reductions in the UK.

Voluntary Agreements – UK Climate Change Programme

The UK is committed to the European Commission's Voluntary Agreements with the automotive industry on new car fuel efficiency. They aim to improve the average fuel efficiency of new cars sold in the EU by 25 per cent by 2008-9 against a 1995 baseline. The target post 2008 will be 120 grams of carbon dioxide per kilometre traveled.

This case study presents an assessment of the likely changes in costs in the Transport Equipment sector as a result of climate change mitigation policies. The impact of internalising the cost of carbon is calculated in terms of changes in production costs and the profitability of the sector. An indication of the long run implications for the sector in the East Midlands is given. In addition, a qualitative review of sectoral responses to the regulatory risk has been undertaken and, where possible, mitigation measures that can be sourced from within the region identified.

Overview of Sector from RES

According to the Regional Economic Strategy (RES), in 2004 the Manufacture of Transport Equipment accounted for 3.5% of total output from the East Midlands. The sector also accounted for 1.9% of the region's total workforce, in terms of Full Time

Equivalent (FTE) employment. The corresponding location quotients for the same year are 1.9 (for output) and 1.4 (for employment). In other words, the share of total output and employment attributable to the Manufacture of Transport Equipment in the East Midlands is 1.9 and 1.4 times higher than for the UK as a whole. This sector is therefore more important to the economy of the East Midlands than it is to the economy of the UK.

Productivity in the sector, in terms of the value of output per FTE employee, is also about one-third higher than the UK average. Indeed, the Manufacture of Transport Equipment is the most productive sector in the East Midlands.

At the beginning of 2004 there were just over 30 large employers (with > 200 employees) in this sector in the region.

Under a business-as-usual scenario, the sector in the East Midlands is forecast to grow by close to 30% over the period 2004-14. In contrast, forecast growth for the sector in the UK is only about 8%. With implementation of the RES, the Manufacture of Transport Equipment is expected to grow by up to an additional 8 percentage points relative to business-as-usual. In contrast to output, employment in the sector is forecast to fall under a business-as-usual scenario, although by a smaller amount in the East Midlands than for the UK as a whole, where FTE employees is forecast to decline by close to 24%. Declines in employment in the sector in the East Midlands are lessened slightly assuming implementation of the RES.

Scope of Case Study

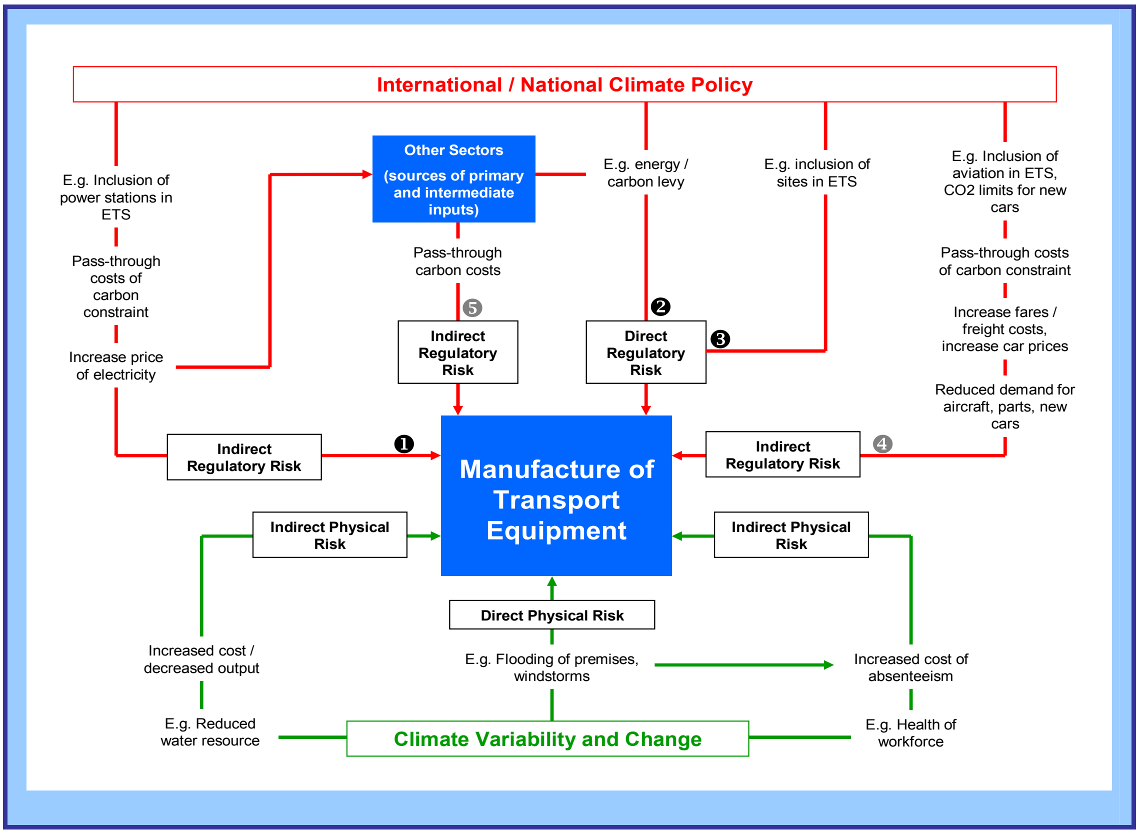
There are many ‘pathways’ through which climate variability and change, and international and national responses to climate change, may directly or indirectly affect on the Manufacture of Transport Equipment sector. Some of the key ‘physical risk’ (green arrows) and ‘regulatory risk’ (red arrows) pathways are highlighted in Figure 1. This case study is concerned solely with regulatory risks.

The regulatory risks potentially faced by enterprises in the sector derive specifically from:

- Direct (impact pathways ❷ and ❸) and indirect (impact pathway ❶) carbon emissions by the sector;
- The carbon content of intermediary products consumed by the sector to manufacture output (impact pathway ❺); and
- Carbon directly and indirectly emitted from the (upstream) use of output from the sector, either as an intermediary input to other manufacturing processes or final demand (impact pathway ❹).

Impact pathways numbered ❶ to ❸ and ❺ are treated quantitatively, whereas pathway ❹ is treated qualitatively. To analyse pathway 4 quantitatively would require a number of heroic assumptions to be made in order to attribute the impact of policy risks to the Manufacture of Transport Equipment sector in the East Midlands, thereby making the results highly uncertain.

Figure 1: Potential Climate Change-related Impact and Regulatory Risks to Manufacture of Transport Equipment Sector



The necessary economic data for the regulatory risk analysis is found at Annex A. The analysis is undertaken at a sub-sector level - for 'average' enterprises - and not with respect to specific enterprises (e.g. Rolls Royce, Toyota, etc.). Due to the availability of both appropriate business statistics and energy data, the analysis is performed at the level of following sub-sectors:

- Manufacture of motor vehicles, trailers and semi-trailers [NACE or SIC (2003) Subsection DM, Division 34].
- Manufacture of motor vehicles [NACE or SIC (2003) Subsection DM, Division 34, Group 34.1].
- Manufacture of other transport equipment [NACE or SIC (2003) Subsection DM, Division 35].
- Manufacture of aircraft and spacecraft [NACE or SIC (2003) Subsection DM, Division 35, Group 35.3].

To put the coverage of sub-sectors in context, the full set of sub-sectors falling under the Manufacture of Transport Equipment is shown in Box 1.

Box 1: Sub-sectors of the Manufacture of Transport Equipment

Subsection DM - Manufacture of Transport Equipment.

34 - Manufacture of motor vehicles, trailers and semi-trailers.

34.1 - Manufacture of motor vehicles.

34.2 - Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers.

34.3 - Manufacture of parts and accessories for motor vehicles and their engines.

35 - Manufacture of other transport equipment.

35.1 - Building and repairing of ships and boats.

35.2 - Manufacture of railway and tramway locomotives and rolling stock.

35.3 - Manufacture of aircraft and spacecraft.

35.4 - Manufacture of motorcycles and bicycles.

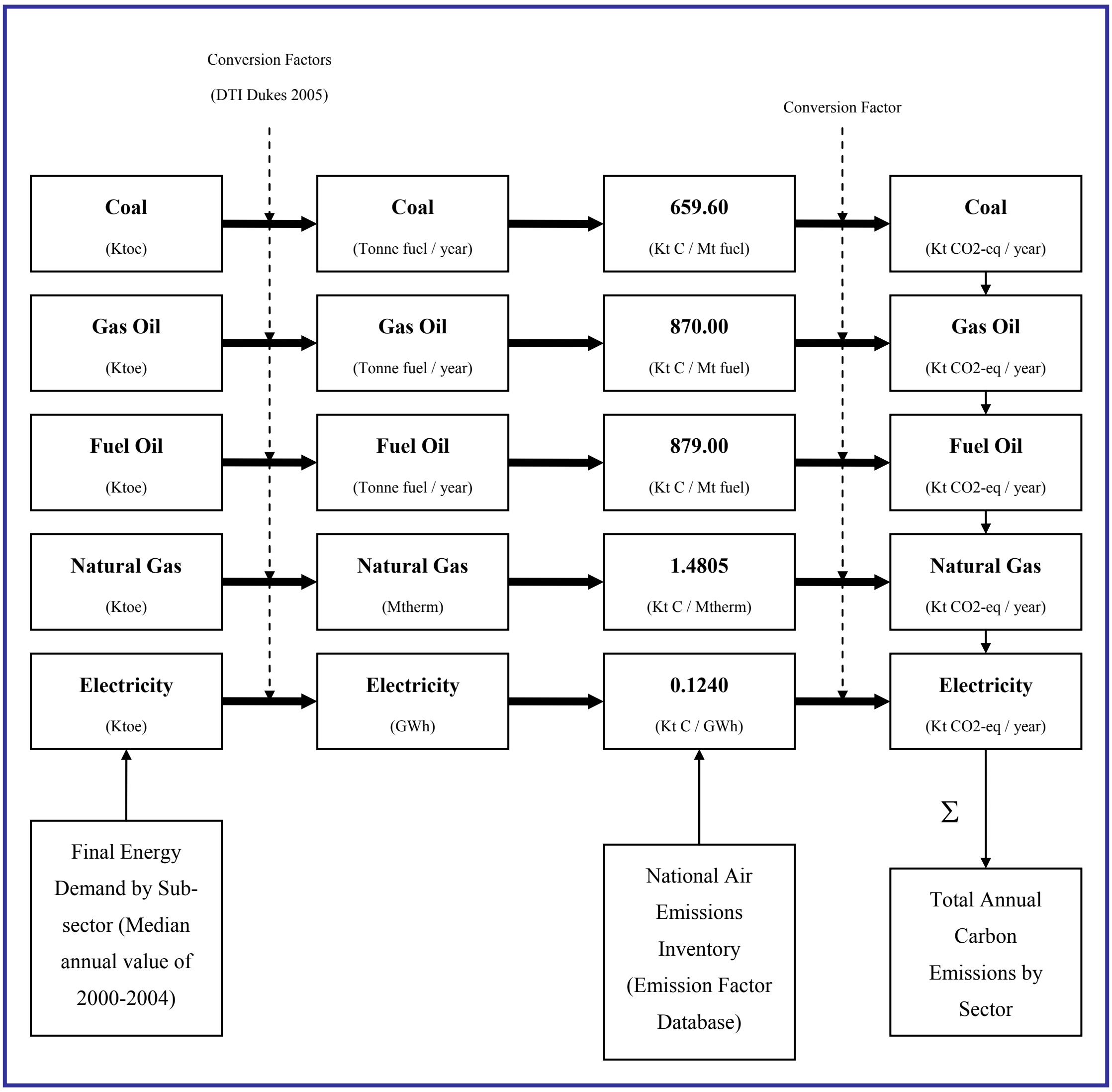
35.5 - Manufacture of other transport equipment not elsewhere classified.

Analysis of Regulatory Risks

Estimating Carbon Emissions from the Sector

The approach followed to quantify the carbon emitted directly (from the consumption of fossil fuels) and indirectly (from the consumption of electricity) by the sub-sectors under study is shown graphically in Figure 2. The necessary data is not collated at the regional level, so we first estimate annual emissions, by sub-sector, for the UK as a whole, and then normalise these estimates to the number of enterprises operating in each sub-sector. Annual emissions per 'average' enterprise are then scaled by the number of enterprises known to operate in each sub-sector in the East Midlands to derive annual regional emissions, by sub-sector.

Figure 2: Process of Calculating Annual Carbon Emissions by Sub-sector



Note: Data on final energy demand, by SIC (2003), was obtained from the Office of National Statistics

Estimated annual carbon emissions by sub-sector in the UK are shown in Table 1 below.

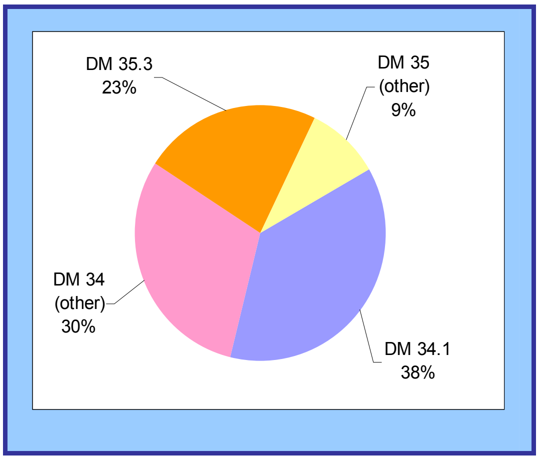
Figure 3 shows the relative shares of different subsectors to emissions.

Table 1: Annual Carbon Emissions by Sub Sector in UK (estimated)

NACE Division	Description	Annual Carbon Emissions (Kt CO_2-eq per year)[1]
Division 34	Manufacture of motor vehicles, trailers and semi-trailers	3,548
Division 34 Group 34.1	Manufacture of motor vehicles	1,957
Division 35	Manufacture of other transport equipment	1,715
Division 35 Group 35.3	Manufacture of aircraft and spacecraft	1,223
Total	Manufacture of Transport Equipment	5,263

[1] Note that 1 Mt = 1,000 Kt

Figure 3: Percentage of Total UK Annual Carbon Emissions from the Manufacture of Transport Equipment Attributable to Selected Sub-sectors (Based on median annual final energy demand over the period 2000-2004) (Total annual carbon emissions from DM = 5,263 Kt CO2-eq)



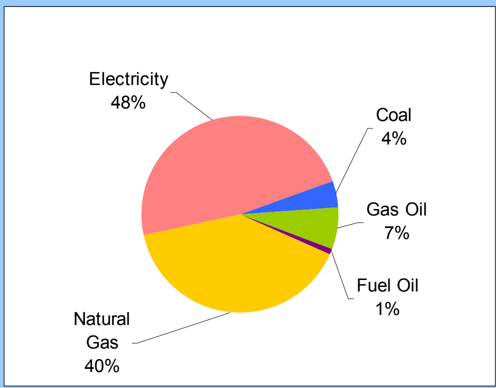
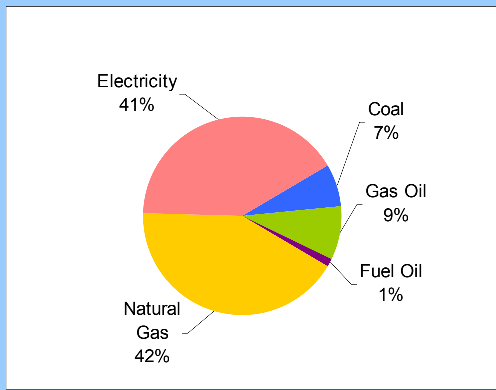
Source: Own calculations.

Looking at the attribution of carbon emissions to the different fuels used by each sub-sector, the use of natural gas contributes about 40% of total carbon emissions across all sub-sectors (see Figure 4 and Figure 5). Electricity use results in between about 40% (Manufacture of Motor Vehicles) and close to 55% (Manufacture of Aircraft and Spacecraft) of total carbon emissions. Despite less electricity (in energy terms) being consumed by the sub-sectors than natural gas, the higher carbon content per unit of electricity supplied vis-à-vis natural gas means that electricity has a greater share of total carbon emissions. The largest potential source of regulatory risk to the sub-sectors, and in particular the Manufacture of Aircraft and Spacecraft, is thus electricity use[2].

The use of coal and gas oil in Division 34 collectively accounts for between about 10% (Division as a whole) and 15% (Manufacture of Motor Vehicles) of total carbon emissions.

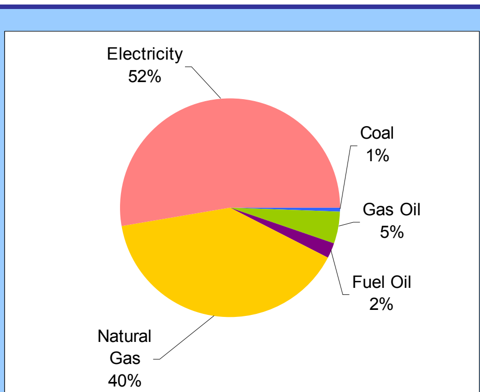
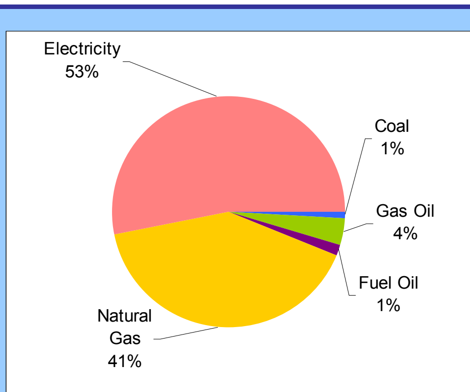
[2] However, it is not necessarily the case the reducing electricity use represents the most cost-effective way for the sectors to reduce carbon emissions.

Figure 4: Attribution of Total UK Annual Carbon Emissions to Fuels Used by Manufacture of Motor Vehicles, Trailers and Semi-trailers (Based on median annual final energy demand over the period 2000-2004)

(a) DM 34 (Median annual carbon emissions = 3,548 Kt CO2-eq)	(b) DM 34.1 (Median annual carbon emissions = 1,957 Kt CO2-eq)
	

Source: Own calculations.

Figure 5: Attribution of Total UK Annual Carbon Emissions to Fuels Used by Manufacture of Other Transport Equipment (Based on median annual final energy demand over the period 2000-2004)

(a) DM 35 (Median annual carbon emissions = 1,715 Kt CO2-eq)	(b) DM 35.3 (Median annual carbon emissions = 1,223 Kt CO2-eq)
	

Source: Own calculations.

Normalising the total carbon emission estimates for the UK to the total number of enterprises in each sub-sector, we derive the estimated emissions for an 'average' enterprise (Table 2). It should be noted that this is for an average enterprise working in the sector in the UK – hence the average for the East Midlands may be larger due to the concentration of large car plants in Group 34.1, but data availability does not allow for this to be adjusted.

Table 2:Emissions for an "average" enterprise

NACE Division	Description	Annual Carbon Emissions (Kt CO_2-eq per year)[3]
Division 34	Manufacture of motor vehicles, trailers and semi-trailers	1.2
Division 34 Group 34.1	Manufacture of motor vehicles	2.9
Division 35	Manufacture of other transport equipment	0.6
Division 35 Group 35.3	Manufacture of aircraft and spacecraft	1.8

Multiplying total carbon emissions by the 'average' enterprise in Division 34 and 35 by the number of enterprises operating each year, on average, in each Division in the East Midlands provides a measure of total annual carbon emissions from the Manufacture of Transport Equipment in the region; estimated at about 515 Kt CO_2-eq per year. Of this total, the Manufacture of Motor Vehicles, Trailers and Semi-trailers accounts for close to 70%, while the Manufacture of Other Transport Equipment accounts for nearly 30%.

[3] Note that 1 Mt = 1,000 Kt

In terms of estimated total UK carbon emissions of 5,623 Kt CO_2-eq per year from the Manufacture of Transport Equipment, the East Midlands contributes at least 10%.

Estimating the Economic Impact of the Risks

Assessing the economic impact of climate change-related regulatory risks is based on the analysis of a number of cost scenarios, in which various estimates of (a) the marginal external cost of carbon and (b) the marginal abatement cost of complying with EU policy goals, are assumed to be internalised in the price of energy used by the average enterprise in each sector. A simple economic model of the firm is used to evaluate the impact of the resulting increases in production costs on the financial performance of the 'average' enterprises.

Impact Pathways 1, 2 and 3

Regulatory risks from direct (impact pathways ❷ and ❸) and indirect (impact pathway ❶) carbon emissions

Table 3 presents the annual costs, by regulatory risk scenario, estimated to be incurred in the short-run by an 'average' enterprise in Division 34 and Division 34 Group 34.1. Table 4 provides the same information for Division 35 and Division 35 Group 34.3. Note that the figures in Table 3 and Table 4 essentially represent the maximum regulatory costs facing the 'average' enterprise, since we have not yet considered potential responses by enterprises. Regulatory Risk Scenario 4 (RRS 4) represents our "best guess" of the most plausible future cost of carbon emissions.

Over the period 2000-04 about 310 and 250 enterprises were active, on average, each year in Division 34 and Division 35, respectively. Using these figures and growth forecasts from the RES, we can scale the additional annual (regulatory) costs per 'average' enterprise given in Table 3 and Table 4 to approximate the total costs incurred by each sector in the East Midlands by 2020. The resulting estimates are shown in Table 5.

Table 3: Total Annual Regulatory Costs Incurred by 'Average' Enterprise in Manufacture of Motor Vehicles, Trailers and Semi-trailers (2005 £)

Scenario	**NACE DM 34: Manufacture of motor vehicles,**	**NACE DM 34.1: Manufacture of motor vehicles**
	£ 000 per year	£ 000 per year
Regulatory Risk Scenario 1	6	14
Regulatory Risk Scenario 2	9	23
Regulatory Risk Scenario 3	16	41
Regulatory Risk Scenario 4	30	75
Regulatory Risk Scenario 5	50	122
Regulatory Risk Scenario 6	69	171
	Annual Regulatory Cost as % of Production Costs	Annual Regulatory Cost as % of Production Costs
Regulatory Risk Scenario 1	0.05%	0.03%
Regulatory Risk Scenario 2	0.07%	0.05%
Regulatory Risk Scenario 3	0.13%	0.10%
Regulatory Risk Scenario 4	0.24%	0.18%
Regulatory Risk Scenario 5	0.39%	0.29%
Regulatory Risk Scenario 6	0.55%	0.41%
	Annual Regulatory Cost (£) per Employee	Annual Regulatory Cost (£) per Employee
Regulatory Risk Scenario 1	78	100
Regulatory Risk Scenario 2	124	159
Regulatory Risk Scenario 3	221	283
Regulatory Risk Scenario 4	406	520
Regulatory Risk Scenario 5	665	852
Regulatory Risk Scenario 6	926	1,187

Table 4: Total Annual Regulatory Costs Incurred by 'Average' Enterprise in Manufacture of Other Transport Equipment (2005 £)

Scenario	NACE DM 35: Manufacture of other transport	NACE DM 35.3: Manufacture of aircraft and
	£ 000 per year	£ 000 per year
Regulatory Risk Scenario 1	3	9
Regulatory Risk Scenario 2	4	14
Regulatory Risk Scenario 3	8	25
Regulatory Risk Scenario 4	15	47
Regulatory Risk Scenario 5	24	76
Regulatory Risk Scenario 6	33	107
	Annual Regulatory Cost as % of Production Costs	Annual Regulatory Cost as % of Production Costs
Regulatory Risk Scenario 1	0.06%	0.06%
Regulatory Risk Scenario 2	0.10%	0.10%
Regulatory Risk Scenario 3	0.18%	0.17%
Regulatory Risk Scenario 4	0.33%	0.32%
Regulatory Risk Scenario 5	0.54%	0.52%
Regulatory Risk Scenario 6	0.75%	0.73%
	Annual Regulatory Cost (£) per Employee	Annual Regulatory Cost (£) per Employee
Regulatory Risk Scenario 1	51	56
Regulatory Risk Scenario 2	81	89
Regulatory Risk Scenario 3	144	158
Regulatory Risk Scenario 4	266	290
Regulatory Risk Scenario 5	435	475
Regulatory Risk Scenario 6	606	662

Table 5: Total Annual Regulatory Costs Incurred by the Manufacture of Transport Equipment Sector in the East Midlands by 2020, by Regulatory Risk Scenario (£ million per year) (2005 £)

(a) Manufacture of Motor Vehicles, Trailers and Semi-trailers		(b) Manufacture of Other Transport Equipment	
Regulatory Risk Scenario 1	3.0	Regulatory Risk Scenario 1	1.1
Regulatory Risk Scenario 2	4.8	Regulatory Risk Scenario 2	1.8
Regulatory Risk Scenario 3	8.5	Regulatory Risk Scenario 3	3.2
Regulatory Risk Scenario 4	15.6	Regulatory Risk Scenario 4	5.9
Regulatory Risk Scenario 5	25.6	Regulatory Risk Scenario 5	9.6
Regulatory Risk Scenario 6	35.7	Regulatory Risk Scenario 6	13.4

Source: Own calculations.

Note: It is assumed that the annualised growth rates for the sector between 2004-2014, under the "RES on" scenario, are maintained until 2020.

The cost estimates given in Table 3 and Table 4 do not necessarily reflect the realised additional cost burden per 'average' enterprise, even before considering measures to reduce carbon emissions, since enterprises may be able to pass on the additional costs, either partially or in full, to customers (or suppliers) in the form of higher prices (or by negotiating lower prices for factor inputs). Figure 6 shows the impact on one indicator of enterprise output (annual turnover) and on indicator of enterprise profitability (annual gross profit) of passing through additional costs for Division 34[4].

Under the worst-case scenario (RRS 6) the turnover of an 'average' enterprise in Division 34 is predicted to decline by as much as £66,700 per year with 100% cost pass through, and by about £32,800 with 50% cost pass through (consider panel (a) in Figure 6). Under RRS 4, by way of contrast, the turnover of an average enterprise is predicted to decline by close to £28,800 and £14,400 per year with 100% and 50% cost pass

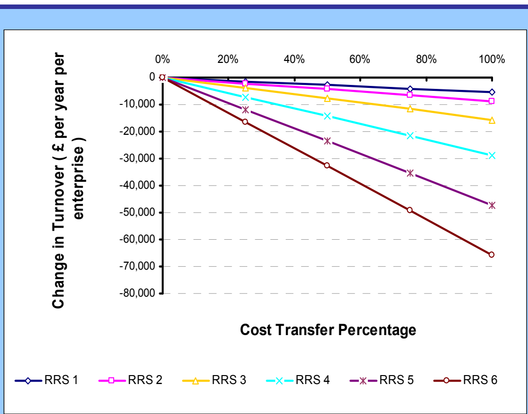
[4] Since we have no information to accurately identify the most likely cost-transfer percentage for each sector, we simply employ a range of cost-transfer assumptions; from 0% to 100%.

through, respectively.

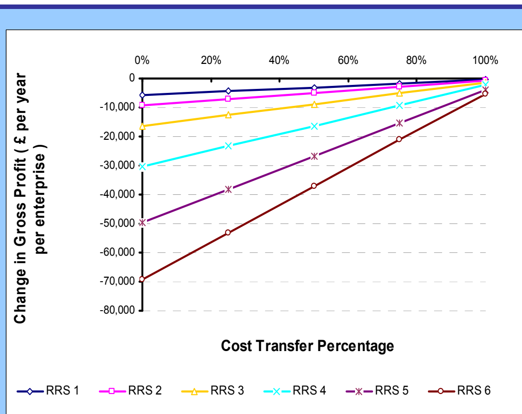
While turnover is unaffected if all of the additional annual costs are absorbed by the enterprise, profitability is reduced (as production costs increase by the full amount of the additional annual costs). Under RRS 4 the gross profit of an 'average' enterprise in Division 34 is estimated to decline by roughly £30,300 per year with no cost pass through, £16,300 with 50% cost pass through, and only £2,300 per year with 100% cost pass through (consider panel (b) in Figure 6). The impact of the regulatory risks on an 'average' enterprise are thus smaller the more the enterprise is able (and willing) to pass on additional costs to customers. Results for the other three sub-sectors are summarised in Figure 7 to Figure 9.

Figure 6: Impact of Absorbing Different Percentages of the Additional Annual Regulatory Risk Cost on an 'Average' Enterprise in Manufacture of Motor Vehicles, Trailers and Semi-trailers (Division 34) (2005 £)

(a) Change in Turnover (negative values indicate reduction in variable)



(b) Change in Gross Profit (negative values indicate reduction in variable)

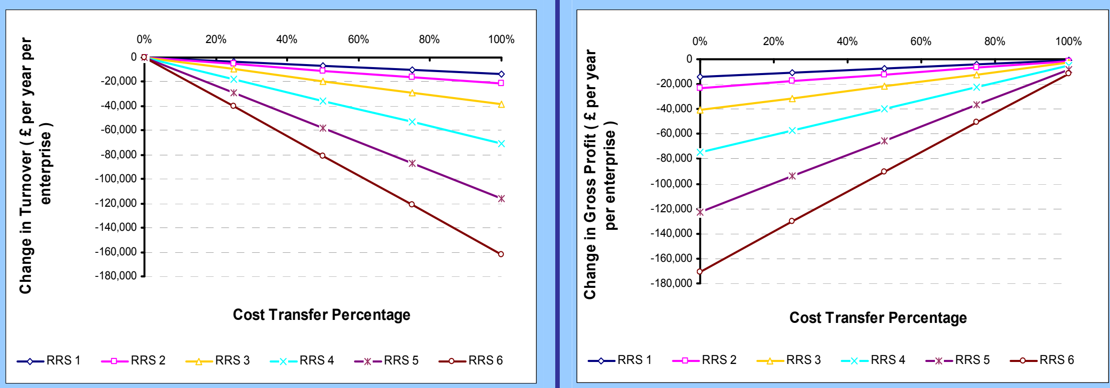


Source: Own calculations.

Note: RRS = Regulatory Risk Scenario.

Figure 7: Impact of Absorbing Different Percentages of the Additional Annual Regulatory Risk Cost on an 'Average' Enterprise in Manufacture of Motor Vehicles (Division 34 Group 34.1) (2005 £)

(a) Change in Turnover (negative values indicate reduction in variable)	(b) Change in Gross Profit (negative values indicate reduction in variable)



Source: Own calculations.

Note: RRS = Regulatory Risk Scenario.

Figure 8 and Figure 9, the impact on annual turnover appears smaller relative to the impact on gross annual profit for Division 35 and the Manufacture of Aircraft and Spacecraft[5]; this is because the assumed own price elasticity of demand applied in these sectors is about half that applied in Division 34 and the Manufacture of Motor Vehicles. Hence, the reduction in demand (and turnover) from passing the additional costs onto customers in the form of higher prices is relatively smaller for Division 35 and the Manufacture of Aircraft and Spacecraft.

In looking at our "best guess" risk scenario (RRS 4), the estimated reductions in gross profit, by sub-sector, are as shown in

Table 6. These are relatively modest increases in costs

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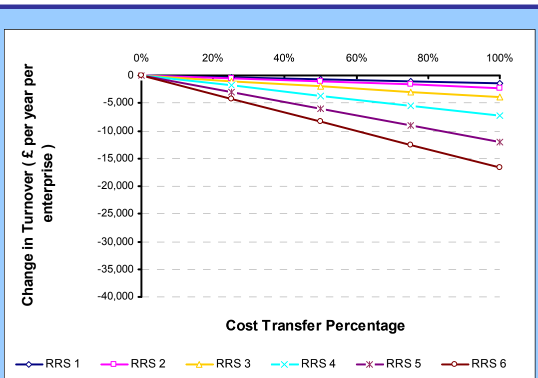
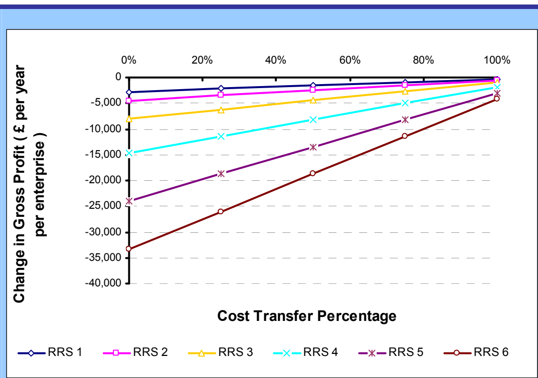
[5] NB panel (a) and panel (b) in Figure 6 and Figure 7 are nearly mirror images of each other, while the impacts shown in panel (b) in Figure 8 and Figure 9 appear to be about double the magnitude of those in panel (a) in both figures.

Table 6: Estimated Reductions in Gross Profits

NACE Division	Description	Reduction in Gross Profit	
		100% cost pass through	Zero cost pass through
Division 34	Manufacture of motor vehicles, trailers and semi-trailers	£2,300	£30,300
Division 34 Group 34.1	Manufacture of motor vehicles	£4,900	£74,700
Division 35	Manufacture of other transport equipment	£1,800	£14,600
Division 35 Group 35.3	Manufacture of aircraft and spacecraft	£6,600	£46,700

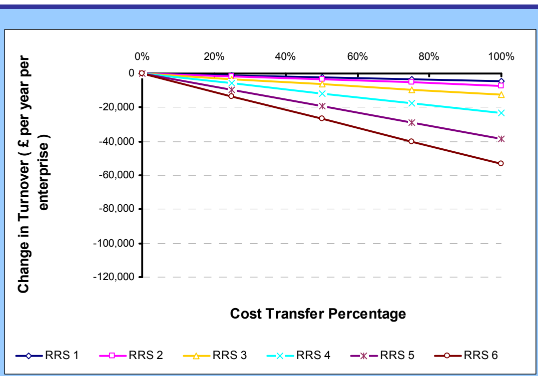
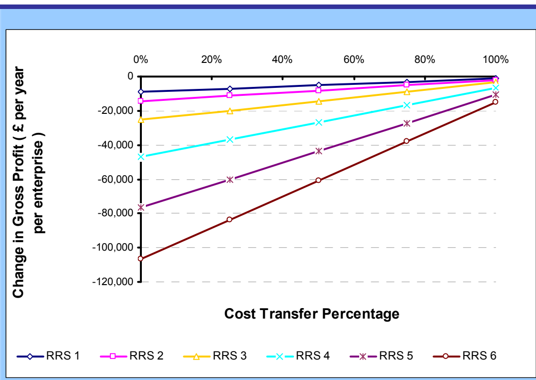
Figure 8: Impact of Absorbing Different Percentages of the Additional Annual Regulatory Risk Cost on an 'Average' Enterprise in Manufacture of Other Transport Equipment (Division 35) (2005 £)

(a) Change in Turnover (negative values indicate reduction in variable)	**(b) Change in Gross Profit (negative values indicate reduction in variable)**
	

Source: Own calculations.

Note: RRS = Regulatory Risk Scenario.

Figure 9: Impact of Absorbing Different Percentages of the Additional Annual Regulatory Risk Cost on an 'Average' Enterprise in Manufacture of Aircraft and Spacecraft (Division 35 Group 35.3) (2005 £)

(a) Change in Turnover (negative values indicate reduction in variable)	(b) Change in Gross Profit (negative values indicate reduction in variable)
	

Source: Own calculations.

Note: RRS = Regulatory Risk Scenario.

Due to a lack of data on the number of enterprises at Group-level in the East Midlands, we can only extrapolate the enterprise-level analysis summarised above to the regional level for Division 34 and Division 35. Estimated reductions in turnover and gross profit of the Manufacture of Motor Vehicles, Trailers and Semi-trailers sector in the East Midlands in 2020 are shown in Table 7. Similar estimates are provided for the Manufacture of Other Transport Equipment sector in Table 8. Note that the reductions in value shown in these tables arise solely from the consumption of energy by enterprises in each sub-sector; other 'pathways' will impact upon turnover and gross profit, as highlighted in Figure 1. We consider these other 'pathways' below.

Table 7: Direct Economic Impact of Total Annual Regulatory Costs Incurred by Enterprises in the Manufacture of Motor Vehicles, Trailers and Semi-trailers (Division 34) in the East Midlands, by 2020 (2005 £)

(a) RRS 1

Cost transfer percentage (%)	Change in Turnover (£ mn per year)	Change in Gross Profit (£ mn per year)
100.0%	- 2.8	- 0.2
75.0%	- 2.1	- 0.9
50.0%	- 1.4	- 1.6
25.0%	- 0.7	- 2.3
0.0%	-	- 3.0

(b) RRS 4

Cost transfer percentage (%)	Change in Turnover (£ mn per year)	Change in Gross Profit (£ mn per year)
100.0%	- 14.9	- 1.2
75.0%	- 11.2	- 4.8
50.0%	- 7.4	- 8.4
25.0%	- 3.7	- 12.0
0.0%	-	- 15.7

(c) RRS 6

Cost transfer percentage (%)	Change in Turnover (£ mn per year)	Change in Gross Profit (£ mn per year)
100.0%	- 34.0	- 2.7
75.0%	- 25.5	- 11.0
50.0%	- 17.0	- 19.2
25.0%	- 8.5	- 27.5
0.0%	-	- 35.7

Source: Own calculations.

Note: The estimates are prior to any responses taken by enterprises in the sub-sector to mitigate risks. The estimated changes in turnover and gross margin do not include indirect and induced effects on the region's economy. It is assumed that the annualised growth rates for the sector between 2004-2014, under the "RES on" scenario, are maintained until 2020.

Table 8: Direct Economic Impact of Total Annual Regulatory Costs Incurred by Enterprises in the Manufacture of Other Transport Equipment (Division 35) in the East Midlands, by 2020 (2005 £)

(a) RRS 1

Cost transfer percentage (%)	Change in Turnover (£ mn per year)	Change in Gross Profit (£ mn per year)
100.0%	- 0.6	- 0.1
75.0%	- 0.4	- 0.4
50.0%	- 0.3	- 0.7
25.0%	- 0.1	- 0.9
0.0%	-	- 1.2

(b) RRS 4

Cost transfer percentage (%)	Change in Turnover (£ mn per year)	Change in Gross Profit (£ mn per year)
100.0%	- 3.1	- 0.8
75.0%	- 2.3	- 2.1
50.0%	- 1.5	- 3.4
25.0%	- 0.8	- 4.8
0.0%	-	- 6.1

(c) RRS 6

Cost transfer percentage (%)	Change in Turnover (£ mn per year)	Change in Gross Profit (£ mn per year)
100.0%	- 7.0	- 1.7
75.0%	- 5.2	- 4.8
50.0%	- 3.5	- 7.9
25.0%	- 1.8	- 10.9
0.0%	-	- 14.0

Source: Own calculations.

Note: The estimates are prior to any responses taken by enterprises in the sub-sector to mitigate risks. The estimated changes in turnover and gross margin do not include indirect and induced effects on the region's economy. It is assumed that the annualised growth rates for the sector between 2004-2014, under the "RES on" scenario, are maintained until 2020.

Under our “best guess” risk scenario, by 2020:

- Gross margin of the Manufacture of Motor Vehicles, Trailers and Semi-trailers sector in the East Midlands is estimated to decline by between £1.2 (100% cost-pass through) and £15.7 million per year (0% cost-pass through) (panel (b) in Table 7).
- Gross margin of the Manufacture of Other Transport Equipment sector in the East Midlands is estimated to decline by between £0.8 (100% cost-pass through) and £6.1 million per year (0% cost-pass through) (panel (b) in Table 8).

Clearly, the estimated reductions in turnover and gross profit are considerably larger for Division 34 than for Division 35.

The latter two figures in the above bullet points represent the maximum possible reduction in gross margin under this risk scenario, since enterprises are assumed (a) to absorb all the additional costs and (b) to have taken no action to mitigate carbon emissions. In looking at the Manufacture of Transport Equipment as a whole in the East Midlands, gross profit could decline by up to £21.8 million per year by 2020. Turnover from the sector could decline by up to £18.0 million by 2020, if enterprises opted to minimise the regulatory cost burden and pass on the additional costs in full. In this case, gross profit of the sector in the East Midlands is estimated to reduce by about £2.0 million per year by 2020.

It is evident from the above analysis that the impact on sector profitability is minimised if the additional regulatory costs are fully passed on to customers. However, as output from the Manufacture of Transport Equipment sector in the East Midlands reduces, due to higher product prices, it will affect demand for output from their suppliers, and so on down the supply chain. These so-called ‘indirect effects’ on the wider economy are estimated using appropriate output multipliers[6]. By 2020, reductions in output from the Manufacture of Transport Equipment sector in the East Midlands are estimated to result in additional output declines in the wider economy of (assuming 100% cost pass through):

[6] Specifically, we used Sub-sector specific Type I output multipliers from the UK Input-Output Analytical Tables.

- Up to £2.9 million per year under RRS 1;
- Up to £15.4 million per year under RRS 4; and
- Up to £35.0 million per year under RRS 6.

The total direct and indirect effects on output of climate change-related regulatory risks associated with energy use by the Manufacture of Transport Equipment sector in the East Midlands, thus range from about £6.3 million per year (under RRS 1) to about £76.0 million per year (under RRS 6); with a "best guess" (under RRS 4) at about £33.4 million per year[7].

Reducing Risk Exposure

The above analysis of climate change-related regulatory risks assumes that GHG emissions associated with energy consumption per unit of output by the Manufacturing of Transport Equipment sector will not change over time; in effect, we assume a fixed baseline with respect to energy-intensity. However, enterprises in the sector will, more than likely, undertake action to reduce GHG emissions, thus reducing their exposure to regulatory risks. For example, Toyota's 4th Environmental Action Plan includes a target to reduce total annual CO_2 emissions to 1.7 million tonnes or less; Rolls-Royce's 2005 Environmental Statement 2005 includes a target to reduce the amount of energy consumed by 9% by the end of 2006, relative to 2003 levels; Ford have cut the CO_2 emissions from plants and facilities by 15 percent relative to 2000 levels, and have targeted even further reductions from the vehicle manufacturing process; and the Advisory Council of Aeronautical Research in Europe (ACARE) have set themselves a voluntary target to cut CO_2 emissions per passenger-kilometre for new aircraft by 50% by 2020. It is not possible within the scope of this case study to evaluate the (planned or implemented) mitigation strategies of individual enterprises in the East Midlands, since we would need to collate information on both the cost and effectiveness of specific actions (or combinations of actions) that may be used by enterprises to: (a) improve energy efficiency at installations; and/or (b) reduce the carbon intensity of fuel inputs.

[7] Recall that we have assumed that enterprises in the sector opt to minimise the regulatory cost burden and therefore fully pass on additional costs to customers.

Nonetheless, we can provide an indication of the maximum benefits (in terms of regulatory costs avoided) for the region. If projected baseline carbon emissions associated with fuel use by the Manufacture of Motor Vehicles, Trailers and Semi-trailers sector in the East Midlands were to decrease by, say, 30% or 50%, the estimated costs of regulatory risks under RRS 4 would fall by £4.7 and £7.8 million per year by 2020, respectively (see panel (a) in Figure 10). Similar reductions by the Manufacture of Other Transport Equipment sector would reduce the estimated costs of regulatory risks under RRS 4 by £1.8 and £3.1 million per year by 2020.

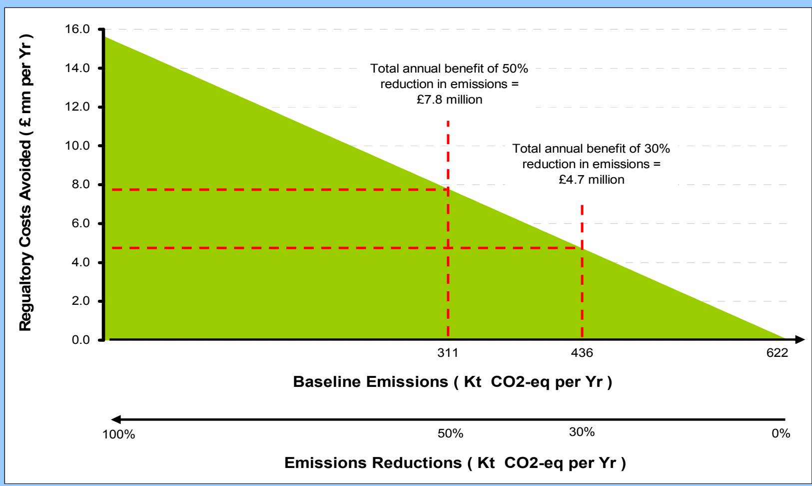
To put these reductions in context, if enterprises were to source an additional 25% and 50% of their electricity from zero-carbon sources, relative to the current situation:

- The estimated costs of regulatory risks faced by the Manufacture of Motor Vehicles, Trailers and Semi-trailers sector in the East Midlands by 2020 under RRS 4 would fall by £1.9 and £3.8 million per year, respectively.
- The estimated costs of regulatory risks faced by the Manufacture of Other Transport Equipment sector in the East Midlands by 2020 under RRS 4 would fall by £0.8 and £1.6 million per year, respectively.

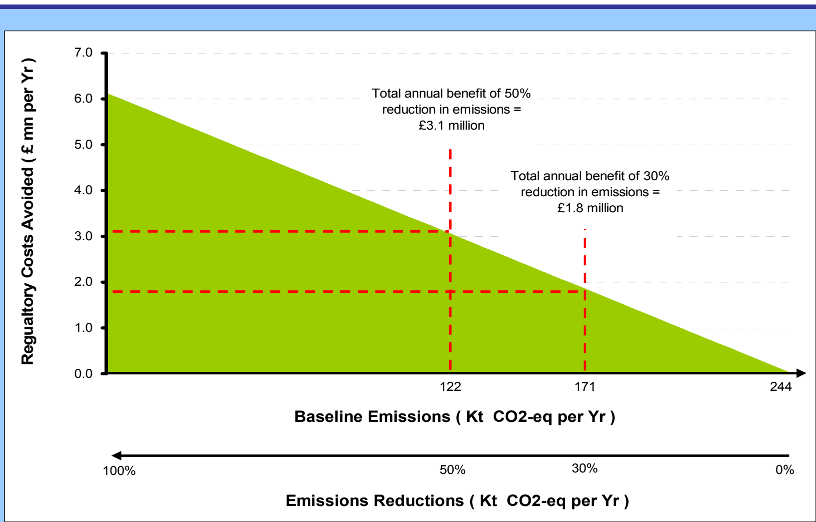
In total, across both sub-sectors, sourcing 25% and 50% of electricity from zero-carbon sources would save, respectively, about 106.3 and 212.7 Kt CO_2-eq per year by 2020. Of course, from the point of few of an enterprise in the sector, these avoided costs (benefits) should be compared with the financial costs of realising the carbon emission reductions, to see whether action is justified on private cost-benefit grounds.

Figure 10: Regulatory Risks from Impact Pathways ❶-❸ Avoided by Enterprises in the Manufacture of Transport Equipment Sector in the East Midlands by 2020, from Reducing Energy-related Carbon Emissions (RRS 4 only)

(a) Manufacture of Motor Vehicles, Trailers and Semi-trailers



(b) Manufacture of Other Transport Equipment



Impact Pathways 4 and 5

Impact Pathway ❹: Qualitative Assessment of Indirect Regulatory Risk via carbon directly and indirectly emitted from the (upstream) use of output from the sector

Impact pathway ❹ – as illustrated in Figure 1 – is essentially concerned with climate change-related regulations that affect demand for products from the Manufacture of Transport Equipment sector. If policy measures to reduce GHG emissions raise, for example, the cost (price) of air travel, this will reduce passenger and freight demand. This, in turn, may affect demand for goods (planes, engines, etc.) and services (maintenance) supplied / supported by the Manufacture of Aircraft and Spacecraft sector.

For aviation the most significant forthcoming climate change-related regulatory risk facing the sector is probably plans by the European Commission (EC) to include aviation in the EU ETS (COM (2005) 459 Final: Reducing the Climate Change Impact of Aviation). The EC recommends that aircraft operators should be the "responsible entities" (i.e. the agents responsible for complying with obligations under the EU ETS), since they have the most direct control over the type of aircraft in operation and the way in which they are flown, and therefore fuel use and carbon emissions. This means that a significant customer of the Manufacture of Aircraft and Spacecraft sector will be facing higher production costs as a result of the carbon price signal created by the EU ETS[8].

Assuming an allowance price of €30 per t CO_2-eq (about £22 in 2005 prices) and a scheme that covers all flights departing from the EU[9], by 2020 revenue tonne-kilometres (a measure of aircraft operator's profitability) are estimated to decrease by 1.7% for domestic flights, 1.9% for flights between Member States, and 1.5% for flights to and from countries outside the EU relative to business as usual levels (EC Impact

[8] Flights by State aircraft (e.g. defence) are excluded from the scheme in the current proposal.

[9] Other proposed options for the geographical coverage of the scheme include (a) intra-EU flights only and (b) all flights arriving at, and all flights departing from, EU airports.

Assessment, COM (2006) 818 Final SEC (2006) 1685)[10]. However, price discrimination is applied in the aviation sector. As a result, airfares for business class passengers would be expected to increase by more than airfares for economy class passengers, since the price elasticity for the former group is less than that for the latter group. As a result, the actual reduction in demand for air travel should be lower than the predicted reduction in demand. Overall, these modelled reductions in demand seem fairly modest. Inclusion of aviation in the EU ETS – at least under the central design scenario modelled by the EC – thus looks unlikely to result in significant up-stream impacts on the Manufacture of Aircraft and Spacecraft sector, in terms of reduced demand for goods and services from the sector.

In contrast, inclusion of aviation in the EU ETS may present opportunities for the Manufacture of Aircraft and Spacecraft sector, as well as manufacturers of other transport modes that compete within air travel. The EC's Impact Assessment predicts that overall transport demand will decrease by 0.1% by 2020 as a result of the inclusion of aviation in the EU ETS (assuming an allowance price of €30 per t CO_2-eq). But, about 14% of the reduction in air travel is predicted to be picked up by other modes; train and coach passenger demand is forecast to increase by 0.3% and 0.1%, respectively. This may have a small knock-on benefit for suppliers of goods and services to train and coach operators in the EU.

In responding to the carbon price signal provided by EU ETS, aircraft operators have a range of operational (short to medium-term) and strategic (medium to long-term) actions that they could take to mitigate increased regulatory costs. Strategic actions relate to how the fleet is managed (e.g. maintenance schedules), investments to make the fleet more fuel efficient (e.g. up-grading engines, retrofitting winglets) and the purchase of new aircraft (newer aircraft are more fuel efficient than older generations). The EU ETS will increase operating costs due to fuel burn, thus making the case for the purchase of newer aircraft more persuasive. These strategic actions in response to the price signals of the EU ETS will create opportunities for the Manufacture of Aircraft and Spacecraft sector.

[10] Business as usual revenue tonne-kilometres are estimated to be 138% above 2005 levels by 2020.

Another proposed piece of Community legislation – to improve the fuel efficiency of light-duty road vehicles (passenger cars and light commercial vehicles) such that the average emission value of 120 g CO_2 per km for newly sold is achieved by 2012 – creates climate change-related regulatory risk for the Manufacture of Motor Vehicles sub-sector (COM (2007) 19: Renewed Community Strategy to Reduce CO_2 from Light Vehicles). Based on an assessment of options, an integrated approach, combining supply-side (e.g. technical options to reduce fuel consumption in passenger cars and light-duty vehicles, application of fuel efficient air conditioning systems, increased use of bio-fuels) and demand-side (e.g. CO_2 taxation schemes for passenger cars, options for improved consumer information, such as CO_2 labelling) measures is most cost-effective (EC Impact Assessment, COM (2007) 19 Final SEC (2007) 61). According to the Commission's analysis, the proposal will actually lead to an increase in vehicles sales in the EU-25 of between 0.1% and 0.3% by 2020, compared to baseline sale levels, although this masks the fact that decreased sales of diesel cars are offset by increased sales of petrol cars. Car prices are expected to rise by, on average, just over £800 (assuming full pass through of costs, and including taxes and supplier margins); however, these higher purchase prices can be offset by the significant savings in operating costs, especially if future fuel prices are high. The risks to the car industry thus seem to be relatively small, although the risks to specific vehicle segments and locations will vary according to the CO_2 / fuel efficiency of the vehicle, and where it is manufactured.

Impact Pathway ❺: Regulatory costs associated with the carbon content of intermediary products consumed by the sector to manufacture output

To produce a unit of output (e.g. an aircraft engine or a motor vehicle) primary and intermediary inputs are required. The production and distribution of these inputs will also generate GHG emissions, and their use by enterprises in the Manufacturing of Transport Equipment sector will therefore also carry an (indirect) regulatory risk to the extent that all GHG emissions are covered by regulatory measures (as illustrated by impact pathway ❺ in Figure 1). Using the UK Input-Output Analytical Tables we have generated indicative values for the regulatory risks arising through impact pathway ❺, for direct and indirect CO_2-eq emissions associated with energy use only. Additional costs are calculated only for our "best guess" risk scenario (RRS 4). The estimates reported below will overstate the true costs of the regulatory risks transmitted through impact pathway ❺, since it is assumed that: (a) 100% of additional costs are passed on to customers along supply chains; and (b) these customers do not take action to reduce exposure to the additional costs (e.g. reduce demand / switch to lower carbon-intensity inputs). Bearing these caveats in mind, the (maximum) cost of regulatory risks associated with the carbon content of all inputs to an 'average' enterprise in each Division are (2005 £):

- Manufacture of Motor Vehicles, Trailers and Semi-trailers = £0.05 million per year, or 0.4% of total baseline production costs (under RSS 4).
- Manufacture of Other Transport Equipment = £0.01 million per year, or 0.2% of total baseline production costs (under RSS 4).

Comparison of regulatory costs of direct (impact pathways ❷ and ❸) and indirect (impact pathway ❶) carbon emissions by the sector and those associated with the carbon content of intermediary products (impact pathway ❺)

The total carbon content of all primary and intermediary inputs required to make a unit of final demand from the Manufacture of Motor Vehicles, Trailers and Semi-trailers is considerably higher than the total carbon content of all inputs required to make a unit of final demand from the Manufacture of Other Transport Equipment. Insufficient data is available to generate estimates for Groups within the Divisions. To put these indirect costs in context, the total regulatory cost per enterprise in Division 34 arising through impact pathways ❶-❸ is £0.03 million per year; for Division 35 it is £0.01 million per enterprise per year. This shows that these costs are potentially quite significant in terms of overall regulatory costs, but still the costs are small in comparison to the gross operating surplus of an average enterprise.

Aggregating over all enterprises in each Division in the East Midlands we find that by 2020 under:

- The maximum cost of the regulatory risks transmitted through impact pathway ❺ is £27.5 million per year for the Manufacture of Motor Vehicles, Trailers and Semi-trailers, which makes the total regulatory cost arising through impact pathways ❶-❸ & ❺ equal to £43.2 million per year (under RSS 4).

- The maximum cost of regulatory risks transmitted through impact pathway ❺ is £5.8 million per year for the Manufacture of Other Transport Equipment, which makes the total regulatory cost arising through impact pathways ❶-❸ & ❺ equal to £12.0 million per year (under RSS 4).

Considering the total regulatory cost arising through impact pathways ❶-❸ & ❺, by 2020 under our "best guess" risk scenario:

- Gross margin of the Manufacture of Motor Vehicles, Trailers and Semi-trailers sector in the East Midlands is estimated to decline by between £3.3 (100% cost-pass through) and £43.2 million per year (0% cost-pass through).
- Gross margin of the Manufacture of Other Transport Equipment sector in the East Midlands is estimated to decline by between £1.5 (100% cost-pass through) and £12.0 million per year (0% cost-pass through).

Recall that the latter two figures in the above bullet points represent the maximum possible reduction in gross margin under this risk scenario.

As noted above, enterprises can minimise the regulatory cost burden (minimise the impact on gross margin) by passing on the additional costs to customers. However, this adversely affects output. If the 'average' enterprise in each Division passed on 100% of the additional costs to customers:

- Output from the Manufacture of Motor Vehicles, Trailers and Semi-trailers in the East Midlands is estimated to decline by £41.0 million per year by 2020 (under RSS 4).
- Output from the Manufacture of Other Transport Equipment in the East Midlands is estimated to decline by £6.0 million per year by 2020 (under RSS 4).

By 2020, these reductions in output from the Manufacture of Transport Equipment sector as a whole in the East Midlands are estimated to result in additional output declines (indirect effects) in the wider economy of £40.6 million per year. The maximum total direct and indirect effects on output from the Manufacture of Transport

Equipment sector in the East Midlands, arising through impact pathways ❶-❸ & ❺, is thus about £87.6 million per year.

Conclusions

Summary of Economic Analysis

Regulatory Risks for Manufacture of Transport Equipment

The Manufacture of Transport Equipment is identified in the RES as one of four priority sectors likely to make the greatest contribution to the East Midlands' economy over the lifetime of the RES.

The climate change-related regulatory risks faced by enterprises in this sector derive specifically from:

- Direct and indirect carbon emissions by the sector;
- The carbon content of intermediary products consumed by the sector to manufacture output; and
- Carbon directly and indirectly emitted from the (upstream) use of output from the sector, either as an intermediary input to other manufacturing processes or final demand.

Carbon emissions

Total annual carbon emissions from the Manufacture of Transport Equipment in the East Midlands are estimated at about 515 Kt CO_2-eq per year. Of this total, the Manufacture of Motor Vehicles, Trailers and Semi-trailers accounts for close to 70%, while the Manufacture of Other Transport Equipment accounts for nearly 30%. An average enterprise in the Manufacture of Motor Vehicles produces over twice as much carbon emissions (2.9 Kt CO_2-eq per enterprise per year) than an average enterprise in the Division (1.2 Kt CO_2-eq per enterprise per year), and nearly 60% more per year than an average enterprise in the Manufacture of Aircraft and Spacecraft (1.8 Kt CO_2-eq per enterprise per year).

The consumption of natural gas contributes about 40% of total carbon emissions across all sub-sectors; electricity use contributes between about 40% (in the Manufacture of Motor Vehicles) and close to 55% (in the Manufacture of Aircraft and Spacecraft) of total carbon emissions.

Estimated Regulatory Risk Costs

The total additional annual (regulatory risk) costs (in terms of £ 000 per year) facing an 'average' enterprise in the Manufacture of Aircraft and Spacecraft sector is over three times that incurred by an 'average' enterprise in the Division, but about 60% less than those estimated to be incurred by an 'average' enterprise in the Manufacture of Motor Vehicles. For example, under our "best guess" scenario, an 'average' enterprise in the Manufacture of Aircraft and Spacecraft incurs additional costs of about £45,000 per year (equivalent to £520 per person employed), as opposed to £75,000 per year (equivalent to £290 per person employed) in the Manufacture of Motor Vehicles. These costs are relatively modest compared to gross operating surpluses.

Based on the forecast growth rates in the RES, in the East Midlands by 2020:

- The Manufacture of Motor Vehicles, Trailers and Semi-trailers is estimated to incur additional annual (regulatory) costs, before taking any kind of action, of £3.0 to £35.7 million per year (the range of values reflects the full range of regulatory risk scenarios considered); £15.6 million per year under our "best guess" scenario (6.6% of average annual gross operating surpluses in 2000-04).
- The Manufacture of Other Transport Equipment is estimated to potentially incur additional annual (regulatory) costs, before taking any kind of action, of £1.1 to £13.4 million per year; £5.9 million under our "best guess" scenario (1.5% of average annual gross operating surpluses in 2000-04).

In looking at the Manufacture of Transport Equipment as a whole in the East Midlands, these additional regulatory costs could reduce gross profit by up to £21.8 million per year by 2020 (3.4% of average annual gross operating surpluses in 2000-04). This represent the maximum possible reduction in gross margin under our "best guess" risk scenario, since enterprises are assumed (a) to absorb all the additional costs and (b) to have taken no action to mitigate carbon emissions. If enterprises are able to pass on the additional costs in full, gross profit of the sector in the region is estimated to reduce by only £2.0 million per year by 2020; although turnover will fall by about £18.0 million. A reduction in output of this magnitude will lead to additional output declines (indirect effects) in the wider economy of £15.4 million per year by 2020.

The maximum regulatory cost arising from the consumption of intermediary inputs (which have embodied carbon) by an 'average' enterprise in the Manufacture of Motor Vehicles, Trailers and Semi-trailers sector is £0.05 million per year; for the Manufacture of Other Transport Equipment sector it is £0.01 million per enterprise per year. Clearly, there is considerably more carbon embodied in inputs to the Manufacture of Motor Vehicles, Trailers and Semi-trailers, than to the Manufacture of Other Transport Equipment.

In looking at the Manufacture of Transport Equipment as a whole in the East Midlands, the maximum cost of the regulatory risks arising from both direct and indirect carbon emissions from the sector, and the consumption of inputs with embodied carbon, is about £55.1 million per year by 2020 under our "best guess" risk scenario (or 8.6% of average annual gross operating surpluses in 2000-04). By maximum, we mean before enterprises take any action. In this case, gross profit of the sector would reduce by an equivalent amount. However, if enterprises passed on the additional costs in full to customers – in an effort to minimise the cost burden - gross profit of the sector would reduce by only £4.8 million per year by 2020. However, output would fall by about £47.0 million per year. This fall in output would, in turn, lead to further declines in output across the wider economy of about £40.6 million per year by 2020.

Potential Reductions in Regulatory Risks from Zero Carbon Electricity

Enterprises can significantly reduce their exposure to regulatory risks by sourcing more electricity from low or zero carbon sources. If enterprises in the Manufacture of Transport Equipment sector in the East Midlands were to source an additional 25% and 50% of their electricity from zero-carbon sources, relative to the current situation, the estimated costs of regulatory risks under our "best guess" risk scenario would fall by £2.7 and £5.4 million per year by 2020, respectively. This would save about 106.3 (25%

zero-carbon electricity) and 212.7 (50% zero-carbon electricity) Kt CO_2-eq per year. Of course, the regulatory risk costs avoided need be compared with the financial costs of realising the carbon emission reductions, to see whether action is justified on private cost-benefit grounds.

This is a significant finding for the sector and the region. It is important that an increase in renewable energy generating capacity in the region is supported in order to reduce the impact of mitigation policy on manufacturing and reduce the region's greenhouse gas emissions.

Aviation and the ETS

Inclusion of aviation in the EU ETS – at least under the central design scenario modelled by the EC – looks unlikely to result in significant, adverse up-stream impacts on the Manufacture of Aircraft and Spacecraft sector, in terms of reduced demand for goods and services provided from the sector. In contrast, inclusion of aviation in the EU ETS may present opportunities for the sector, as well as manufacturers of other transport modes that compete within air travel. In responding to the carbon price signal provided by EU ETS, aircraft operators have a range of operational and strategic actions that they could take to mitigate increased regulatory costs. These strategic actions, which include investment in up-grades or newer aircraft, are likely to create opportunities for enterprises in the sector.

Emission Reduction Targets for Light Duty Road Vehicles

Another proposed piece of Community legislation – to achieve an average emission value of 120 g CO_2 per km for newly sold light-duty road vehicles by 2012 – may give rise to climate change-related regulatory risks for the Manufacture of Motor Vehicles-sector, although this will depend on the CO_2 / fuel efficiency of the vehicles currently manufactured in the region, and mix between petrol and diesel vehicles.

Policy Implications

Primarily, mitigation policy represents a risk to the growth of the Manufacture of Transport Equipment sector in the East Midlands, due to an increase in the cost of energy. This may alter the relative competitiveness of the East Midlands, for example compared with enterprises located outside the EU. The significance of this will partly depend on demand and the ability and willingness of enterprises to pass through additional costs.

In general, the additional costs are modest compared to gross margins of firms in this sector. In addition, the benefits of operating in the East Midlands (e.g. trained labour force) mean the consequences on industrial location are not likely to be that significant. However, cost savings can be made with appropriate mitigation actions.

Risks from climate mitigation are likely to be small compared to the wider issues facing the sector. Changes in demand for vehicles arising from the current global financial crisis are likely to be more significant than changes due to environmental related drivers, such as taste or economic incentives for smaller vehicles. The sector is increasingly facing challenges – so although climate related risks are relatively small, the additional stress may be the proverbial straw that breaks the camel's back. Thus, care should be taken to provide support for businesses facing cost burdens associated with mitigation policy.

The actual outcome will depend strongly on mitigation measures employed by enterprises, by upstream suppliers and by energy producers. Measures include improvements in energy efficiency and a reduction in the GHG intensity of fuel inputs for example by generating or purchasing electricity from renewable sources. Enterprises can significantly reduce their exposure to regulatory risks by sourcing more electricity from low or zero carbon sources. This is a significant finding for the sector and the region. It is important that an increase in renewable energy generating capacity in the region is supported in order to reduce the impact of mitigation policy on manufacturing and reduce the region's greenhouse gas emissions.

There are also potential opportunities for the sector, for example in relation to aviation fuel efficiencies. Opportunities may also be realised by being an early mover –

maximising gains under the EU ETS or the CCL and more generally through competitive advantage.

Significant uncertainties remain regarding policy targets and the costs of carbon and it will be prudent for emda to maintain a watching brief on these, along with emerging mitigation measures.

A number of initial recommendations can be drawn for emda to consider:

- Research into the ability and likelihood of companies passing on additional costs and the relationship with net effects on the regional economy.
- Facilitation of the generation of electricity from renewable sources – both at enterprise level and more widely. This could take a number of forms, including advocacy and awareness raising or potentially funding support.
- Working with high demand energy users to resolve energy infrastructure and supply issues to mitigate against risks to industrial development;
- Development of a mitigation measures toolkit to help enterprises consider how to reduce GHG emissions and how much this may cost.

Emda's support in climate change mitigation for this sector will also help achieve other Priority Actions set out in the RES including:

- Providing Business Support on Resource Efficiency
- Reducing the Demand for Energy and Resources
- Utilising Renewable Energy Technologies
- Exploiting Low Carbon Technologies.

Annex A – Basis Data

Table 9 presents summary business statistics for Division 34 and Division 34 Group 34.1. Note that:

- The data is for the UK; data is only available for a limited set of variables for the East Midlands.
- The data are median annual values over the period 2000-04. Rather than working with the most recent data, we decided to work with an average over a number of years in case the most recent year was unrepresentative of sector activity.

In order to facilitate analysis for the East Midlands, the business statistics in Table 9 are first normalised to the number of enterprises shown in row 1; the resulting statistics per enterprise are shown in Table 10. The statistics in Table 10 can be viewed as pertaining to the 'average' enterprise in the sector. The analysis of regulatory risks outlined below is conducted for this 'average' enterprise.

To generate impact costs for the East Midlands, the enterprise-level results are subsequently aggregated over the number of enterprises operating in the sector in the region. Over the period 2000-04 about 310 and 250 enterprises were active, on average, each year in Division 34 and Division 35, respectively. No data are available at the Group level. It is therefore only possible to generate aggregate results for the East Midlands at the level of the Division – i.e. for the Manufacture of Motor Vehicles, Trailers and Semi-trailers and for the Manufacture of Other Transport Equipment.

In adopting this approach we assume that the 'average' enterprise in Division 34 and Division 34 Group 34.1 in the UK has identical economic performance characteristics to the 'average' enterprise in the East Midlands. Furthermore, by working with the 'average' enterprise we ignore the possibility that economic performance may vary markedly with enterprise size across a sub-sector. Thus, while our results relate to the 'average' enterprise, they may not accurately reflect outcomes for very small enterprises or very large enterprises. While we can obtain the necessary business statistics for enterprises of different sizes, the matching energy data is not available. We are therefore restricted to working with the average enterprise.

Table 9: Business Statistics for the Manufacture of Motor Vehicles, Trailers and Semi-trailers (2005 £) (Median annual values over the period 2000-2004)

Variable	Unit	NACE DM 34: Manufacture of motor vehicles, trailers and semi-trailers	NACE DM 34.1: Manufacture of motor vehicles
Number of enterprises	number	2,948	659
Turnover or gross premiums written	£ million	46,566	32,585
Production value	£ million	39,103	25,730
Gross margin on goods for resale	£ million	2,567	2,435
Value added at factor cost	£ million	8,844	4,289
Gross operating surplus	£ million	2,257	991
Total purchases of goods and services	£ million	37,356	27,581
Personnel costs	£ million	6,587	3,298
Number of persons employed	number	220,111	94,708
Gross value added per person employed (apparent labour productivity)	£ 000 per employee	40	45
Personnel cost per employee (unit labour cost)	£ 000 per employee	30	35
Gross operating surplus/turnover (gross operating rate) (%)	%	4.8%	3.0%

Source: Eurostat, Structural Business Statistics Database (Industry, Construction, Trade and Services), Annual Enterprise Statistics.

As Table 10 shows, the ‘average’ enterprise in Group 34.1 is considerably larger than the ‘average’ enterprise in the Division as a whole; employing close to 145 workers in contrast to 75 workers. Turnover is also significantly higher, at about £50 million per year as opposed to about £15 million per year. However, gross operating surplus per employee is nearly the same in both sectors at roughly £10,500 per employee per year.

Table 11 presents summary business statistics for Division 35 and Division 35 Group 35.3. The economic performance of the ‘average’ enterprise in each of these two sectors is shown in Table 12. Again, the ‘average’ enterprise in the Group is larger than the ‘average’ enterprise in the Division as a whole; employing nearly 3 times the number of workers per enterprise. Gross operating surplus per employee in the Group 35.3 is close to £37,300 per employee per year, about £10,000 higher than in the Division as a whole.

Considering the gross operating rate, the Manufacture of Other Transport Equipment (and in particular, the Manufacture of Aircraft and Spacecraft) is considerably more profitable than the Manufacture of Motor Vehicles, Trailers and Semi-trailers.

Table 10: Average Business Statistics for Enterprise in Manufacture of Motor Vehicles, Trailers and Semi-trailers (2005 £) (Median annual values per enterprise over the period 2000-2004)

Variable	Unit	NACE DM 34: Manufacture of motor vehicles, trailers and semi-trailers	NACE DM 34.1: Manufacture of motor vehicles
Turnover or gross premiums written	£ mn per enterprise	15.8	49.4
Production value	£ mn per enterprise	13.3	39.0
Gross margin on goods for resale	£ mn per enterprise	0.9	3.7
Value added at factor cost	£ mn per enterprise	3.0	6.5
Gross operating surplus	£ mn per enterprise	0.8	1.5
Total purchases of goods and services	£ mn per enterprise	12.7	41.9
Personnel costs	£ mn per enterprise	2.2	5.0
Number of persons employed	number per enterprise	75	144

Source: Own calculations.

Table 11: Business Statistics for the Manufacture of Other Transport Equipment (2005 £) (Median annual values over the period 2000-2004)

Variable	Unit	NACE DM 35: Manufacture of other transport equipment	NACE DM 35.3: Manufacture of aircraft and spacecraft
Number of enterprises	number	2,707	716
Turnover or gross premiums written	£ million	23,651	18,087
Production value	£ million	22,511	17,216
Gross margin on goods for resale	£ million	126	89
Value added at factor cost	£ million	9,951	8,053
Gross operating surplus	£ million	4,367	3,982
Total purchases of goods and services	£ million	13,160	9,603
Personnel costs	£ million	5,584	4,071
Number of persons employed	number	162,432	106,117
Gross value added per person employed (apparent labour productivity)	£ 000 per employee	61	76
Personnel cost per employee (unit labour cost)	£ 000 per employee	34	38
Gross operating surplus/turnover (gross operating rate) (%)	%	18.5%	22.0%

Source: Eurostat, Structural Business Statistics Database (Industry, Construction, Trade and Services), Annual Enterprise Statistics.

Table 12: Average Business Statistics for Enterprise in Manufacture of Other Transport Equipment (2005 £) (Median annual values per enterprise over the period 2000-2004)

Variable	Unit	NACE DM 35: Manufacture of other transport equipment	NACE DM 35.3: Manufacture of aircraft and spacecraft
Turnover or gross premiums written	£ mn per enterprise	8.0	27.4
Production value	£ mn per enterprise	7.6	26.1
Gross margin on goods for resale	£ mn per enterprise	0.0	0.1
Value added at factor cost	£ mn per enterprise	3.4	12.2
Gross operating surplus	£ mn per enterprise	1.5	6.0
Total purchases of goods and services	£ mn per enterprise	4.5	14.6
Personnel costs	£ mn per enterprise	1.9	6.2
Number of persons employed	number per enterprise	55	161

Source: Own calculations.

CASE STUDY 2: HEALTH SECTOR

Introduction

Healthcare is one of the four key sectors identified in the Regional Economic Strategy (RES) as priorities for economic growth (emda 2006). It was identified in Phase 1 of this study as a key sector which may be subject to direct and indirect regulatory risk related to energy use and associated GHG emissions at manufacturing sites & NHS Estates.

The East Midlands is home to a number of well known companies manufacturing pharmaceuticals, medical instruments and equipment. The Region also has a number of significant hospitals and other health care services.

The impact of climate change on the healthcare sector will be primarily felt through changes in UK and international legislation. This case study assesses the mitigation risk posed to the sector in the East Midlands by polices that aim to internalise the cost of carbon. Direct risks are related to fossil fuel energy use and greenhouse gas (GHG) emissions at manufacturing sites and National Health Service (NHS) estates. In addition, an indirect risk relates to use of electricity (generated from non-renewable sources). Mitigation policies likely to affect the Healthcare sector include:

- EU emissions trading scheme (EU ETS);
- Climate Change Levy (CCL);
- NHS energy efficiency targets.

EU Emissions Trading Scheme

The EU ETS aims to reduce emissions cost-effectively by facilitating the trading of allowances between installations, such that allowances flow to their highest valued use. Combustion plants with an output of 20 mega watts (MW) or more are covered by the scheme, resulting in a number of Healthcare sites in the Region being included. Rises in electricity prices as a result of the EU ETS may indirectly affect all energy intensive sectors of the healthcare industry. Installations emitting more CO_2 than is covered by their allocation have to buy permits from firms who have emitted less than their allowance. The EU ETS thus represents an economic risk for large emitters that are unwilling or unable to reduce their CO_2 emissions but presents an opportunity to those that can.

The proposed expansion of the ETS to include nitrous oxide and perfluorocarbons (PFCs) from 2013 may increase the risk to the healthcare sector. Both PFCs and nitrous oxide are greenhouse gases with a global warming potential many times greater than carbon dioxide. Nitrous oxide is used in the healthcare sector as a general anesthetic and PFCs are used in eye surgery, medical imaging and the manufacture of artificial blood.

Climate Change Levy

The CCL is a levy on business use of non-renewable energy. Discounts of up to 80% are available to energy intensive industries that enter into energy efficiency or emission reduction targets (known as Climate Change Agreements (CCA)). Revenue generated by the levy is returned to the non-domestic sector in the form of support for energy efficiency measures. The aim of the levy is to encourage users to improve energy efficiency and reduce emissions of greenhouse gases. The chemical industry, which includes pharmaceutical manufacturing, is covered by an umbrella CCA. The CCL only represents a significant material risk if the CCA targets are challenging enough to present the risk of non-compliance. However, the CCA targets are set at a level which means the majority of organisations can meet them through incremental efficiency require. For most businesses in the healthcare sector, the CCA targets can be met through improvements in energy efficiency and the increase in energy costs is limited to 20% of the full CCL amount. The CCL can be avoided if firms use electricity generated from renewable sources of good quality CHP.

NHS Energy Efficiency Targets

The NHS is a significant consumer of energy, accounting for around 1% of England's annual energy demand. The Minister of State for Health has set mandatory energy efficiency targets for all NHS trusts:

- Reduce levels of primary energy consumption by 15% or 0.15 million tones carbon emissions from a base year of March 2000 to March 2010;
- Achieve 35-55 Gj/100 m^3 energy efficiency performance in all new capital developments, major redevelopments or refurbishments and existing facilities.

This case study presents a quantitative estimate of the impacts associated with policies which aim to internalize the cost of carbon. An assessment of the change in production costs and profitability of the sector is presented along with an indication of the long term implications for the regional economy. A qualitative assessment of responses to climate change mitigation risks in the healthcare sector is presented and market opportunities are discussed.

Overview of Sector from RES

According to the RES, in 2004 the Chemicals, Electrical and Optical Equipment and Health Care Sectors accounted for, respectively, 2.0%, 1.7% and 6.9% of total output from the East Midlands[11]. These sectors also accounted for, respectively, 1.1%, 1.5% and 9.7% of the region's total workforce, in terms of Full Time Equivalent (FTE) employment. The corresponding location quotients for the same year are:

- Chemicals – 1.1 (for output) and 1.3 (for employment);
- Electrical and Optical Equipment – 0.9 (for output) and 1.0 (for employment); and
- Health Care - 1.0 (for output) and 1.1 (for employment).

In other words, for example, the share of total output and total employment attributable

[11] In the RES the "Health Sector" was defined to include the provision of Health Care, as well as the Manufacture of Medical Instruments and Equipment and Pharmaceuticals. However, due to difficulties with disaggregating data, the Manufacture of Electrical and Optical Equipment (SIC(2003) Sub-section DL) was used as a proxy for the Manufacture of Medical Instruments and Equipment. The 2003 Annual Business Inquiry suggests that the Manufacture of Medical Instruments and Equipment accounts for about 7.5% of the Manufacture of Electrical and Optical Equipment. For the same reason, the Manufacture of Chemicals and Chemical Products (SIC(2003) Sub-section DG 24) was used as a proxy for the Manufacture of Pharmaceuticals. The Manufacture of Pharmaceuticals accounts for 17% of the Manufacture of Chemicals and Chemical Products. Note that this definition excludes health care service sectors.

to the Manufacture of Chemicals in the East Midlands is, respectively, 1.1 and 1.3 times higher than for the UK as a whole. In 2004 the Health Sector, as defined in the RES, collectively accounted for around 7.5% of the East Midland's output and around 10% of total FTE employment; making it one of the largest sectors in the region. Location quotients show that the sector as a whole is just as important to the East Midlands economy as the national economy; Chemicals is relatively more important in the region than nationally.

Productivity in the Health Sector, in terms of the value of output per FTE employee, is about 10% less than the UK average. The sector thus has a small productivity disadvantage.

At the beginning of 2004 there were just over 70 large employers (with > 200 employees) in the Health Sector in the region.

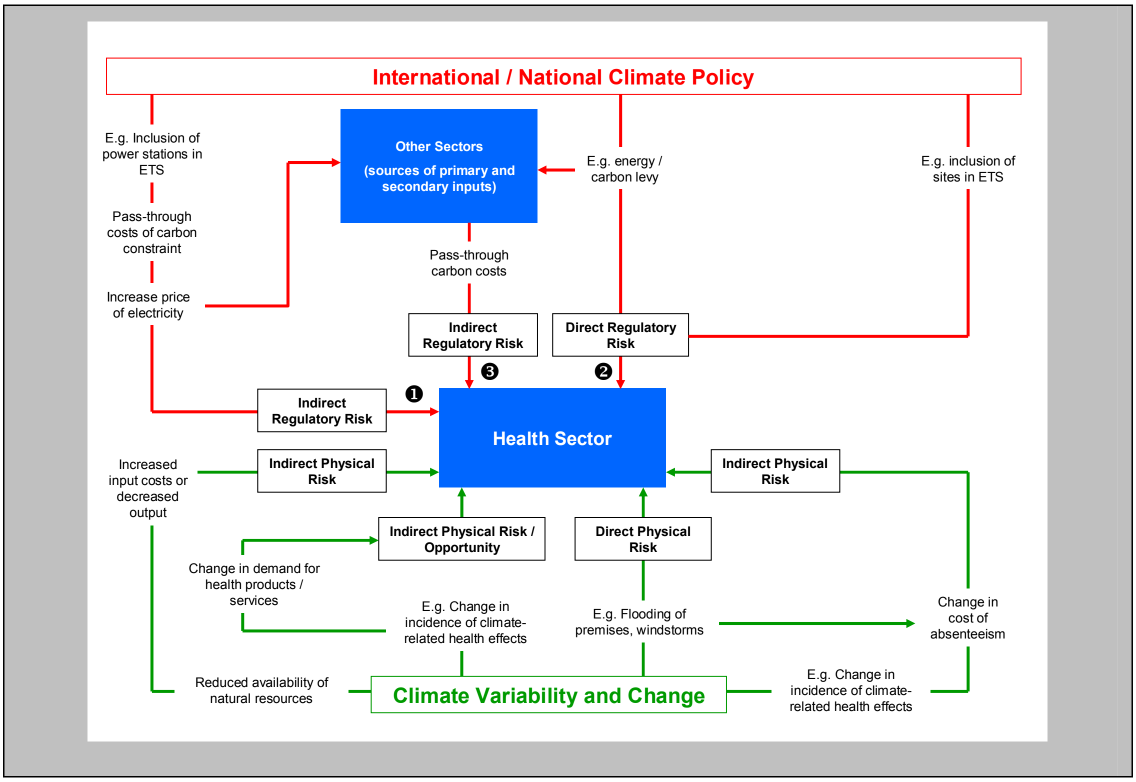
Under a business-as-usual scenario, the Health Sector in the East Midlands, as a whole, is forecast to grow by close to 47% over the period 2004-14. In contrast, forecast growth for the sector in the UK is about 42%. With implementation of the RES, the Health Sector is expected to grow by up to an additional 1-2 percentage points relative to business-as-usual.

Projected growth in employment for the Health Sector is between about 16% (implementation of the RES) and 18% (business-as-usual scenario) in the East Midlands during the forecast period (compared to about 13% for the UK). This equates to between an additional 25,500 and 29,000 FTEs. The Health Sector is the only sector where FTE employment is expected to be lower with implementation of the RES. Increased productivity in this sector is less likely to result in a more competitive sector, which is more able to compete in export markets thereby increasing market share and employment. Health care services are less likely to be exported, so that productivity gains in this sector will tend to lead to job losses.

Scope of Case Study

There are many 'pathways' through which climate variability and change, and international and national responses to climate change, may directly or indirectly affect on the Health Sector. Some of the key 'physical risk' (green arrows) and 'regulatory risk' (red arrows) pathways are highlighted in Figure 1[12]. This case study is concerned solely with regulatory risks.

Figure 11: Potential Climate Change-related Impact and Regulatory Risks to Health Sector



The regulatory risks[13] potentially faced by enterprises / institutions in the sector derive mainly from:

- Direct (impact pathway ❷) and indirect (impact pathway ❶) carbon emissions by the sector; and
- The carbon content of intermediary products consumed by the sector to manufacture output (impact pathway ❸).

All impact pathways (❶ to ❸) are treated quantitatively.

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[12] The distinction between these two categories of risk is explained in the Methodology Section..

[13] A regulatory risk is defined as the risk associated with the potential for laws related to a given industry or country to change and impact relevant investments (after ww.investorwords.com).

In order to reflect the different operating objectives of the private sector / public sector elements of the Health Sector, as defined in the RES, regulatory risks faced by the former element (the manufacture of medical instruments and equipment and pharmaceuticals) are quantified separately from those faced by the latter element (health care services).

The necessary economic data for analysis of the regulatory risks faced by the private sector element of the Health Sector is found at Annex A. The analysis is undertaken at a sub-sector level - for 'average' enterprises - and not with respect to specific enterprises. Due to the availability of both appropriate business statistics and energy data, the analysis is performed at the level of following sub-sectors:

- Manufacture of Pharmaceuticals, Medicinal Chemicals and Botanical Products [NACE or SIC(2003) Sub-section DG, Division 24, Group 4]. This includes the Manufacture of Basic Pharmaceutical Products (DG 24.41) and the Manufacture of Pharmaceutical Preparations (DG 24.42).
- Manufacture of Medical and Surgical Equipment and Orthopaedic Appliances [NACE or SIC(2003) Sub-section DL, Division 33, Group 1].

Note that these are more precise definitions of the manufacture of medical instruments and equipment and pharmaceuticals than used in the RES and do not include supply chain businesses outside these definitions.

Concerning health care services, we simply quantify the regulatory risks faced by the East Midlands Strategic Health Authority.

Analysis of Regulatory Risks – Private Sector Element of "Health Sector"

Estimating Carbon Emissions

The approach used to quantify the carbon emitted directly (from the consumption of fossil fuels) and indirectly (from the consumption of electricity) by the sub-sectors under study was described in detail in Case Study 1 and is not repeated here.

The estimated total annual carbon emissions for an 'average' enterprise in each sub-sector is:

- DG 24.4 = 4.6 Kt CO_2-eq per year; and
- DL 33.1 = 0.1 Kt CO_2-eq per year.

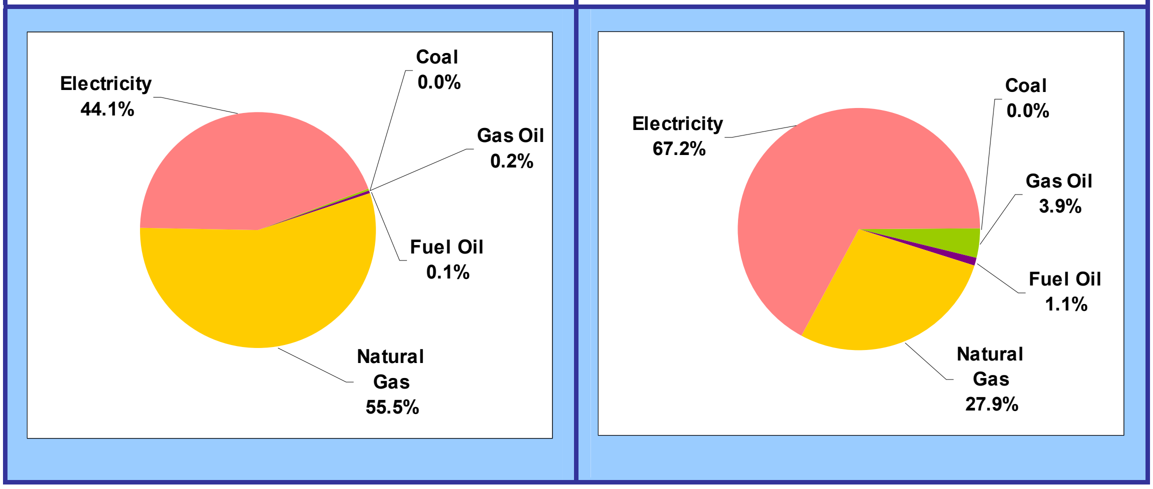
An average enterprise in DG 24.4 produces nearly 40 times as much carbon emissions than an average enterprise in DL 33.1. This reflects both differences in the scale of production of these sectors and also differences in the energy-intensity of productive processes.

Figure 2 shows the attribution of carbon emissions to the different fuels used by an average enterprise in each sub-sector, the use of natural gas plus electricity contribute over 90% total carbon emissions across both sub-sectors. The figure shows that electricity is most significant for carbon emissions in DL 33.1 and natural gas is most significant for carbon emissions for DG24.4.

The largest potential source of regulatory risk faced by enterprises in DG 24.4 and DL 33.1 arising through pathways ❶ and ❷ is thus consumption of natural gas and electricity, respectively.

Figure 12: Attribution of Total Annual Carbon Emissions to Fuels Used by Sub-sector (Based on median annual final energy demand over the period 2000-2004)

(a) DG 24.4 (Median total annual carbon emissions = 4.6 Kt CO_2-eq per enterprise)	(b) DL 33.1 (Median annual carbon emissions = 0.4 Kt CO_2-eq per enterprise)



Source: Own calculations.

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Multiplying total carbon emissions by the 'average' enterprise in DG 24.4 and DL 33.1 by the number of enterprises operating each year, on average, in each sub-sector in the East Midlands provides a measure of total annual carbon emissions in the region; estimated at about 260 Kt CO_2-eq per year. Of this total, DG 24.4 accounts for about 98%, while DL 33.1 accounts for only about 2%[14]. In terms of estimated total UK carbon emissions from these sub-sectors, the East Midlands contributes about 11%.

Estimating the Economic Impact of the Risks

Assessing the economic impact of climate change-related regulatory risks is based on the analysis of a number of cost scenarios, in which various estimates of (a) the marginal external cost of carbon and (b) the marginal abatement cost of complying with EU policy goals, are assumed to be internalised in the price of energy used by the average enterprise in each sub-sector. A simple economic model of the firm is used to evaluate the impact of the resulting increases in production costs on the financial performance of the 'average' enterprises.

Impact Pathways 1 and 2

Table 3 presents the annual costs, by regulatory risk scenario, estimated to be incurred in the short-run by an 'average' enterprise in Division 34 and Division 34 Group 34.1. Note that the figures in Table 3 essentially represent the maximum regulatory costs facing the 'average' enterprise, since we have not yet considered potential responses by enterprises. Note that Regulatory Risk Scenario 4 (RRS 4) represents our "best guess" of the most plausible future cost of carbon emissions.

Over the period 2000-04 roughly 55 and 45 enterprises were active, on average, each year in DG 24.4 and DL 33.1, respectively[15]. Using these figures and growth forecasts from the RES, we can scale the additional annual (regulatory) costs per 'average' enterprise given in Table 3 to approximate the total costs incurred by each sub-sector in the East Midlands by 2020. The resulting estimates are shown in Table 5.

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[14] For DG24.4, total emissions of 253 are derived from the sum of 55 enterprises with unit emissions of 4.6 Kt CO_2-eq per year. For DG33.1, total emissions of 4.5 are derived from the sum of 45 enterprises with unit emissions of 0.1 Kt CO_2-eq per year.

[15] EUROSTAT/ONS regional average data for the East Midlands was used over the period 2000-04.

Table 13: Total Annual Regulatory Costs Incurred by 'Average' Enterprise in Each Sub-sector (2005 £)

Scenario	**NACE DG 24.4: Manufacture of pharmaceuticals, medicinal chemicals and botanical products**	**NACE DL33.1: Manufacture of medical and surgical equipment and orthopaedic appliances**
	£ 000 per year	£ 000 per year
Regulatory Risk Scenario 1	23	1
Regulatory Risk Scenario 2	36	1
Regulatory Risk Scenario 3	64	2
Regulatory Risk Scenario 4	118	3
Regulatory Risk Scenario 5	193	5
Regulatory Risk Scenario 6	269	7
	Annual Regulatory Cost as % of Production Costs	Annual Regulatory Cost as % of Production Costs
Regulatory Risk Scenario 1	0.12%	0.00%
Regulatory Risk Scenario 2	0.19%	0.00%
Regulatory Risk Scenario 3	0.33%	0.01%
Regulatory Risk Scenario 4	0.61%	0.02%
Regulatory Risk Scenario 5	1.00%	0.03%
Regulatory Risk Scenario 6	1.39%	0.04%
	Annual Regulatory Cost (£) per Employee	Annual Regulatory Cost (£) per Employee
Regulatory Risk Scenario 1	149	4
Regulatory Risk Scenario 2	238	6
Regulatory Risk Scenario 3	423	11
Regulatory Risk Scenario 4	778	20
Regulatory Risk Scenario 5	1,274	32
Regulatory Risk Scenario 6	1,775	45

Table 14: Total Annual Regulatory Costs Incurred by Each Sub-sector in the East Midlands by 2020, by Regulatory Risk Scenario (£ million per year) (2005 £)

(a) NACE DG 24.4: Manufacture of pharmaceuticals, medicinal chemicals and botanical products		(b) NACE DL33.1: Manufacture of medical and surgical equipment and orthopaedic appliances	
Regulatory Risk Scenario 1	2.3	Regulatory Risk Scenario 1	0.1
Regulatory Risk Scenario 2	3.7	Regulatory Risk Scenario 2	0.1
Regulatory Risk Scenario 3	6.6	Regulatory Risk Scenario 3	0.2
Regulatory Risk Scenario 4	12.2	Regulatory Risk Scenario 4	0.3
Regulatory Risk Scenario 5	20.0	Regulatory Risk Scenario 5	0.5
Regulatory Risk Scenario 6	27.8	Regulatory Risk Scenario 6	0.7

Source: Own calculations.

Note: It is assumed that the annualised growth rates for the sector between 2004-2014, under the "RES on" scenario, are maintained until 2020.

The cost estimates given in Table 3 do not necessarily reflect the realised additional cost burden per 'average' enterprise, even before considering measures to reduce carbon emissions, since enterprises may be able to pass on the additional costs, either partially or in full, to customers (or suppliers) in the form of higher prices (or by negotiating lower prices for factor inputs). Figure 6 shows the impact on one indicator of enterprise output (annual turnover) and on indicator of enterprise profitability (annual gross profit) of passing through additional costs for DG 24.4[16].

Under the worst-case scenario (RRS 6) the turnover of an 'average' enterprise in DG 24.4 is predicted to decline by as much as £129,000 per year with 100% cost pass through, and by about £65,000 with 50% cost pass through (consider panel (a) in Figure 6). Under RRS 4, by way of contrast, the turnover of an average enterprise is predicted to decline by close to £57,000 and £28,000 per year with 100% and 50% cost pass through, respectively.

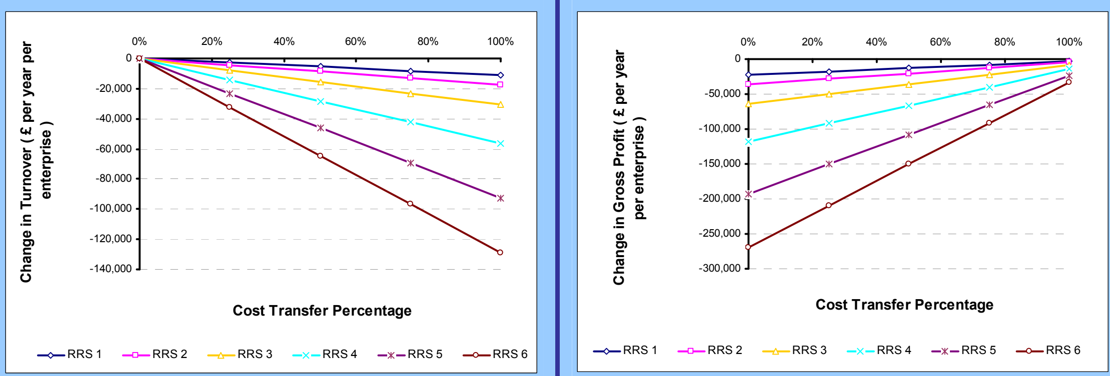
While turnover is unaffected if all of the additional annual costs are absorbed by the

[16] Since we have no information to accurately identify the most likely cost-transfer percentage for each sector, we simply employ a range of cost-transfer assumptions; from 0% to 100%.

enterprise, profitability is reduced (as production costs increase by the full amount of the additional annual costs). Under RRS 4 the gross profit of an 'average' enterprise in DG 24.4 is estimated to decline by roughly £178,000 per year with no cost pass through, £66,000 with 50% cost pass through, and only £14,000 per year with 100% cost pass through (consider panel (b) in Figure 6). The impact of the regulatory risks on an 'average' enterprise are thus smaller the more the enterprise is able (and willing) to pass on additional costs to customers. Results for DL 33.1 are summarised in Figure 7.

Figure 13: Impact of Absorbing Different Percentages of the Additional Annual Regulatory Risk Cost on an 'Average' Enterprise in DG 24.4 (2005 £)

(a) Change in Turnover (negative values indicate reduction in variable)	(b) Change in Gross Profit (negative values indicate reduction in variable)

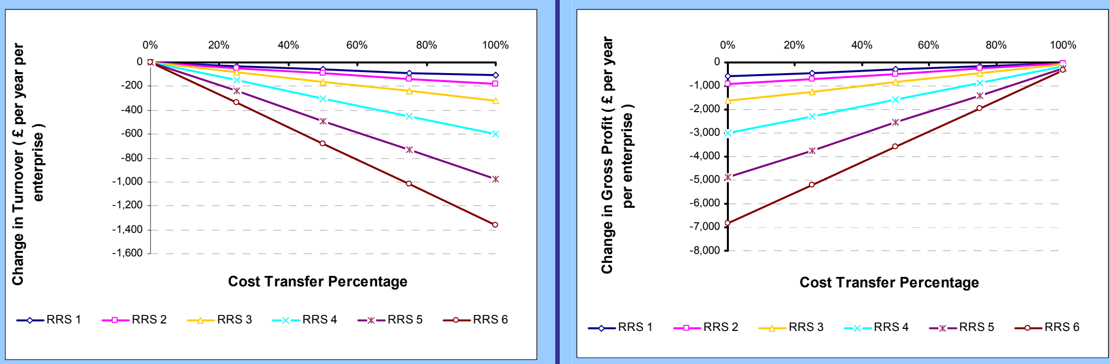


Source: Own calculations.

Note: RRS = Regulatory Risk Scenario.

Figure 14: Impact of Absorbing Different Percentages of the Additional Annual Regulatory Risk Cost on an 'Average' Enterprise in DL 33.1 (2005 £)

(a) Change in Turnover (negative values indicate reduction in variable)	(b) Change in Gross Profit (negative values indicate reduction in variable)



Source: Own calculations.

Note: RRS = Regulatory Risk Scenario.

In looking at our "best guess" risk scenario (RRS 4), the estimated reductions in gross profit, by sub-sector, are as follows (£ 'average' per enterprise per year) (rounded to the nearest £ 000):

- DG 24.4 = £14,000 (100% cost pass through) to £118,000 (no cost pass through); and
- DL 33.1 = negligible (100% cost pass through) to £3,000 (no cost pass through).

Estimated reductions in turnover and gross profit of DG 24.4 in the East Midlands in 2020 are shown in Table 7. Similar estimates are provided for DL 33.1 in Table 8. Note that the reductions in value shown in these tables arise solely from the consumption of energy by enterprises in each sub-sector; other 'pathways' will impact upon turnover and gross profit, as highlighted in Figure 1. We consider one of these other 'pathways' below.

Table 15: Direct Economic Impact of Total Annual Regulatory Costs Incurred by Enterprises in DG 24.4 in the East Midlands, by 2020 (2005 £)

(a) RRS 1

Cost transfer percentage (%)	Change in Turnover (£ 000 per yr)	Change in Gross Profit (£ 000 per yr)
100%	- 1,120	- 290
75%	- 840	- 800
50%	- 560	- 1,310
25%	- 280	- 1,820
0%	-	- 2,340

(b) RRS 4

Cost transfer percentage (%)	Change in Turnover (£ 000 per yr)	Change in Gross Profit (£ 000 per yr)
100%	- 5,860	- 1,490
75%	- 4,390	- 4,160
50%	- 2,930	- 6,840
25%	- 1,460	- 9,520
0%	-	- 12,200

(c) RRS 6

Cost transfer percentage (%)	Change in Turnover (£ 000 per yr)	Change in Gross Profit (£ 000 per yr)
100%	- 13,370	- 3,400
75%	- 10,020	- 9,490
50%	- 6,680	- 15,590
25%	- 3,340	- 21,710
0%	-	- 27,840

Source: Own calculations.

Note: The estimates are prior to any responses taken by enterprises in the sub-sector to mitigate risks. The estimated changes in turnover and gross margin do not include indirect and induced effects on the region's economy. It is assumed that the annualised growth rates for the sector between 2004-2014, under the "RES on" scenario, are maintained until 2020.

Table 16: Direct Economic Impact of Total Annual Regulatory Costs Incurred by Enterprises in DL 33.1 in the East Midlands, by 2020 (2005 £)

(a) RRS 1

Cost transfer percentage (%)	Change in Turnover (£ 000 per yr)	Change in Gross Profit (£ 000 per yr)
100.0%	- 10	-
75.0%	- 10	- 20
50.0%	- 10	- 30
25.0%	-	- 40
0.0%	-	- 60

(b) RRS 4

Cost transfer percentage (%)	Change in Turnover (£ 000 per yr)	Change in Gross Profit (£ 000 per yr)
100.0%	- 60	- 10
75.0%	- 40	- 80
50.0%	- 30	- 150
25.0%	- 10	- 220
0.0%	-	- 290

(c) RRS 6

Cost transfer percentage (%)	Change in Turnover (£ 000 per yr)	Change in Gross Profit (£ 000 per yr)
100.0%	- 130	- 30
75.0%	- 100	- 190
50.0%	- 70	- 350
25.0%	- 30	- 500
0.0%	-	- 660

Source: Own calculations.

Note: The estimates are prior to any responses taken by enterprises in the sub-sector to mitigate risks. The estimated changes in turnover and gross margin do not include indirect and induced effects on the region's economy. It is assumed that the annualised growth rates for the sector between 2004-2014, under the "RES on" scenario, are maintained until 2020.

Under our "best guess" risk scenario, by 2020:

- Gross profit of DG 24.4 in the East Midlands is estimated to decline by between £1.5 (100% cost-pass through) and £12.2 million per year (0% cost-pass through) (panel (b) in Table 7).

- Gross profit of DL 33.1 in the East Midlands is estimated to decline by between less than £0.1 (100% cost-pass through) and £0.3 million per year (0% cost-pass through) (panel (b) in Table 8).

Clearly, the estimated regulatory cost impacts are considerably larger for DG 24.4 than for DL 33.1.

The latter two figures in the above bullet points represent the maximum possible reduction in gross margin under this risk scenario, since enterprises are assumed (a) to absorb all the additional costs and (b) to have taken no action to mitigate carbon emissions. In looking at both sub-sectors in the East Midlands, gross profit could decline by up to £12.5 million per year by 2020 (RSS 4). Turnover from both sub-sectors could decline by up to £5.9 million by 2020 (RSS 4), if enterprises opted to minimise the regulatory cost burden and pass on the additional costs in full. In this case, gross profit of both sub-sector in the East Midlands is estimated to reduce by about £1.5 million per year by 2020 (RSS 4).

It is evident from the above analysis that the impact on sub-sector profitability is minimised if the additional regulatory costs are fully passed on to customers. However, as output from these sub-sectors in the East Midlands reduces, due to higher product prices, it will affect demand for output from their suppliers, and so on down the supply chain. These so-called 'indirect effects' on the wider economy are estimated using appropriate output multipliers[17]. By 2020, reductions in output from both sub-sector in the East Midlands are estimated to result in additional output declines in the wider economy of (assuming 100% cost pass through):

- Up to £0.9 million per year under RRS 1;
- Up to £4.8 million per year under RRS 4; and
- Up to £10.9 million per year under RRS 6.

The total direct and indirect effects on output (turnover) of climate change-related regulatory risks associated with energy use by both DG 24.4 and DL 33.1 in the East Midlands, thus range from about £2.0 million per year (under RRS 1) to about £24.5

[17] Specifically, we used Sub-sector specific Type I output multipliers from the UK Input-Output Analytical Tables.

million per year (under RRS 6); with a "best guess" (under RRS 4) at about £10.5 million per year[18].

Reducing Risk Exposure

The above analysis of climate change-related regulatory risks assumes that GHG emissions associated with energy consumption per unit of output by sub-sectors will not change over time; in effect, we assume a fixed baseline with respect to energy-intensity. However, enterprises in both sub-sectors will, more than likely, undertake action to reduce GHG emissions, thus reducing their exposure to regulatory risks. For example:

- Boots have set a target of reducing energy consumption by 10% over the next three years on their main site in Nottingham. Boots use combined heat and power (CHP) plant to generate around 90% of all the power needed on the 300 acre site, and around 80% of the heat (Boots 2006).
- Astra Zeneca (Charnwood) has a target of an absolute reduction of 12% in greenhouse gases (GHGs) compared to 2005 levels by 2010 (Astra Zeneca 2006).
- 3M Healthcare (Loughborough) of a reduction in energy consumption of 20% (relative to 2005) by 2010 (3M, 2007).

It is not possible within the scope of this case study to evaluate the (planned or implemented) mitigation strategies of individual enterprises in the East Midlands, since we would need to collate information on both the cost and effectiveness of specific actions (or combinations of actions) that may be used by enterprises to: (a) improve energy efficiency at installations; and/or (b) reduce the carbon intensity of fuel inputs. Nonetheless, we can provide an indication of the maximum benefits (in terms of regulatory costs avoided) for the region. If projected baseline carbon emissions associated with fuel use by DG 24.4 in the East Midlands were to decrease by, say, 30% or 50%, the estimated costs of regulatory risks under RRS 4 would fall by £3.7 and £6.1 million per year by 2020, respectively (see panel (a) in Figure 10). Similar reductions

[18] Recall that we have assumed that enterprises in the sector opt to minimise the regulatory cost burden and therefore fully pass on additional costs to customers.

within DL 33.1 would reduce the estimated costs of regulatory risks under RRS 4 by £0.09 and £0.15 million per year by 2020.

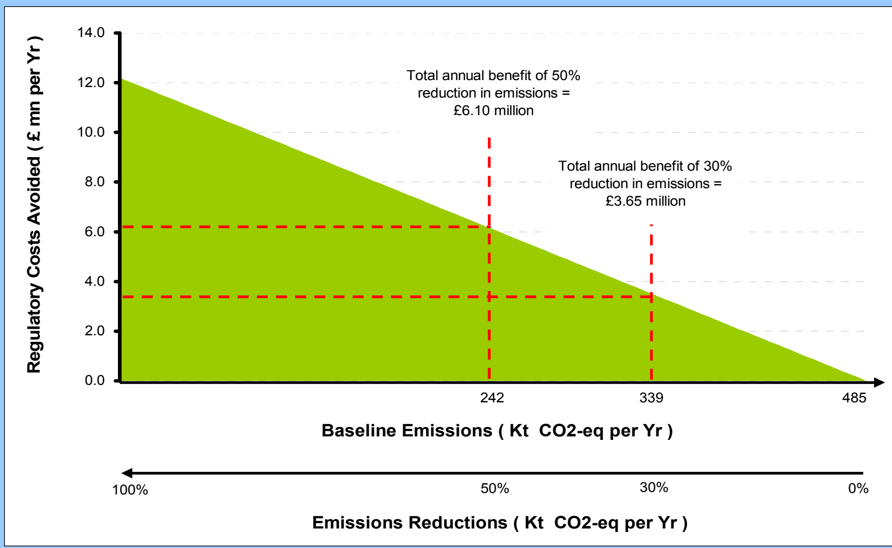
To put these reductions in context, if enterprises were to source an additional 25% and 50% of their electricity from zero-carbon sources, relative to the current situation:

- The estimated costs of regulatory risks faced by DG 24.4 in the East Midlands by 2020 under RRS 4 would fall by £1.35 and £2.70 million per year, respectively.
- The estimated costs of regulatory risks faced by DL 33.1 in the East Midlands by 2020 under RRS 4 would fall by £0.05 and £0.10 million per year, respectively.

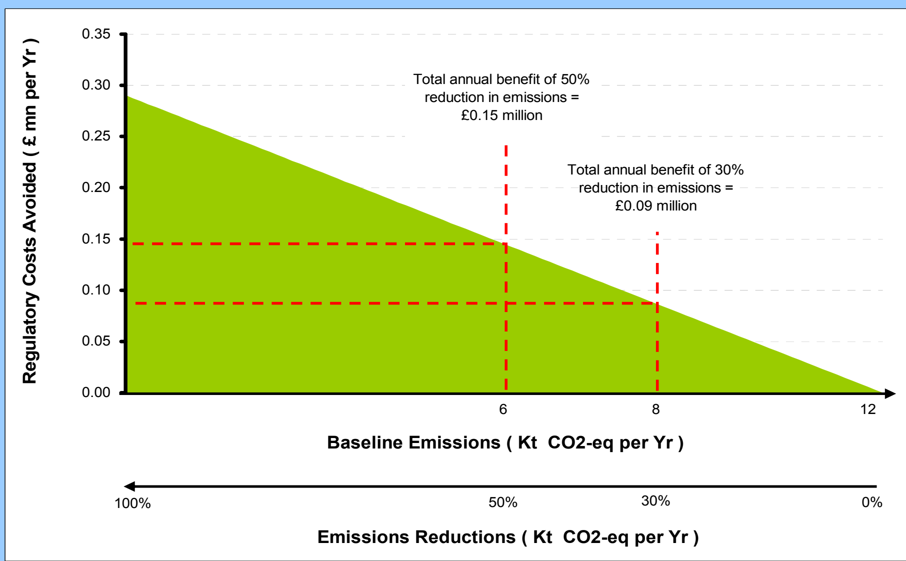
In total, across both sub-sectors, sourcing 25% and 50% of electricity from zero-carbon sources would save, respectively, about 28 and 56 Kt CO_2-eq per year by 2020. Of course, from the point of view of an enterprise in these sub-sectors, these avoided costs (benefits) should be compared with the financial costs of realising the carbon emission reductions, to see whether action is justified on private cost-benefit grounds.

Figure 15: Regulatory Risks from Impact Pathways ❶-❷ Avoided by Enterprises in DG 24.4 and DL 33.1 in the East Midlands by 2020, from Reducing Energy-related Carbon Emissions (RRS 4 only)

(a) NACE DG 24.4: Manufacture of pharmaceuticals, medicinal chemicals and botanical products



(b) NACE DL33.1: Manufacture of medical and surgical equipment and orthopaedic appliances



Impact Pathway 3

To produce a unit of output (e.g. a pharmaceutical product or an orthopaedic appliance) primary and intermediary inputs are required. The production and distribution of these inputs will also generate GHG emissions, and their use by enterprises in the Manufacturing of Healthcare sectors will therefore also carry an (indirect) regulatory risk to the extent that all GHG emissions are covered by regulatory measures (as illustrated by impact pathway ❸ in Figure 1). Using the UK Input-Output Analytical Tables we have generated indicative values for the regulatory risks arising through impact pathway ❸, for direct and indirect CO_2-eq emissions associated with energy use only. Additional costs are calculated only for our "best guess" risk scenario (RRS 4). The estimates reported below will overstate the true costs of the regulatory risks transmitted through impact pathway ❸, since it is assumed that: (a) 100% of additional costs are passed on to customers along supply chains; and (b) these customers do not take action to reduce exposure to the additional costs (e.g. reduce demand / switch to lower carbon-intensity inputs). Bearing these caveats in mind, the (maximum) cost of regulatory risks associated with the carbon content of all inputs to an 'average' enterprise in each sub-sector are (2005 £):

- DG 24.4 = £45,800 per year, or 0.2% of total baseline production costs (under RSS 4).
- DL 33.1 = £2,900 per year, or 0.2% of total baseline production costs (under RSS 4).

The total carbon content of all primary and intermediary inputs required to make a unit of final demand from DG 24.4 is considerably higher than the total carbon content of all inputs required to make a unit of final demand from DL 33.1. To put these indirect costs in context, the total regulatory cost per enterprise in DG 24.4 arising through impact pathways ❶-❷ is £117,800 per year; for DL 33.1 it is £3,000 per enterprise per year. This is relatively small for the average enterprise –gross operating surpluses in the period 2000-2004 averaged £7.1mn for DG24.4 and £0.3mn for DL 33.1. Thus, for the "average" enterprise this is not so significant – but for marginal cases this may be more significant.

Aggregating over all enterprises in each Division in the East Midlands we find that by 2020 under:

- The maximum cost of the regulatory risks transmitted through impact pathway ❸ is £4.8 million per year for DG 24.4, which makes the total regulatory cost arising through impact pathways ❶-❸ equal to £17.0 million per year (under RSS 4).
- The maximum cost of regulatory risks transmitted through impact pathway ❸ is £0.3 million per year for DL 33.1, which makes the total regulatory cost arising through impact pathways ❶-❸ equal to £0.6 million per year (under RSS 4).

Considering the total regulatory cost arising through impact pathways ❶-❸, by 2020 under our "best guess" risk scenario:

- Gross profit of DG 24.4 in the East Midlands is estimated to decline by between £2.1 (100% cost-pass through) and £16.9 million per year (0% cost-pass through).
- Gross profit of DL 33.1 in the East Midlands is estimated to decline by between less than £0.1 (100% cost-pass through) and £0.6 million per year (0% cost-pass through).

Recall that the latter two figures in the above bullet points represent the maximum possible reduction in gross margin under this risk scenario.

As noted above, enterprises can minimise the regulatory cost burden (minimise the impact on gross margin) by passing on the additional costs to customers. However, this adversely affects output. If the 'average' enterprise in each sub-sector passed on 100% of the additional costs to customers:

- Output from DG 24.4 in the East Midlands is estimated to decline by £8.1 million per year by 2020 (under RSS 4).
- Output from DL 33.1 in the East Midlands is estimated to decline by £0.1 million per year by 2020 (under RSS 4).

By 2020, these reductions in output from both sub-sectors in the East Midlands are estimated to result in additional output declines (indirect effects) in the wider economy of £6.7 million per year. The maximum total direct and indirect effects on output from the Manufacture of Healthcare sector in the East Midlands, arising through impact pathways ❶-❸, is thus about £14.9 million per year.

The key policy messages arising from this are as follows:

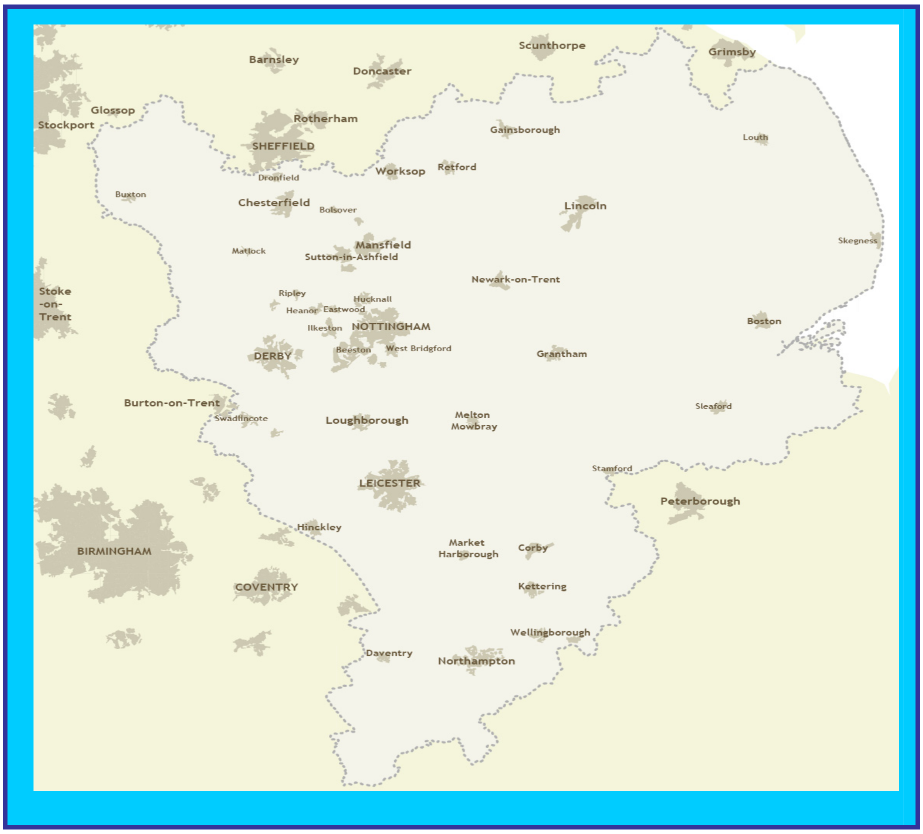
a. that "average" firms may not bear an overly great burden from regulatory risks associated with climate change mitigation, though on aggregate the impacts are significant and so region-wide actions to encourage the sourcing of renewable energy and energy saving actions by the healthcare manufacturing sector;

b. that some firms "at the margin" may suffer proportionately more and actions may be needed to assist such firms in developing coping mechanisms to adapt to changes in regulations. In our analysis we have very much focussed on the "average" firm – which in this sector is highly profitable. However, smaller enterprises and enterprises with comparatively lower profit margins will likely face greater pressures that other firms in the same industry.

Analysis of Regulatory Risks – Strategic Health Authority

NHS East Midlands (the Strategic Health Authority for the Region) provides strategic leadership to 9 acute hospital NHS trusts, 5 mental health and learning disabilities NHS Trusts, 9 Primary Care Trusts, the East Midlands Ambulance Service and a number of independent treatment centres. These organisations have a total NHS budget of £5.7bn, and serve a combined population of 4.3 million (see Figure 6). The role of NHS East Midlands is to ensure that local health systems operate effectively and efficiently and that national standards and priorities are met.

Figure 16: Map of East Midlands Strategic Health Authority, July 2006



Source: East Midlands Strategic Health Authority 2007

Overview of Approach

The regulatory risks potentially faced by the East Midlands SHA are assessed with respect to direct (impact pathway ❷) and indirect (impact pathway ❶) carbon emissions.

Similar to the analysis conducted for DG 24.4 and DL 33.1, the economic impact of climate change-related regulatory risks is analysed on the basis of a number of cost scenarios, in which various estimates of (a) the marginal external cost of carbon and (b) the marginal abatement cost of complying with EU policy goals, are assumed to be internalised in the price of energy used by each "organisation" with the SHA. Being a public sector entity, no attempt is made to evaluate the impact of the resulting increases in operating costs on the financial performance (e.g. profitability) of each "organisation", and the SHA as a whole. Rather, we consider the likely increase in baseline energy costs per square metre (m^2) of occupied floor space, as the cost of carbon emissions is internalised in energy prices.

The method is similar to that used above:

1. We collate data on energy delivered (GJ per year), by fuel, to each organisation (site) in the SHA from utility companies (intake energy[19]), local sources (local energy[20]) and suppliers of renewable energy. Energy consumption figures are based on energy consumed by site buildings, and include distribution losses from pipes and cables up to the buildings.
2. Data is also collated on total annual energy costs[21] (£ per year) (all energy supplies) and occupied floor area[22] (m^2 per year), by organisation site.
3. The data used is that provided by NHS Trusts via the Department of Health's online Estate Returns Information Collection (ERIC) system. It does not include data from the independent healthcare sector. We obtained the data from The Information Centre web-site of the NHS, and covers the period 1999 to 2005.
4. Appropriate emission factors from the National Air Emissions Inventory web-site are next applied to the data on total annual energy use, by fuel, and then aggregated across all fuels to estimate total annual CO_2-eq emissions per organisation (in kt CO_2-eq per year). Summing across all organisation sites

[19] The total annual amount of energy used in GJ by the organisation site supplied by the national / regional energy supplier, net of any energy that may have been supplied by the NHS Trust to other organisation sites. It include energy used to feed CHP plant associated with the site, and energy used by the organisation for processing purposes (e.g. laundry), but excludes energy derived from an eligible renewable energy source (NHS, The Information Centre, ROCR / OR / 0042 / FT6 / 004, 2006).

[20] The annual amount of energy in GJ used by the organisation site which has been supplied by an organisation other than the national / regional energy supplier (e.g. a neighboring NHS Trust supplying electricity to the site from their central distribution system). It exclude energy derived from an eligible renewable energy source (NHS, The Information Centre, ROCR / OR / 0042 / FT6 / 004, 2006).

[21] The total annual cost of energy consumed by all of the organisation sites occupied premises, inclusive of electricity, gas, oil, and coal from whatever source (e.g. utility supplier, local source, renewable source etc.), net of any costs that are charged to other organisations for which the Trust provides energy (NHS, The Information Centre, ROCR / OR / 0042 / FT6 / 004, 2006).

[22] The total internal floor area of all buildings or premises or part therein, which are in operational use and required for the purpose of delivering the function / activities of the NHS Trust (i.e. occupied by the NHS Trust), and either owned by the NHS Trust or defined within the terms of a lease, license, Service Level Agreement or tenancy agreement. Include leased-in areas, multi-storey car parks, industrial process areas. Includes embedded education and training facilities and university accommodation which are occupied. Measured as for the Gross Internal Floor Area, inclusive of plant rooms, and circulation spaces, but excluding areas which are not required for operational purposes (i.e. non-occupied areas and not in use). Excludes leased-out and licensed-out areas (NHS, The Information Centre, ROCR / OR / 0042 / FT6 / 004, 2006).

provides a measure of total annual CO_2-eq emissions for the SHA as a whole. The calculations are performed for 2005 data.

5. Total annual CO_2-eq emissions (kt CO_2-eq per year), by organisation, are next multiplied by the price of carbon (2005 £ per t CO_2-eq) under each of our six Regulatory Risk Scenarios (RRS). Summing across all organisation sites provides a measure of the total potential regulatory costs, under each RRS, for the SHA as a whole. The calculations are performed for 2005 data.

6. To provide an estimate of the total potential regulatory costs in 2020 we:

   - Estimate the average area of occupied floor space per resident (m^2 per person) of the East Midlands in 2005, using population data from the RES evidence base.

   - The RES evidence base also includes population projections for the region through to 2028, from which we interpolate a figure for 2020. Assuming that the average area of occupied floor space per resident is held constant over the period 2005-2020, the population projection for 2020 is used to estimate the total area of occupied floor space in the SHA in 2020 (an increase of close to 8% relative to 2005 levels). We then assume that the total area of occupied floor space in each organisation increases by a similar percentage over the period 2005-2020.

   - For each fuel consumed by an organisation over the period 1999-2005, we estimate the quantity used per area of occupied floor space (GJ per m^2). The trend over the period 1999-2005 is then extrapolated to 2020. Consistent with the picture for England and Wales as a whole, total electricity use per m^2 increased between 1999 and 2005, whereas, total fossil fuel use (gas, oil and coal) per m^2 declined. These trends were assumed to continue through to 2020.

   - Total annual energy use in 2020, by fuel, for each organisation is then given by the product of projected energy use, by fuel, per m^2 of occupied floor space and projected total occupied floor space. Summing, first, across all fuels used by an organisation, and second, across all organisation sites provides a measure of the total energy consumption in 2020 for the SHA as a whole.

- Steps four and five are then repeated for projected annual energy use in 2020, by organisation, and for the SHA as a whole.
- For each £ spent on energy by an organisation over the period 1999-2005, we estimate the quantity expenditure, by fuel, per area of occupied floor space (£ per m^2). The trend over the period 1999-2005 is then extrapolated to 2020. The projected values through to 2020 are in current prices. Using actual annual inflation rates through the end of 2005 and assuming the Government's inflation target (2.5% per annum) is hit exactly through to 2020, we converted the current price projections to a constant price series in 2005 £ (consistent with the other case studies).
- Total annual energy costs in 2020, by fuel, for each organisation is then given by the product of projected energy costs, by fuel, per m^2 of occupied floor space and projected total occupied floor space. Summing, first, across all fuels used by an organisation, and second, across all organisation sites provides a measure of total energy costs in 2020 for the SHA as a whole.

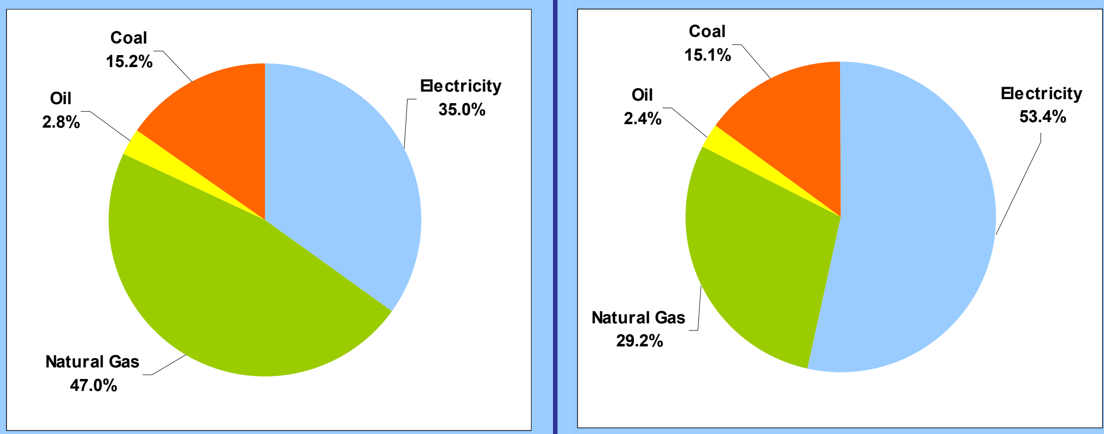
Results

Total annual energy use by the East Midlands SHA is estimated at 3.57 PJ by 2020; equivalent to about 1.7 GJ per m^2 of projected occupied floor space. This compares with total annual energy consumption of 3.83 PJ in 2005 (or about 1.9 GJ per m^2 of occupied floor space). Total energy costs for the SHA in 2020 are estimated at about £33.6 million (2005 prices); equivalent to about £9.4 per GJ of projected energy supplied.

Nearly half of total annual energy use by the SHA in 2020 is provided by natural gas, with electricity accounting for about one-third (see Figure 17 (a)). Extrapolating recent trends, about 3.5 percent of total annual energy use in 2020 is projected to be sourced from renewable supplies.

Figure 17: Projected Annual Total Energy Use and Carbon Emissions by the East Midlands Strategic Health Authority in 2020

(a) Total Annual Energy Use (3.57 PJ per year)	(b) Total Annual Carbon Emissions (286.0 kt CO_2-eq per year)



Source: Own calculations.

Total annual carbon emission from the East Midlands SHA is estimated at 286 kt CO_2-eq. by 2020; equivalent to just under 135 kg per m^2 of projected occupied floor space or 80 kg per GJ of projected energy supplied. This compares with total annual carbon emission of 271 kt CO_2-eq. in 2005 (or just over 135 kg per m^2 of occupied floor space or 70 kg per GJ of energy supplied). Nearly half of total annual carbon emissions from the SHA in 2020 arises from electricity use, with natural gas use accounting for close to one-third (see Figure 17 (b)).

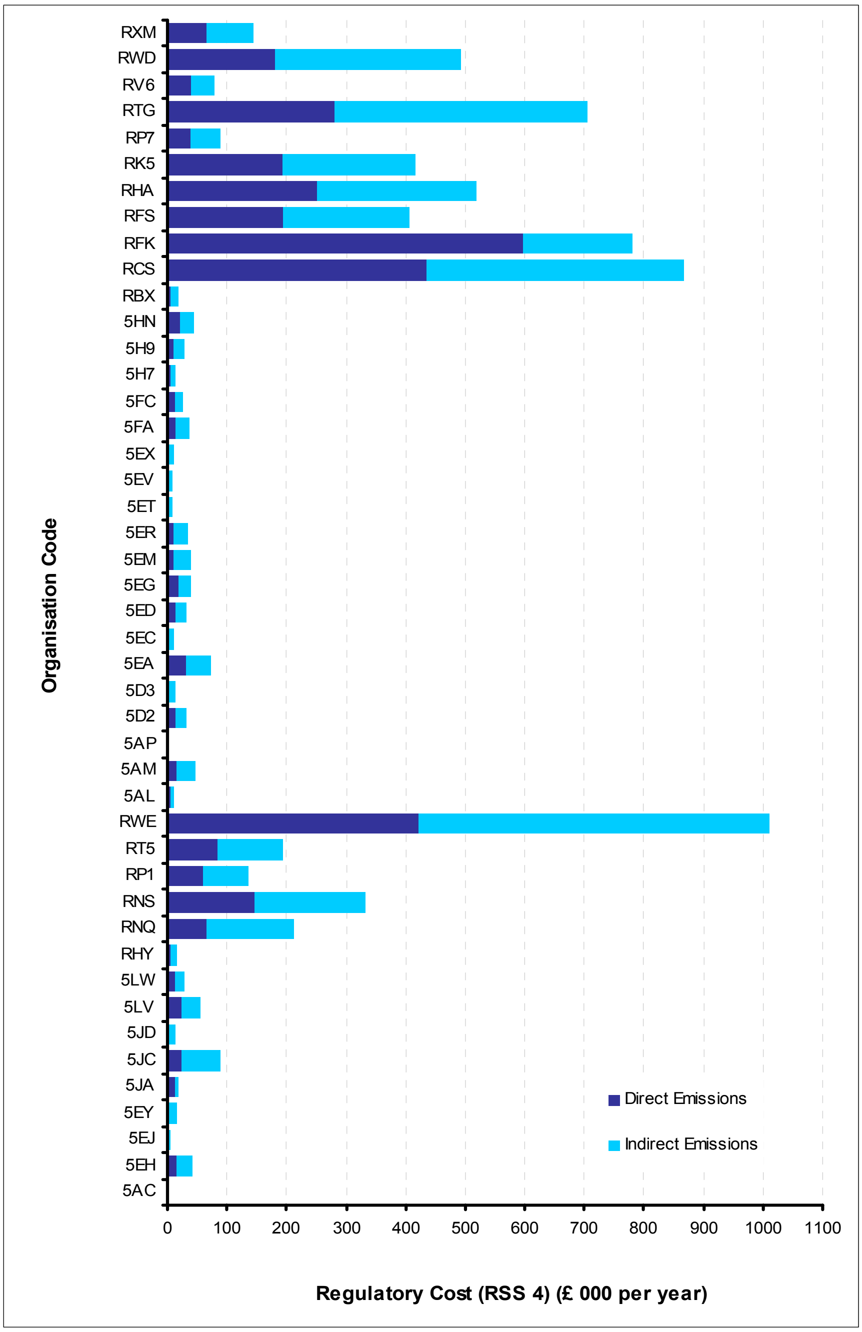
Estimated total annual regulatory costs faced by the East Midlands SHA in 2020 are shown in Table 17 (a), by Regulatory Risk Scenario. Additional potential costs faced by the SHA in 2020 range from (2005 prices) £1.4 to £16.4 million per year. Under our "best guess" scenario, additional annual costs are about £7.2 million. Note that these estimates represent maximum risk exposure under each scenario, since they do not allow for action taken by the SHA in response to higher energy costs – e.g. increased use of energy efficiency measures or renewable energy supplies. The split of total costs between direct emissions (from natural gas, oil and coal use) and indirect emissions (from electricity use) reflects the shares shown in see Figure 17 (b).

Total annual regulatory costs faced by each organisation in the East Midlands SHA by 2020 under our "best guess" scenario (RRS 4) are shown in

Figure 18. Across all organisations the average total annual costs is about £82,000; however, annual costs to individual organisations range from less than one thousand pounds (e.g. Newark and Sherwood PCT) to just over one million pounds (e.g. University Hospitals Of Leicester NHS Trust).

Estimated average annual regulatory costs faced by the East Midlands SHA in 2020 per m^2 of occupied floor space are shown in Table 17 (b), by Regulatory Risk Scenario. Additional potential costs faced by the SHA in 2020 range from (2005 prices) £0.6 to £7.7 per m^2. Under our "best guess" scenario, additional average costs are about £3.4 per m^2. To put this in context, projected average energy costs across the SHA by 2020 are about (2005 prices) £15.5 per m^2 of occupied floor space. Average annual regulatory costs faced by each organisation in the East Midlands SHA by 2020 under our "best guess" scenario (RRS 4) are shown in Figure 19. Additional average costs to individual organisations range from 60 pence per m^2 (e.g. Leicester City West PCT) to nearly £5.2 per m^2 (e.g. Nottingham City NHS Trust).

Figure 18: Annual Regulatory Risk Costs, by Organisation, in the East Midlands Strategic Health Authority from Impact Pathways ❶-❷ by 2020 (RRS 4 only) (2005 £ 000 per year)



Note: Organisation Codes are defined in Table 18

Table 17: Total Annual Regulatory Risk Costs Faced by the East Midlands Strategic Health Authority from Impact Pathways ❶-❷ by 2020, by Regulatory Risk Scenario

(a) By Impact Pathway ❶ and ❷

	RRS 1 (£ mn / yr)	**RRS 2** (£ mn / yr)	**RRS 3** (£ mn / yr)	**RRS 4** (£ mn / yr)	**RRS 5** (£ mn / yr)	**RRS 6** (£ mn / yr)
Direct Emissions	0.6	1.0	1.8	3.4	5.5	7.7
Indirect Emissions	0.7	1.2	2.1	3.8	6.3	8.8
Total	1.4	2.2	3.9	7.2	11.8	16.4

(b) Average Total Costs per Area of Occupied Floor Space

	RRS 1 (£ / m2)	**RRS 2** (£ / m2)	**RRS 3** (£ / m2)	**RRS 4** (£ / m2)	**RRS 5** (£ / m2)	**RRS 6** (£ / m2)
	0.6	1.0	1.8	3.4	5.5	7.7

(c) Percentage Increase Total Annual Energy Costs with Addition of Regulatory Risk Costs

	RRS 1 (%)	**RRS 2** (%)	**RRS 3** (%)	**RRS 4** (%)	**RRS 5** (%)	**RRS 6** (%)
	4%	7%	12%	21%	35%	49%

Predicted increases in the East Midlands SHA's total annual energy costs with the addition of the estimated annual regulatory costs are shown in Table 17 (c), by Regulatory Risk Scenario. Total energy costs incurred by the SHA in 2020 are predicted to increase by between 4% and 49%; under our "best guess" scenario the predicted increase is 21%. The predicted increase in costs faced by each organisation in the East Midlands SHA by 2020 under our "best guess" scenario (RRS 4) is shown in Figure 20. Across all organisations the average increase in energy costs is about 21%; however, the increase to individual organisations ranges from 6% (e.g. Central Derby PCT) to 46% (e.g. Leicester City West PCT).

The above analysis assumes that carbon emissions associated with energy consumption by organisation in the SHA will not change over time, except in accordance with recent trends (over the period to 2005). Organisations, however, are likely to undertake action to reduce their exposure to these regulatory risks. For example money raised from CCL is available to healthcare sector through the Low Carbon Innovation Programme run by the Carbon Trust. Support available includes: advice on energy management; information on technical performance of building components, services and equipment; feasibility studies and buildings design advice covering all aspects of procurement, refurbishment and capital projects; and grants and incentives for Combined Heat and Power (CHP). Glenfield Hospital in Leicester has installed CHP plant generating 570kWe of CHP capacity. This has resulted in a CCL saving of around £20,000 per year (CHP Club 2002).

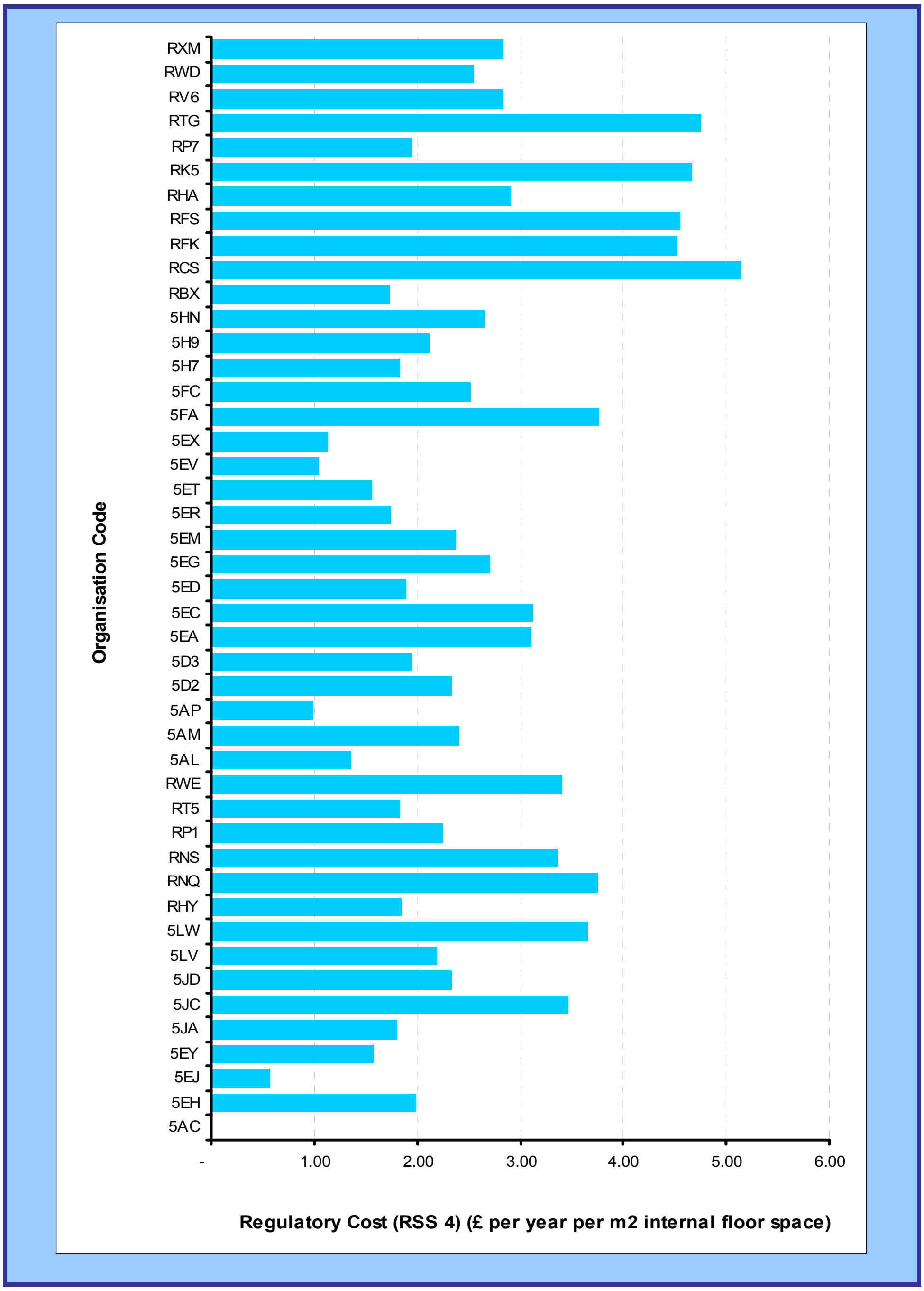
As noted above, it is not possible within the scope of this case study to evaluate the (planned or implemented) mitigation strategies of individual organisations in the East Midlands SHA. We do, nonetheless, provide an indication of the maximum benefits (in terms of regulatory costs avoided) for the SHA as a whole for fixed reductions in carbon emissions. If projected carbon emissions associated with energy use by the SHA were to decrease by, say, 30% or 50%, the estimated costs of regulatory risks under RRS 4 would fall by £2.2 and £3.6 million per year by 2020, respectively (see panel Figure 21). To put these reductions in context, if the SHA as a whole were to source an additional 25% and 50% of its electricity from zero-carbon sources, relative to the projected situation for 2020: the estimated costs of regulatory risks faced by the SHA by 2020 under RRS 4 would fall by close to £1.0 and £1.9 million per year, respectively. Sourcing an additional 25% and 50% electricity from zero-carbon sources would save, respectively, about 38 and 76 kt CO_2-eq per year by 2020.

Following on from this analysis we can conclude the following in terms of policy needs:

a) that awareness of the resources available to the health care sector through the Low Carbon Innovation Programme needs to be verified, and if necessary capacity building carried out; and

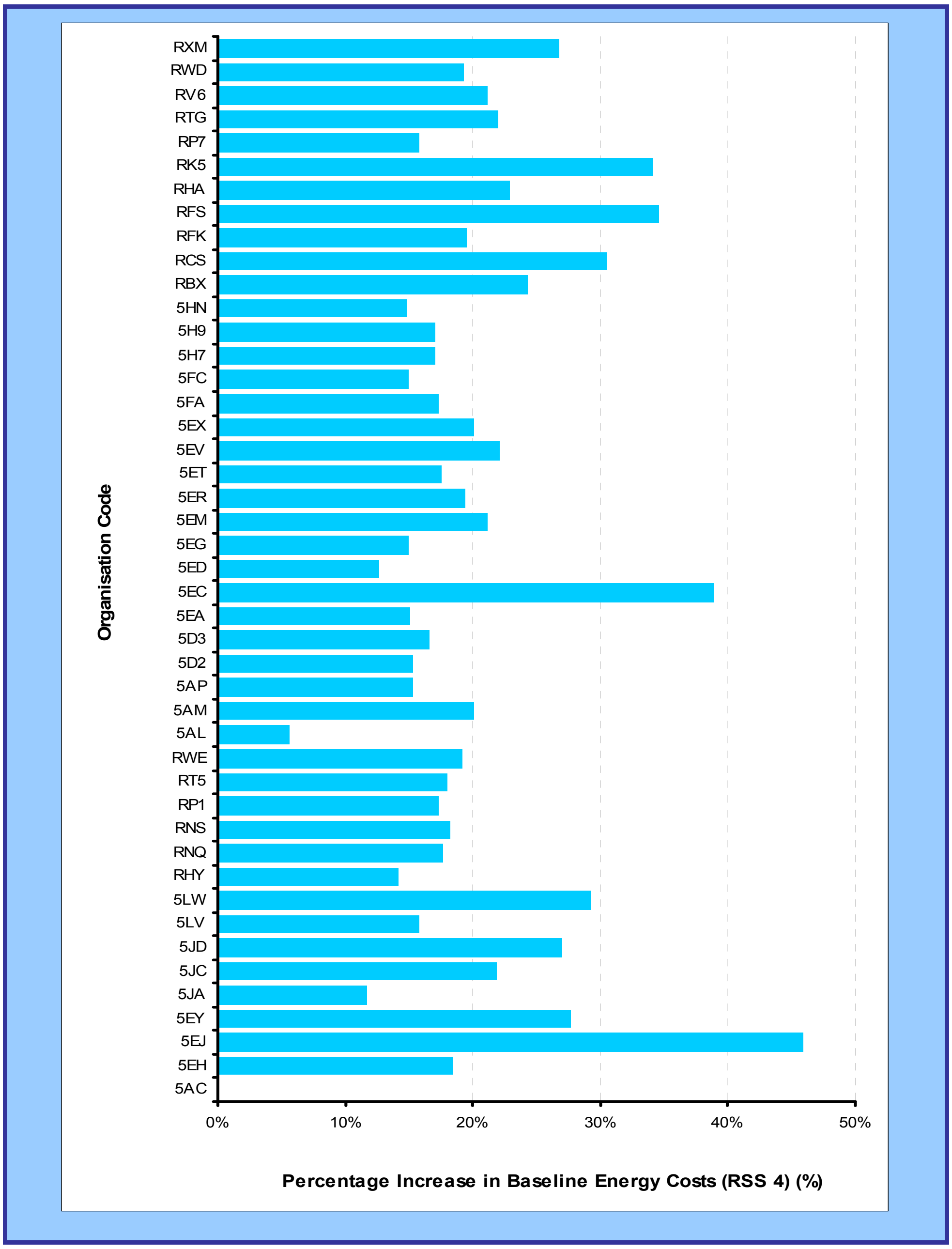
b) from the point of view of the SHA, avoided costs (benefits) should be compared with the financial costs of realising the carbon emission reductions, to see whether action is justified on private cost-benefit grounds. This would require a detailed examination of mitigation options for the SHA.

Figure 19: Annual Regulatory Risk Costs, by Organisation, in the East Midlands Strategic Health Authority from Impact Pathways ❶-❷ by 2020 (RRS 4 only) (2005 £ per m² of occupied floor space)



Note: Organisation Codes are defined in Table 18

Figure 20: Percentage Increase in 2020 Total Annual Energy Costs, by Organisation, in the East Midlands Strategic Health Authority from Incurring the Regulatory Risk Costs from Impact Pathways ❶-❷ (RRS 4 only)



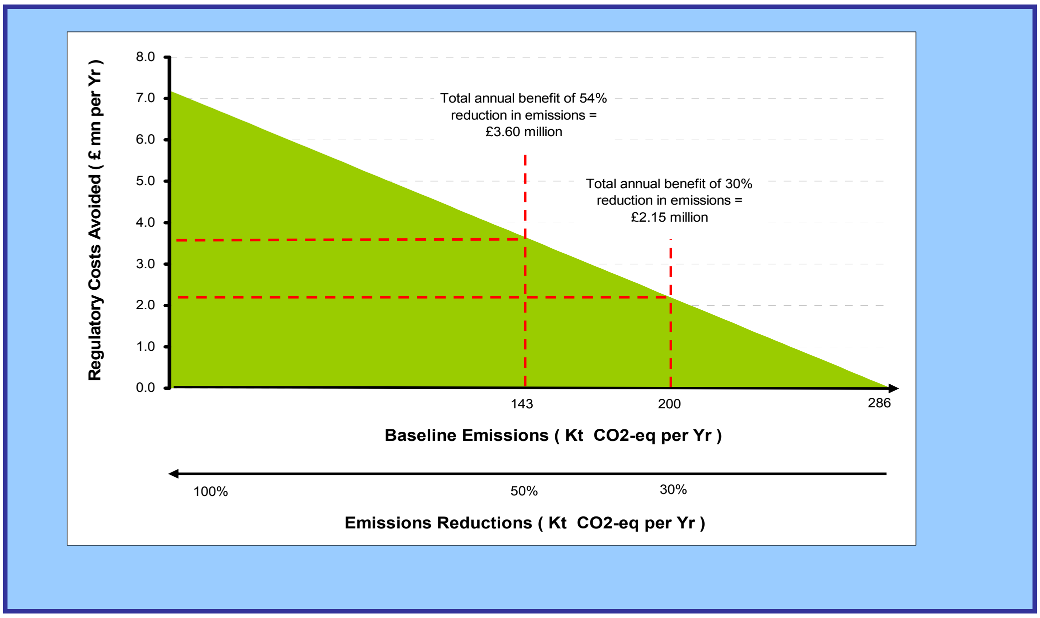
Note: Organisation Codes are defined in Table 18

Table 18: Organisation Codes, Names and Types in the East Midlands Strategic Health Authority

Organisation Code	Organisation Name	Strategic Health Authority	Organisation Type
5AC	PCT	LEIC., NORTH. & RUTLAND	PCT
5EH	MELTON RUTLAND AND HARBOROUGH PCT	LEIC., NORTH. & RUTLAND	PCT
5EJ	LEICESTER CITY WEST PCT	LEIC., NORTH. & RUTLAND	PCT
5EY	EASTERN LEICESTER PCT	LEIC., NORTH. & RUTLAND	PCT
5JA	HINCKLEY AND BOSWORTH PCT	LEIC., NORTH. & RUTLAND	PCT
5JC	LEICESTERSHIRE	LEIC., NORTH. & RUTLAND	PCT
5JD	SOUTH LEICESTERSHIRE PCT	LEIC., NORTH. & RUTLAND	PCT
5LV	NORTHAMPTONSHIRE HEARTLANDS PCT	LEIC., NORTH. & RUTLAND	PCT
5LW	NORTHAMPTON PCT	LEIC., NORTH. & RUTLAND	PCT
RHY	TWO SHIRES AMBULANCE NHS TRUST	LEIC., NORTH. & RUTLAND	AMBULANCE
RNQ	KETTERING GENERAL HOSPITAL NHS TRUST	LEIC., NORTH. & RUTLAND	SMALL ACUTE OUTSIDE LONDON
RNS	TRUST	LEIC., NORTH. & RUTLAND	MEDIUM ACUTE OUTSIDE LONDON
RP1	TRUST	LEIC., NORTH. & RUTLAND	COMMUNITY WITH MENTAL HEALTH
RT5	LEICESTERSHIRE PARTNERSHIP NHS TRUST	LEIC., NORTH. & RUTLAND	MENTAL HEALTH
RWE	TRUST	LEIC., NORTH. & RUTLAND	ACUTE TEACHING OUTSIDE LONDON
5AL	CENTRAL DERBY PCT	TRENT	PCT
5AM	MANSFIELD DISTRICT PCT	TRENT	PCT
5AP	NEWARK AND SHERWOOD PCT	TRENT	PCT
5D2	WEST LINCOLNSHIRE PCT	TRENT	PCT
5D3	LINCOLNSHIRE SOUTH WEST TEACHING PCT	TRENT	PCT
5EA	CHESTERFIELD PCT	TRENT	PCT
5EC	GEDLING PCT	TRENT	PCT
5ED	AMBER VALLEY PCT	TRENT	PCT
5EG	NORTH EASTERN DERBYSHIRE PCT	TRENT	PCT
5EM	NOTTINGHAM CITY PCT	TRENT	PCT
5ER	EREWASH PCT	TRENT	PCT
5ET	BASSETLAW PCT	TRENT	PCT
5EV	BROXTOWE AND HUCKNALL PCT	TRENT	PCT
5EX	GREATER DERBY PCT	TRENT	PCT
5FA	ASHFIELD PCT	TRENT	PCT
5FC	RUSHCLIFFE PCT	TRENT	PCT
5H7	PCT	TRENT	PCT
5H9	EAST LINCOLNSHIRE PCT	TRENT	PCT
5HN	HIGH PEAK AND DALES PCT	TRENT	PCT
RBX	LINCOLNSHIRE AMBULANCE & NHS TRUST	TRENT	AMBULANCE
RCS	NOTTINGHAM CITY HOSPITAL NHS TRUST	TRENT	ACUTE TEACHING OUTSIDE LONDON
RFK	QUEEN'S MEDICAL CENTRE - NOTTINGHAM	TRENT	ACUTE TEACHING OUTSIDE LONDON
RFS	CHESTERFIELD ROYAL HOSPITAL NHS TRUST	TRENT	MEDIUM ACUTE OUTSIDE LONDON
RHA	NOTTINGHAMSHIRE HEALTHCARE NHS TRUST	TRENT	MENTAL HEALTH
RK5	SHERWOOD FOREST HOSPITALS NHS TRUST	TRENT	MEDIUM ACUTE OUTSIDE LONDON
RP7	LINCOLNSHIRE PARTNERSHIP NHS TRUST	TRENT	MENTAL HEALTH
RTG	DERBY HOSPITALS NHS FOUNDATION TRUST	TRENT	LARGE ACUTE OUTSIDE LONDON
RV6	TRUST	TRENT	AMBULANCE
RWD	UNITED LINCOLNSHIRE HOSPITALS NHS TRUST	TRENT	LARGE ACUTE OUTSIDE LONDON
RXM	TRUST	TRENT	MENTAL HEALTH

Note: The East Midlands SHA comprises the former Trent SHA and former Leicestershire, Northamptonshire and Rutland SHA

Figure 21: Regulatory Risks from Impact Pathways ❶-❷ Avoided by the East Midlands Strategic Health Authority by 2020, from Reducing Energy-related Carbon Emissions (RRS 4 only)



Conclusions

Summary of Economic Analysis

The Healthcare Sector is identified in the RES as one of four priority sectors likely to make the greatest contribution to the East Midlands' economy over the lifetime of the RES.

The climate change-related regulatory risks faced by enterprises in this sector derive specifically from:

- Direct and indirect carbon emissions by the sector; and
- The carbon content of intermediary products consumed by the sector to manufacture output.

Total annual carbon emissions from the Manufacture of Pharmaceuticals, Medicinal

Chemicals and Botanical Products and the Manufacture of Medical and Surgical Equipment and Orthopaedic Appliances in the East Midlands are estimated at about per 260 Kt CO_2-eq per year, of which 98% derive from the first group of manufacturers. Energy consumption is derived from natural gas and electricity in broadly equal measures over the two manufacturing groups.

Based on the forecast growth rates in the RES, in the East Midlands by 2020, and using our "best guess" risk scenario, we estimate that:

- The Manufacture of Pharmaceuticals, Medicinal Chemicals and Botanical Products sub-sector is estimated to incur additional annual (regulatory) costs, before taking any kind of action, of £17.0 million per year.
- The Manufacture of Medical and Surgical Equipment and Orthopaedic Appliances is estimated to potentially incur additional annual (regulatory) costs, before taking any kind of action, of £0.6 million per year.

Assuming that (a) the sub-sectors absorb all the additional costs and (b) that they take no action to mitigate carbon emissions, gross profits would be reduced by corresponding amounts.

If enterprises are able to pass on the additional costs in full, gross profit of the sector in the region is estimated to reduce by only £2.2 million per year by 2020.

Output from the whole sector in the East Midlands is estimated to decline by £8.2 million per year by 2020. A reduction in output of this magnitude will lead to additional output declines (indirect effects) in the wider economy of £6.7 million per year by 2020.

If enterprises in the Healthcare sector in the East Midlands were to source an additional 25% and 50% of their electricity from zero-carbon sources, relative to the current situation, the estimated costs of regulatory risks under our "best guess" risk scenario would fall by £1.4 and £2.8 million per year by 2020, respectively. This would save about 28 (25% zero-carbon electricity) and 56 (50% zero-carbon electricity) Kt CO_2-eq per year. Of course, the regulatory risk costs avoided need be compared with the financial costs of realising the carbon emission reductions, to see whether action is justified on private cost-benefit grounds.

Considering next the health care sector, total annual energy consumption by the East

Midlands Strategic Health Authority is estimated at 3.57PJ by 2020 (equivalent to 1.7GJ per m^2 of projected occupied floor space). Total annual carbon emissions from the East Midlands SHA are estimated at 286kt CO_2 eq. by 2020, compared to 271kt CO_2 eq. in 2005. Of this total, nearly half the total annual carbon emissions in 2020 arise from electricity use, with natural gas use accounting for a third.

Additional annual regulatory costs faced by the East Midlands SHA in 2020 are estimated to range from £1.4 to £16.4 million. Under our "best guess" scenario additional annual costs are estimated to be about £7.2 million. This represents the maximum possible additional annual cost under our "best guess" risk scenario, and assumes that the Trusts take no action to mitigate carbon emissions.

The average increase in total annual costs per trust, across all NHS Trusts in the East Midlands SHA, is £82,000. Annual costs to individual organisations range from less than £1000 (e.g. Newark and Sherwood PCT) to over £1 million (e.g. University Hospitals of Leicester NHS Trust).

Total energy costs incurred by the East Midlands SHA are predicted to rise between 4 and 49%; under our "best guess scenario" the predicted increase is 21%. The average increase in energy costs across all organisations is 21%, ranging from 6 – 46%.

If NHS Trusts in the East Midlands SHA were to source an additional 25% and 50% of their electricity from zero-carbon sources, relative to the current situation, the estimated costs of regulatory risks under our "best guess" risk scenario would fall by £1.0 and £1.9 million per year by 2020, respectively. This would save about 38 (25% zero-carbon electricity) and 76 (50% zero-carbon electricity) Kt CO_2-eq per year. Of course, the regulatory risk costs avoided need to be compared with the financial costs of realising the carbon emission reductions, to see whether action is justified on private cost-benefit grounds.

Policy Implications

Mitigation policy primarily represents a risk to the growth of the Healthcare sector in the East Midlands due to the increase in the cost of energy. The cost increases may alter the relative competitiveness of the East Midlands, for example, compared with enterprises located outside the EU. The significance of this will partly depend on demand and the ability and willingness of enterprises to pass through additional costs.

The actual outcome will depend strongly on mitigation measures employed by enterprises, by upstream suppliers and by energy producers. Measures include improvements in energy efficiency and a reduction in the GHG intensity of fuel inputs for example by generating or purchasing electricity from renewable sources.

There are also potential opportunities for the sector, for example, in relation to energy and fuel efficiencies. Opportunities may also be realised by being an early mover – maximising gains under the CCL and more generally through competitive advantage.

Potential barriers to taking advantage of opportunities or to reduce risks include awareness of mitigation options, awareness of the availability of funds in some cases to assist in mitigation efforts (e.g. Low Carbon Innovation Programme), and uncertainty as to the relative relationship between costs and benefits for the enterprise. Smaller scale enterprises and enterprises with relatively lower profit margins may face greater risks due to a lack of capacity to mitigate carbon emissions and actions may be needed to prevent an excess cost to such enterprises.

A further complicating factor in considering exploitation of these types of advantages is that the sector comprises a mix of private and public enterprises, as well as joint public-private financed (e.g. PPP) enterprises. There are also extended supply chains in this sector that comprise a mix of private and public sectors. Consequently, policy initiatives in the sector need to recognise the implied differences in policy design required to bring about effective mitigation action.

Significant uncertainties remain regarding policy targets and the costs of carbon and it will be prudent for emda to maintain a watching brief on these, along with emerging mitigation measures.

A number of initial recommendations can be drawn for emda to consider:

- Research into the ability and likelihood of companies passing on additional costs and the relationship with net effects on the regional economy.
- Facilitation of the generation of electricity from renewable sources – both at enterprise level and more widely.
- Development of a mitigation measures toolkit to help enterprises consider how to reduce GHG emissions and how much this may cost.

Emda's support in climate change mitigation for this sector will also help achieve other Priority Actions set out in the RES including:

- Providing Business Support on Resource Efficiency
- Reducing the Demand for Energy and Resources
- Utilising Renewable Energy Technologies
- Exploiting Low Carbon Technologies.

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Annex A – Basic Data

Table 19 presents summary business statistics for NACE DG 24.4 and DL 33.1. (Definitions of the business statistics are provided in the Method Section.) Note that:

- The data is for the UK; data is only available for a limited set of variables for the East Midlands.
- The data are median annual values over the period 2000-04. Rather than working with the most recent data, we decided to work with an average over a number of years in case the most recent year was unrepresentative of sector activity.

In order to facilitate analysis for the East Midlands, the business statistics in Table 19 are first normalised to the number of enterprises shown in row 1; the resulting statistics per enterprise are shown in Table 20. The statistics in Table 20 can be viewed as pertaining to the 'average' enterprise in each of the sectors. The analysis of regulatory risks outlined above is conducted for this 'average' enterprise.

To generate impact costs for the East Midlands, the enterprise-level results are subsequently aggregated over the number of enterprises operating in each sector in the region. Over the period 2000-04 about 55 and 45 enterprises were active, on average, each year in DG 24.4 and DL 33.1, respectively.

In adopting this approach we assume that the 'average' enterprise in DG 24.4 and DL 33.1 in the UK has identical economic performance characteristics to the 'average' enterprise in the East Midlands. Furthermore, by working with the 'average' enterprise we ignore the possibility that economic performance may vary markedly with enterprise size across a sector. Thus, while our results relate to the 'average' enterprise, they may not accurately reflect outcomes for very small enterprises or very large enterprises. While we can obtain the necessary business statistics for enterprises of different sizes, the matching energy data is not available. We are therefore restricted to working with the average enterprise.

Table 19: Business Statistics for NACE DG 24.4 and NACE DL 33.1 (2005 £) (Median annual values over the period 2000-2004)

Variable	Unit	NACE DG 24.4: Manufacture of pharmaceuticals, medicinal chemicals and botanical products	NACE DL33.1: Manufacture of medical and surgical equipment and orthopaedic appliances
Number of enterprises	number	481	1,726
Turnover or gross premiums written	£ million	15,747	3,100
Production value	£ million	14,049	2,684
Gross margin on goods for resale	£ million	1,054	222
Value added at factor cost	£ million	6,403	1,371
Gross operating surplus	£ million	3,433	586
Total purchases of goods and services	£ million	9,275	1,693
Personnel costs	£ million	2,970	785
Number of persons employed	number	72,873	34,444
Gross value added per person employed (apparent labour productivity)	£ 000 per employee	88	40
Personnel cost per employee (unit labour cost)	£ 000 per employee	41	23
Gross operating surplus/turnover (gross operating rate) (%)	%	0.2	0.2

Source: Eurostat, Structural Business Statistics Database (Industry, Construction, Trade and Services), Annual Enterprise Statistics.

Table 20: Average Business Statistics for Enterprise in NACE DG 24.4 and NACE DL 33.1 (2005 £) (Median annual values per enterprise over the period 2000-2004)

Variable	Unit	NACE DG 24.4: Manufacture of pharmaceuticals, medicinal chemicals and botanical products	NACE DL 33.1: Manufacture of medical and surgical equipment and orthopaedic appliances
Turnover or gross premiums written	£ mn per enterprise	32.7	1.8
Production value	£ mn per enterprise	29.2	1.6
Gross margin on goods for resale	£ mn per enterprise	2.2	0.1
Value added at factor cost	£ mn per enterprise	13.3	0.8
Gross operating surplus	£ mn per enterprise	7.1	0.3
Total purchases of goods and services	£ mn per enterprise	19.3	1.0
Personnel costs	£ mn per enterprise	6.2	0.5
Number of persons employed	number per enterprise	152	20

Source: Own calculations.

CASE STUDY 3: LOW CARBON OPPORTUNITIES OF LARGE SCALE BUILDING SCHEMES

Introduction

Construction is identified as a priority economic growth sector in the East Midlands Regional Economic Strategy (RES). This status partly results from the large-scale new-build housing development underway in the Milton Keynes-South Midlands (MKSM) sub-region. However, since construction, occupation and maintenance of buildings are responsible for around half of the UK's emissions of carbon dioxide, it is likely that the sector will be at the forefront of mitigation efforts. As such, it is important to assess the extent to which climate change mitigation activities may impact on the operations and activities of the sector in the region.

This case study therefore explores the effect of greenhouse gas mitigation on the energy use of the Construction sector, with particular regard for the MKSM development, and the potential that exists for businesses in the construction, and related, sectors, to exploit the resulting economic opportunities.

Overview of Sector

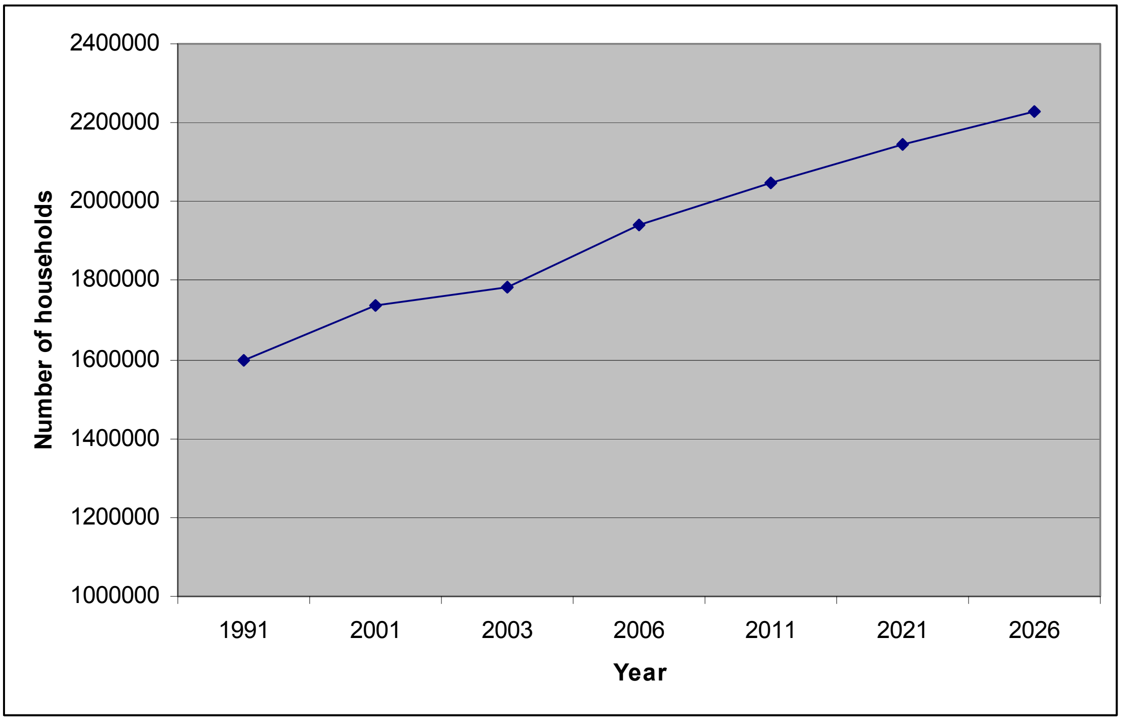
Construction is one of the four key sectors identified in the RES as priorities for economic growth (emda 2006). In 2006, the construction sector in the East Midlands employed 158,100 people and Construction output was worth £5.8bn (in 2000 prices) , accounting for around 9% of the UK sectoral total (Construction Skills Network, February 2008). Construction in the East Midlands has enjoyed a long period of continuous growth between 2001 and 2005, though with a 1% fall in 2006, reflecting the national trend. There is considerable scope for the construction sector in the East Midlands to grow. Figure 22 shows the increase in projected household numbers in the East Midlands (based on 2003 figures). The Regional Spatial Strategy for the East

Midlands (RSS) makes provision for this growth in households, providing for 320,000 new houses by 2020 (GOEM 2005). Within the Region there are a number of areas identified to be the focus of this housing growth, one of which is the MKSM sub-region. It is anticipated that an additional 169,800 houses will be built in MKSM by 2021 (GOEM 2005).

Projections of regional employment requirements in the construction sector forecast that the East Midlands will have an annual requirement of approximately 5000 construction workers between 2008 and 2012 (Construction Skills Network, 2008). Wood Trades and Interior Fit-outs are the sub-sectors with the largest annual employment requirement and are one of the largest existing occupational groups in the East Midlands.

The average house price in the Region was £159,000 in 2005 (DCLG 2007) and prices are expected to increase by 14% by 2011 (Construction Skills Network). This represents a significant opportunity for house builders and associated sub-sectors in the construction industry. However, it should be noted that this projection does not account for the current economic down-turn that is likely to limit house price increases in the short term at least.

Figure 22. Proposed increase in household numbers in the East Midlands



Source: DCLG 2006

Opportunities for low carbon building

Climate change represents both risks and opportunities to the construction sector. The construction industry has traditionally been a significant consumer of natural resources (e.g. energy, water, land) and producer of GHG emissions and so, as suggested above, is susceptible to mitigation risk. Clearly, though, there are likely to be corresponding opportunities in the sustainable property design and construction sector, as far as it is able to supply technical solutions that respond to international and UK legislation that requires lower emissions.

The Department for Communities and Local Government (DCLG) has published a timetable to achieve zero carbon homes (defined by the standards set out in the Code for Sustainable Homes (CSH)) by 2016. The CSH sets out national standards for sustainable design and construction of new homes. The Code measures the sustainability of a new home against categories of sustainable design, rating the 'whole home' as a complete package. The Code uses a 1 to 6 star rating system to communicate the overall sustainability performance of a new home; GHG emission reductions are one criteria of this sustainability performance measure.

DCLG's definition of a zero carbon home is a home which "*delivers zero carbon (net over the year) for all energy use in the home – cooking, washing and electronic entertainment appliances as well as space heating, cooling, ventilation, lighting and hot water*" (DCLG 2006b). The definition can be applied at a building or development level. The timetable for attaining this is as follows:

- 2010 - 25% improvement in the energy/carbon performance set in building regulations. This is equivalent to the level 3 energy/CO_2 standard in the CSH;
- 2013 - 44% improvement. This is equivalent to the level 4 energy/CO_2 standard in the CSH;
- 2016 - zero carbon. This is equivalent to the level 6 energy/CO_2 standard in the CSH.

This initiative is reinforced by EU-level legislation, in the form of the European Energy Performance of Buildings Directive (EPBD) which promotes the improvement of energy performance of buildings with the following four requirements to be fully implemented by the Member States by 2009:

- General framework for a methodology of calculation of the integrated performance of buildings;
- Setting of minimum standards in new and existing buildings;
- Energy Certification of Buildings;
- Inspection and assessment of heating and cooling installations.

The initiative is also currently supported at the regional government level within the UK. For instance, the East Midlands Regional Spatial Strategy (RSS) has two specific policies that align with these objectives: Policy 4: Promoting Better Design requires Local Authorities, regional bodies utility providers and developers to work together to ensure standards of design and construction are constantly improved. In addition, Policy 40: Regional Priorities for Energy Reduction and Efficiency requires Local Authorities to include policies and proposals to secure a reduction in the need for energy through the location of development, site layout and building design in Development Plans and Local Development Frameworks (GOEM 2005).

The construction of 169,800 homes in the MKSM growth area between 2006 and 2021 therefore represents a significant opportunity for the development of low carbon building materials and techniques in the East Midlands. The scale of the development is likely to be unique in the UK in this period and might be expected to present the opportunity for scale-economies to be exploited. This will allow cost advantages to be developed and utilized in parallel and subsequent construction programmes in the UK and internationally. DCLG 2006b also recognizes this potential, saying: “Driving forward an ambitious agenda of change with our housebuilding programme.…allows us to lead an emerging market in environmental technologies, pushing innovation and driving costs down. Estimates based on experience of low and zero carbon technologies indicate that costs could be reduced significantly for each doubling of installed capacity.”

Scope of Case Study

The overall purpose of the case study is to identify the economic and environmental impacts of GHG emission mitigation initiatives in the East Midlands construction sector, with emphasis on the economic opportunities arising, and so inform the policy decision making of emda and its partners. Since the MKSM development is the principal reason why construction is one of the four priority growth sectors in the RES the focus of the case study is on this development.

The case study identifies the benefits of GHG mitigation under the stated CSH targets above and explores the additional costs and benefits that would accrue were the development to adopt the CSH 6 Zero Carbon Standard for all construction from 2008 onwards. The case study will consider regulation on construction and building operations in the wider life-cycle context, the intention being to draw conclusions on the relative importance of this legislation in the overall construction process. Comparison of the costs and benefits associated with meeting the CSH Zero Carbon Standard in 2016 and in 2008 allows us to judge whether bringing forward the compliance requirement to 2008 is supported from an economic efficiency view. We then supplement this analysis by assessing the size of the potential additional market in clean technologies and associated products, and constraints that might exist in the realisation of these market opportunities. The study is therefore designed to inform emda, in its support for the Construction sector as a priority growth sector, as to how it can most effectively combine these economic objectives with its climate change objectives.

Estimating Costs and Benefits of reducing Carbon Emissions in the MKSM (EM) Housing Development

In order to investigate whether it is justified to bring forward the current schedule of adopting increasing CSH standards from 2016 to 2008 we identify the additional emission reductions and monetise these so that a direct comparison can be made with the costs of bringing about these reductions. In order to estimate the benefits of reducing carbon emissions in the MKSM housing development, we implement the following steps:

1. Establish baseline and mitigation scenarios for GHG emissions;
2. Estimate the annual emission reductions in the mitigation scenarios from the MKSM development, relative to the baseline;
3. Monetise the benefits from the mitigation scenario emission reductions;

4. Identify the annual costs associated with the GHG mitigation measures;
5. Estimate the net present value of the net monetary benefits (benefits minus costs) over the assumed development lifetime

Per household emissions under the current building regulations define an emissions baseline. Two mitigation scenarios are adopted: a) emission levels under currently proposed Government policy, as outlined above (CSH level 3 by 2010; level 4 by 2013 and level 6 by 2016); b) emission levels conforming to CSH level 6 from 2008.

In Table 21 the emission reductions required to meet each of the six code levels relative to those under current building regulations are indicated. Note that the Target Emission Rate is the maximum allowable carbon dioxide emissions per m^2 for energy use in heating, hot water and lighting which would meet the Building Regulations as defined in AD L1A of the Building Regulations[23]. The Dwelling Emission Rate is the estimated carbon dioxide emissions per m^2 for the building, as designed, for energy in use for heating, hot water and lighting[24]. CSH level 6 differs from CSH 5 because here it is required that net carbon dioxide emissions resulting from all energy used in the dwelling are zero or better. This includes the energy consumed in the operation of the space heating/cooling and hot water systems, ventilation, all internal lighting, cooking and all electrical appliances.

Table 21. CSH Carbon emissions relative to TER baseline

Code levels	Minimum % reduction in Dwelling Emission Rate Over Target Emission Rate*
1	10
2	18
3	25
4	44
5	100
6	"Zero carbon home"

[23] The Building Regulations for England and Wales Approved Document L1A: Conservation of Fuel and Power in New Dwellings (2006).

[24] Note that the effectiveness of design features in lowering carbon emissions depends principally on their being used appropriately by occupiers of the property.

Per household reductions are assumed to be 0.3 and 2.7 tons/annum under CSH levels 3 and 6, respectively (DCLG, 2007). The Regulatory Risk Scenarios (RRS) 1, 4 (Best Guess), and 6 were utilised to monetise the CO_2 emission reductions.

The partial Regulatory Impact Assessment of the proposed policy to make the stepped adoption of the CSH levels mandatory (DCLG, 2007) suggested a range of per property costs of meeting the different standards and we adopted these in the first instance. In line with the RIA we assume a typical dwelling size and so do not differentiate between different sized properties. In recognition of the substantial economies of scale and technical innovation possible in building technologies available, as highlighted in DCLG (2005b) and DCLG (2007) and the experience of the C40 project which brings together 40 mega cities in their efforts to mitigate climate change, we also make adjustments to the capital costs that appear reasonable given evidence to date (DCLG (2005b)). The range of capital costs assumed to meet CSH level 6 are £10,000, £15,000 and £30,000 per property, the latter figure being based on that used in the partial RIA undertaken in consideration of making the CSH standards mandatory (DCLG, 2007); the former figures are essentially sensitivities that reflect the possibility of technological innovation and subsequent economies. Technical innovation cost impacts are included using annual capital cost reduction rates of 2%, 5% and 10%. A twenty-year lifetime for each property is assumed, again in line with the assumption made in the partial RIA (DCLG, 2007), though this is likely to under-estimate GHG benefits that might accrue over a more realistic longer lifetime.

Results

The total CO_2 emission reductions in the MKSM development resulting from the two mitigation scenarios are presented in Table 22, below. A total of almost 70,000 new houses are planned to be built in the East Midlands part of the MKSM between 2008 and 2021. If the currently proposed policy of a stepped introduction of the CSH levels is adopted, the resulting emission reductions for MKSM (EM) from the planned new properties total 1.5 million tons of CO_2. If CSH level 6 were to be adopted from 2008, 3.72 million tons of CO_2 emission reductions would be realized in MKSM (EM). The equivalent savings for the entire MKSM development are 3.7 and 6.1 million tons respectively.

Table 22. Number of new dwellings in the MKSM sub-region and CO^2 reductions under alternative scenarios

	Number of New Dwellings				CO2 emission savings (Tons over 20-yr lifetime)	
Sub-area	**2008-11**	**2012-16**	**2017-21**	**Total 2008-2021**	**Current proposed policy**	**CSH level 6 from 2008**
S. Northants	990	1650	1650	4290	91,064	231,660
Northampton	4350	8750	8750	21850	482,778	1,179,900
E.Northants	1560	2100	2100	5760	115,944	311,040
Corby	2040	5300	5300	12640	292,336	682,560
Kettering	2430	3150	3150	8730	173,930	471,420
Wellingborough	1785	3425	3425	8635	188,985	466,290
Daventry	1620	2700	2700	7020	149,013	379,080
Total MKSM (EM)	**14775**	**27075**	**27075**	**68925**	**1,494,049**	**3,721,950**
Bedford/Kempston/northern Marston Vale	3150	5250	5250	13650	289,748	737,100
Luton/Dunstable/Houghton Regis and Leighton Linslade	3900	8000	8300	20200	457,585	1,090,800
Aylesbury urban area	2280	4400	4400	11080	242,782	598,320
Total MKSM (All regions)	**24105**	**44725**	**45025**	**113855**	**2,484,163**	**6,148,170**

In monetary terms, the benefits vary according to the value of the social cost of carbon assumed[25]. For the currently proposed policy scenario, the benefit ranges are shown in present value (i.e. discounted) terms in Table 23.

Table 23. Present value benefits of current proposed policy (£m)

	MKSM (EM)	MKSM (All)
SCC	PV Benefits	PV Benefits
RRS 1	19	34
RRS 4	24	42
RRS 6	31	55

For the CSH level 6 now scenario, the present value benefits are given in Table 24. It shows that the benefits are over 10 times higher in this scenario that those identified in Table 24 for the currently proposed policy.

[25] Note that the use of the social cost of carbon reflects the fact that public sector appraisal increasingly requires this monetary metric to be utilized to reflect the social welfare change (benefit) attached to a reduction of carbon emissions by one tonne.

Table 24. Present value benefits of adopting CSH level 6 from 2008 (£m)

	MKSM (EM)	MKSM (All)
SCC	PV Benefits	PV Benefits
RRS 1	235	404
RRS 4	278	478
RRS 6	346	594

The capital costs of bringing about these benefits are presented in present value terms in Table 25 and Table 26, respectively.

Table 25. Present value costs of current proposed policy under alternative policy cost assumptions (£m)

Cost/property	Costs rate of decline %	PV Costs	PV Costs
30000	2	661	1096
15000	5	304	503
10000	10	160	264

Table 26. Present value costs of adopting CSH level 6 from 2008 under alternative policy cost assumptions (£m)

		MKSM (EM)	MKSM (All)
Cost/property	Costs rate of decline %	PV Costs	PV Costs
30000	2	1394	2300
15000	5	580	955
10000	10	290	477

The results show that when the per property cost is £10,000, and the time-dependent cost reductions due to technical innovation are 10% per year, the PV costs are at most one-quarter of those when the per property cost is £30,000, and the time-dependent cost reductions due to technical innovation are 2% per year. The PV costs are around twice the size when CSH level 6 is adopted in 2008, compared to the current proposed policy.

When the PV benefits and costs are combined to derive net present values under the current proposed policy and CSH level 6 now, the results can be seen – as in Table 27 and Table 28 – to depend on the assumptions made; negative NPVs result with relatively high capital costs, combined with low social costs of carbon, whilst positive NPV results from relatively low capital costs and high rates of social cost of carbon. Comparison of Tables 3 - 6 shows that the capital cost assumptions dominate the results. Additional sensitivity analysis suggests that lengthening the assumed lifetime of the property will increase the PV benefits, but not sufficiently to change our conclusions.

Table 27. Net present value of current proposed policy under alternative policy cost assumptions (£m)

Cost/property	Costs rate of decline %	SCC	MKSM (EM) NPV	MKSM (All) NPV
30000	2	RRS 1	-444	-726
15000	5	RRS 4	-49	-68
10000	10	RRS 6	154	274

Table 28. Net present value of adopting CSH level 6 from 2008 under alternative policy cost assumptions (£m)

Cost/property	Costs rate of decline %	SCC	MKSM (EM) NPV	MKSM (All) NPV
30000	2	RRS 1	-1159	-1896
15000	5	RRS 4	-302	-477
10000	10	RRS 6	56	117

The positive NPVs in Tables 7 and 8, resulting from the lower capital cost assumptions, show that there is a strong public policy argument for incentives to be provided to construction-related businesses to pursue technical innovation and exploit economies of scale. Maximising the benefits of economies of scale could be seen as a matter for public policy to address. The experience gained at the mega city level from the C40 project can be translated to a regional level through partnerships between developments within the East Midlands. There is a potential role for emda in coordinating and facilitating the establishment of such partnerships. However, it is interesting to note – as shown in

Table 29 - that the incremental NPV of adopting CSH level 6 over the levels in the current proposed policy is negative for the MKSM(EM) and the entire MKSM development, thus warding against adopting the tighter emissions requirement until capital costs are lowered further. The main caveat in drawing these conclusions is that the analysis is based on an incomplete set of costs and benefits. Whilst there are no administrative costs included – which may be non-trivial – there is also no inclusion of

other environmental impacts (benefits or costs) or economic and social benefits e.g. energy security. It seems likely that the balance of these will make adoption of CSH level 6 now, more attractive relative to the currently proposed policy – though it is not known by how much.

Table 29. Incremental NPV between current proposed policy and CSH level 6 adoption in 2008 (£m)

Cost/property	Costs rate of decline %	SCC	MKSM (EM) NPV	MKSM (All) NPV
30000	2	RRS 1	-715	-1170
15000	5	RRS 4	-253	-409
10000	10	RRS 6	-98	-157

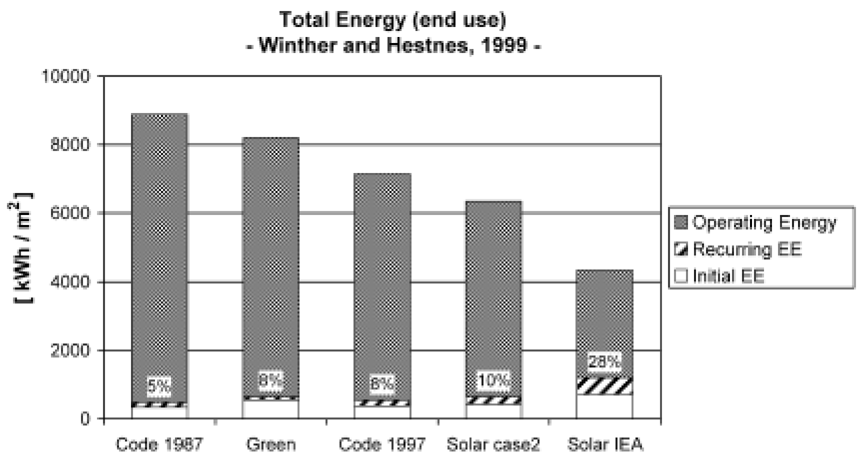
Construction sector climate change mitigation – Life Cycle Assessment considerations

One criticism that has been levelled at the proposed introduction of household emissions regulation using the CSH levels is that the DCLG definition of zero carbon is narrow; it only accounts for carbon dioxide released in the household's operation. Emissions during production and transportation of materials, construction and demolition are not included. In order to remedy this imbalance, the embodied energy of a house needs to be accounted for in the quantitative analysis. Embodied energy of a house is the total energy used (and resulting emissions) to manufacture, transport and dispose of materials, construct the building and demolish the building. As a rule, the more processing a material requires before it can be used, the greater its embodied energy. For this reason, metals such as steel, aluminium and copper have the highest embodied energy values. By considering embodied energy associated with a building, a whole life analysis of carbon dioxide emissions can be made.

In order to evaluate the significance of the criticism regarding the potential importance of embodied energy compared to operational energy use we reviewed the scientific literature. We found that the typical result is that the operational energy use comprises the vast majority of total energy. This is illustrated in

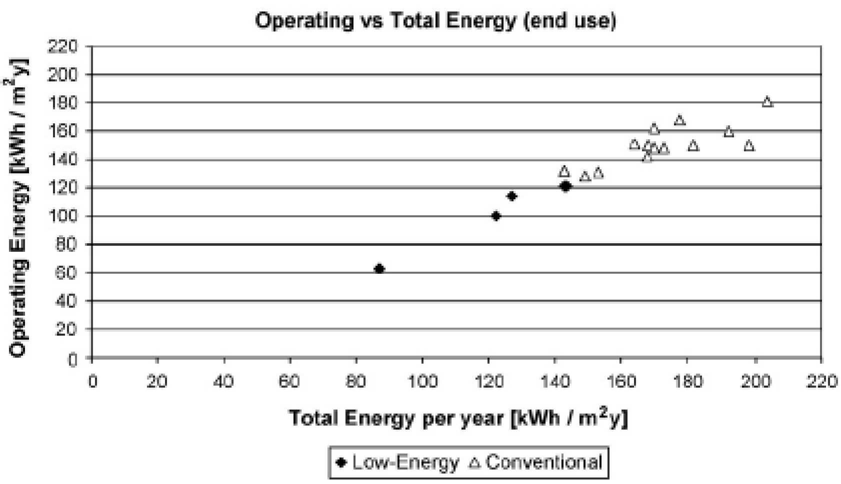
Figure 23 where five different energy sources and construction materials are utilized in a single residential unit specification. The figure demonstrates that the properties reliant on either solar or passive heating have higher proportions – on average - of total energy attributed to non-operational, embodied, energy than conventional constructions. Apart from the Solar IEA residence, all have 10% or less of total energy attributed to recurring and initial embodied energy. However, as the evidence in Figure 24 serves to re-iterate, a trend towards more energy conserving properties is likely to raise this proportion, whilst lowering the absolute levels of per property emissions.

Figure 23. Life cycle total energy in five versions of residential unit in Norway



Source: Sartori and Hestnes (2007). Note: Solar case2 and Solar IEA are low-energy buildings, the others are conventional technologies. “Green” means use of natural building materials.

Figure 24. Life cycle total energy plotted against operational use energy in alternative constructions



Source: Sartori and Hestnes (2007).

The evidence suggests that reducing the demand for operating energy is the most important aspect for the design of buildings that are energy efficient throughout their lifecycle. However, the secondary need to address embodied energy may be best dealt with by encouraging more recycling of high energy-embodying construction materials (Sartori and Hestnes, 2007). The finding also confirms that the reductions in absolute levels of emissions resulting from buildings that are operationally energy efficient further reinforces the overall net energy savings that accrue to society.

Estimating the Economic Impact of the Opportunities arising from responses to Regulatory Risks

The previous section quantified the extent to which carbon reductions from current baseline levels would be realised by the introduction of Zero Carbon Houses standards by 2016 (the current national target), or by 2008, and the costs associated with achieving these reductions. A principal finding was that a bringing forward of the target to 2008 would only be justified if the capital costs of meeting the target were lowered, through e.g. technical innovation or economies of scale. However, that notwithstanding, the size of the MKSM development is thought to be significant enough in market terms to realize some scale economies. The key issues that arise in relation to business opportunity, therefore, are: the likely scale of business opportunity, and its additionality to current business opportunities; the extent to which capacity presently exists to meet the current profile of implementation to 2016, and to meet an accelerated schedule to 2008. This section addresses these issues.

Nature of Low/Zero Carbon Opportunity

The scale of the market created by the MKSM development is defined by its projected profile of new-build. The MKSM sub-regional strategy projects an annual 5,110 new houses until 2011 before increasing to 5,730 between 2011 and 2021. As noted above, the additional capital expenditure required to bring about the emission reductions ranges between £10,000 and £30,000 per house. The annual increased expenditure is therefore between £51.1 million and £171.9 million. Assuming a mid-point of £86 million in addition to this range, and applying a GVA multiplier of 2[26], we estimate that an

[26] Derived from http://openscotland.gov.uk/Topics/Statistics/Browse/Economy/Input-Output/Tables2004Multipliers

addition to GDP of between £100 million and £340 million, with a mid-point of £170 million may be generated. Additional employment of 4,250 would then be associated with the mid-point expenditure, assuming a value of £40,000 per employee.

These estimates should though be caveated. For instance, the proportion of the additional expenditure that accrues to the East Midlands regional economy depends on where the low emission technology is sourced from and whether employees are imported in to the area. To explore these issues, in the following paragraphs we therefore present a range of technical measures that may be utilized on a household basis to reduce emissions before identifying business capacity that currently exists to implement such measures.

Designing and constructing a zero carbon building relies on two major principles;

- Reduce energy demand from the operation of the house as far as possible;
- Make provision for renewable energy sources to provide the energy that is required.

Table 30 lists a selection of measures and techniques that can be incorporated into the design and construction of new homes to reduce its energy demand and the potential renewable sources that can be used to generate electricity.

Table 30. Technologies and materials that could be included in a zero carbon home

Technology	Cost	Annual saving £/year	Carbon savings
Cavity wall insulation	£135	£100 – £120	>1 tonne per year
Internal wall insulation	$£40/m^2$	£210 - £260	0.5 – 1 tonne per year
External wall insulation	£1800	£220 - £270	0.5 – 1 tonne per year
Loft insulation	£135	£140 - £170	0.5 – 1 tonne per year
Condensing boiler	£100-£300 more to buy and install than a conventional modern boiler	£350	0.5 – 1 tonne per year
CHP (district)	£600-1500/kWe £3000-8000 per dwelling		
Micro CHP	£2500-3500 per home	£150	1.5 tonnes a year (1KW CHP unit)
Solar water heating	£2000-3000 for 4m2	£35 - £60	350 – 400kg per year

Technology	Cost	Annual saving £/year	Carbon savings
Solar photovoltaic	£2000-4000 5m2	£35	Each kWp can save approximately 325kg per year
Ground source heat pump	£800-1000 per kW heat. Typical 6-8kW system costs £6,500 - £11,500	£650	4.5 – 5 tonnes per year
Micro wind	Typical small system costs £2,500 - £5,000 per kW		0.1 – 0.5 tonnes per year
Biomass boiler	Typical 15kW around £5,000 - £11,000	£350	6 – 7 tonnes per year

Sources: National Energy Foundation http://www.nef.org.uk/actonCO2/carbonsavings.htm; EST 2007 and SDC 2007.

Figure 3. Relative cost and carbon savings of low carbon technologies

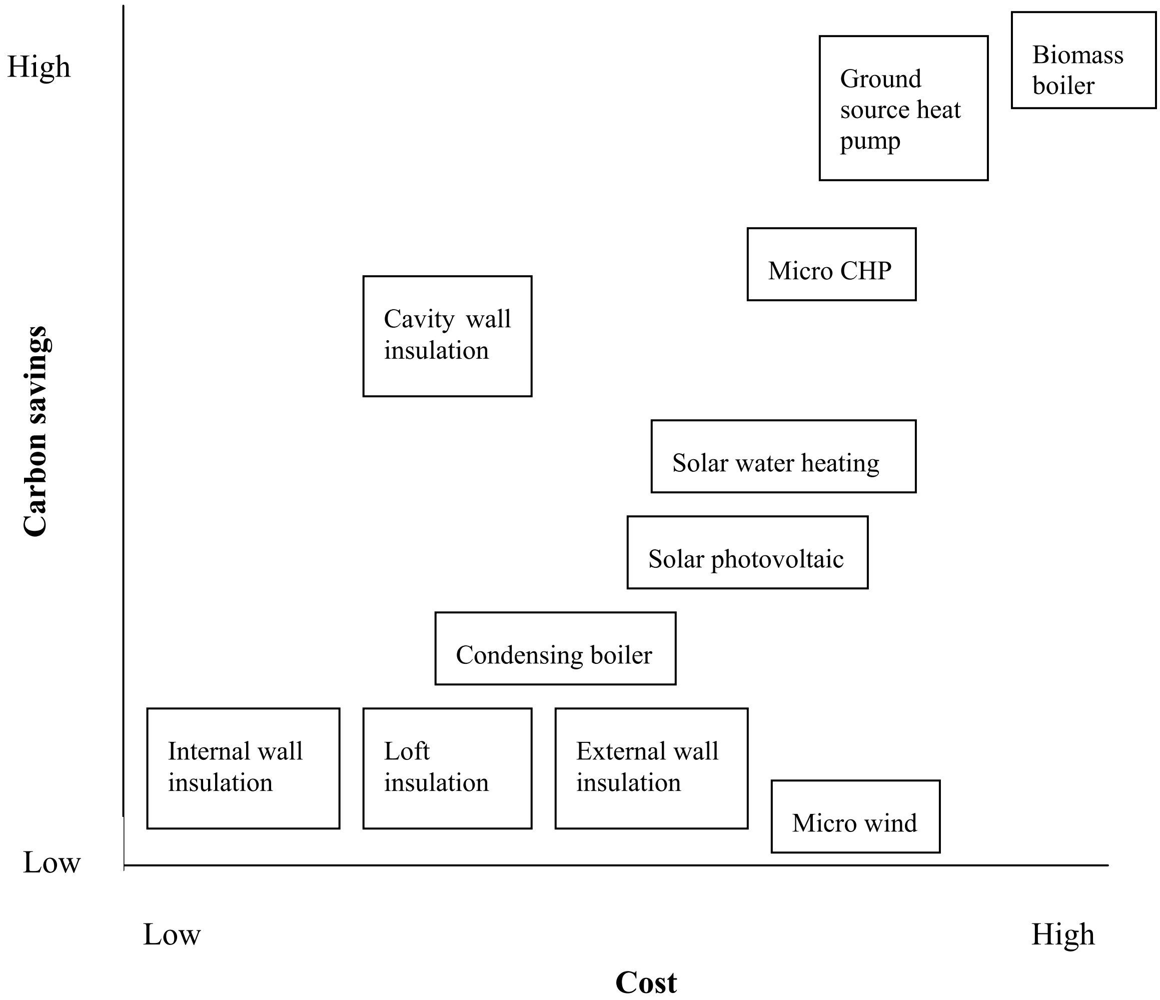


Table 30 serves to demonstrate, first, that there exists a wide range of different measures to reduce carbon emissions. The measures listed in Table 10 vary in cost and complexity. Figure 3 illustrates the relative costs and complexity of the technologies that could be included in a zero carbon home. One possible consequence of having such a wide selection of measures is that different house-builders use different measures so that the potential economies of scale possible in such a large development are not exploited. There is therefore a role for regional public policy to ensure a coherent and consistent response to the mitigation challenge in the MKSM development, augmented by use of criteria that include e.g. cost effectiveness, local availability of supplies etc.

Second, Table 10 illustrates that the majority of these measures can potentially be retro-fitted into existing houses, and so add to the potential market size. In this case, there is once again a public policy role for information dissemination that builds on the existing network of Energy Efficiency Advice Centres in the region, and the introduction of a financial incentive structure that allows market failures in the financing of capital investments in low carbon technologies to be overcome. In a similar vein, as a number of local authorities nationally have done, it would be useful to introduce in the RSS, a requirement to existing property owners to retrofit their properties as a pre-requisite for granting planning permission for extensions, change of use, attic conversions etc. Indeed, the South East Regional Spatial Strategy makes a similar demand on local authorities and other public bodies, as well as private property owners, when refurbishing their existing stock.

In addition to the technologies listed in Table 10, design can be used to reduce the operating emissions of property. For example, design that maximizes passive solar gain can reduce the energy requirement of heating and lighting systems within a property. However, the benefits of passive solar gain to reduce emissions must be weighed against the cost associated with adapting buildings to higher summer temperatures. Designing buildings to take account of natural ventilation can also reduce the need for mechanical ventilation and cooling. For example, orientating a building to face prevailing south-westerly winds and using a curved façade maximizes the effectiveness of natural ventilation and passive cooling.

Existing capacity in the Region

There are a number of firms within the East Midlands already offering the goods and services listed in Table 30, identified in Table 31. These firms are well placed to benefit from the first mover advantage available to those offering sustainable building services. There is scope for these companies to grow their business within the Region as demand for their products and service increases.

Table 31. Potential suppliers of low carbon construction technologies in the East Midlands

<table>
<tr><th colspan="2">Technology</th><th>East Midlands companies</th></tr>
<tr><td colspan="2">Micro wind electricity generation</td><td>- Iskra Wind Turbines Limited (Loughborough) – manufacture 5kw wind turbines
- Marlec Engineering Co Ltd (Corby) - manufacture battery charging wind turbines
- Sasie Ltd (Nottingham) – install StealthGen and Swift turbines
- Navitorn (Oakham) – turbine supplier
- Renpower Ltd (Wellingborough) – installers and consultants
- Willow Energy (Reepham)</td></tr>
<tr><td colspan="2">Solar hot water system</td><td>- Bright Energy Ltd (Derby) - design and installation of solar Heating
- Atmos Heating Systems (Daventry) – installer, supplier
- M E Mech (Lincoln) – installer
- Newark Copper Cylinder Co Ltd (Newark) - Designers and manufacturers of storage vessels specifically for solar applications.
- Solar Supply UK (Nottingham)</td></tr>
<tr><td colspan="2">Solar electricity generation</td><td>- Powersun Solar Systems Ltd (Nottingham) - Specification and Installation of Solar Thermal and PV systems.
- Solar Tech Ltd (Northamptonshire) - Installer, Supplier</td></tr>
<tr><td colspan="2">Micro CHP - <15kW electrical output</td><td>- Powergen is trialling WhisperGen micro CHP in East Midlands</td></tr>
<tr><td colspan="2">Ground Source Heat Pump</td><td>- Cool Planet Technologies (Higham Ferrers) - Designer and installers of Ground Source Heat Pumps and associated systems
- Hellidon Group Ltd (Daventry) - Installer and consultant
- Radiant Heating Solutions Ltd (Grantham) - Installer, Consultant, Designer, Manufacturer Specialist heating & cooling
- Hidden Energy (Daventry)
- Ground Source Solutions (Chesterfield, Derbyshire)</td></tr>
<tr><td colspan="2">Biomass heating system</td><td>- Rural Energy (Oakham) – supplier of wood fuel
- Koolfuel (Retford) – supplier of wood fuel</td></tr>
<tr><td rowspan="2">Roof insulation</td><td>Conventional materials (mineral wool, EPS)</td><td rowspan="4">- Isover Insulation UK (Loughborough) - manufacturer and innovator in mineral wool insulation
- YBS Insulation (Creswell) - manufacturers of reflective foil Insulation
- Mark Group (Leicester) - services for individual homeowners as well as builders, architects, local authorities and government bodies</td></tr>
<tr><td>New materials(news paper, Neopor, VIPs)</td></tr>
<tr><td rowspan="2">Wall insulation</td><td>Conventional materials – mineral wool, EPS</td></tr>
<tr><td>New materials – heat storage materials (Micronal), Neopor insulation board, VIPs</td></tr>
</table>

Scale of future opportunity

Projections of regional employment requirements in the construction sector forecast that the East Midlands will have an annual requirement of approximately 5000 construction workers between 2007 and 2011 (Construction Skills Network, undated). Wood Trades & Interior Fit-out are the sub-sectors with the largest annual requirement and are amongst the largest occupational groups in the East Midlands. It is forecast, (Construction Skills Network 2006), that total construction employment in the East Midlands will rise by 23% to 202,170 by 2011. Table 32 shows how this total is disaggregated by occupation. Additionally, we highlight, using italics, the occupational categories that correspond with the list of construction services presented in Table 30, above.

Following from our above mid-point estimate of 4,150 additional jobs, it is projected that the increased demand for sustainable construction services will further increase the number of jobs available in these occupations by 30-40% to 2021. This suggests that emda should target these areas as priority training needs. It also suggests that if there exist current skill shortages, there is little to be gained for the region in requiring a bringing forward of the Zero Carbon House standard to 2008.

Table 32 Employment within the East Midlands employment sector by occupation

Occupation ***Sustainable construction skills in italics***	**Employment (2005)**	**Employment forecast (2011)**
Senior and executive managers	580	720
Business process managers	3690	4420
Construction managers	13080	15560
Office based staff (not managers)	12590	14750
Other professionals/technical staff/IT	2470	3090
Wood trades and interior fit-out	19480	24390
Bricklayers	8050	10820
Building envelope specialists *Installation of insulation*	8720	11720
Painters and decorators	5940	7610
Plasterers and dry liners	3110	3690
Roofers	1310	1710
Floorers	2710	3300
Glaziers *Installation of low-e glass*	2810	3110
Specialist building operatives	4040	4930
Scaffolders	740	970
Plant operatives	2080	2510
Plant mechanics/fitters	2880	3250
Steel erectors/structural	1390	1660
Labourers	7070	8640

Occupation ***Sustainable construction skills in italics***	**Employment (2005)**	**Employment forecast (2011)**
Electrical trade and installation *Installation of energy efficient lighting, solar panels*	13030	15920
Plumbing *Installation of condensing boilers, solar hot water systems*	10020	12670
Logistics	2230	2830
Civil engineering operatives	2940	3740
Non-construction operatives	19430	23180
Construction professionals and technical staff	14420	16980
TOTAL	**164810**	**202170**

Source: Construction Skills Network (2006)

Policy Implications

The importance of the construction sector in accounting for current total national carbon emissions and the high profile of the large-scale MKSM development, amongst other developments, combine to ensure that the sector retains a prominent focus for carbon mitigation initiatives with the East Midlands. Whilst our analysis is incomplete, excluding the full range of relevant costs and benefits, it does suggest that the current national policy proposal for a stepped adoption over time of the carbon emission reductions specified in the Code for Sustainable Housing passes a social cost-benefit test. However, the bringing forward of the CSH Zero Carbon House standard is only justified in cost-benefit terms if the capital construction costs are able to benefit from sufficient economies of scale and technological innovation. If this is judged a worthwhile ambition, it is suggested that there may be a case for emda to leverage support for these industrial processes using fiscal, and other, incentives available to it.

The findings relating to wider life cycle emissions from housing do not alter, but rather re-iterate, the robustness of this policy implication. An additional policy requirement that arises from consideration of these wider effects; namely, the need to address embodied energy through encouraging more recycling of high energy-embodying construction materials.

There are significant implications for potential business opportunities stemming from these findings. First, the additional expenditures implied by the low emission construction technologies entailed suggest a potential annual boost to the regional economy of £100m - £370m. Second, the extent to which this potential is realised will be determined by the degree to which regional suppliers are able to meet this demand. A cursory survey of existing businesses has shown a significant supply capacity within the East Midlands, over a range of technologies.

Third, the very fact that there is a range of technologies on offer suggests the business community should work in conjunction with emda to ensure that a balance between supporting a diversity of technologies able to respond to an evolving market place, and focusing development of the sector in such a way as to fully exploit economies of scale from potential clustering of technologies within the region. Additionally, the capacity for retrofitting in existing households supports this argument and re-iterates the importance paid to information dissemination initiatives, and the introduction of a financial incentive structure that allows market failures in the financing of capital investments in low carbon technologies to be overcome, within the current Regional Energy Strategy documents. There is also scope for the RSS to encourage retrofitting of energy efficiency measures through planning policy. Fourth, the potential scale of expansion identified highlights the possible need to target training initiatives in this sector to ensure that the scale of opportunity is fully exploited by the region's businesses.

It is clear that if these suggestions for policy development are adopted, emda's support for mitigation in this sector will also help achieve other Priority Actions set out in the RES including:

- Developing Adult Workforce Skills
- Matching Skills Provision to Employer Demand
- Supporting Innovation and Diversification in Manufacturing
- Developing and Applying New Technologies
- Reducing the Demand for Energy and Resources
- Utilising Renewable Energy Technologies
- Exploiting Low Carbon Technologies.

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CASE STUDY 4: AGRICULTURE – COASTAL LAND PROTECTION

Introduction

It is widely appreciated that the East coast of England is vulnerable to climate change, as a result of projected sea level rise, tidal flooding, increased frequency of storm surges and salt-water intrusion. Analysis of climate change scenarios suggest that these types of impacts will become increasingly marked over the course of the current century. The Foresight research into future flood risks (Evans *et al*., 2004) also anticipated that coastal flood risk would increase to 2100; the research estimated that total expected annual damages in the coastal floodplain of the Environment Agency's Anglian Region (which includes the Lincolnshire coast) may rise from around £80 million to between £130 million and £1,400 million depending on the socio-economic and emissions scenarios. As a consequence of these projected changes, and as suggested by the impact costs provided by the Foresight research, the coastal zone is likely to be disrupted in a number of different ways. For example, increased property damage may result from greater flood risks in settlements, whilst coastal ecosystems may be vulnerable to sea level rise. The Lincolnshire coastline is at present predominantly rural, with the land mainly used for farm production. This case study seeks to investigate the impact of climate change on this agricultural activity. It adopts a more small-scale, sectoral-specific, perspective than the previous work by the Foresight project.

Context

Agricultural land uses cover over 1.2 millions hectares in the East Midlands, accounting for approximately 77% of land use (Defra, 2004). The Region is home to around 20,000 farms, employing over 41,000 people on a full or part time basis (ibid). The proportion of high quality, versatile agricultural land (grades 1, 2 and 3a) is higher in the East Midlands (47%) than the UK average (39%) (Emda, 2006a). Much of the Region's highest quality agricultural land is found in Lincolnshire.

The coastal zone comprises the administrative district of South Holland District Council, Boston Borough Council and East Lindsey District Council, following the working definition being used by the Lincolnshire Coastal Study Group (see Figure 1). Almost the entire Lincolnshire coast is currently at risk from tidal flooding (see Figure 2). Approximately 1,300 square kilometres of land is below normal high tide level, with 82,000 properties at risk (EA 2007). There is approximately 700 square kilometres of Grade 1 agricultural land at risk of coastal flooding and erosion. Flood risk along the Lincolnshire coast is a result of a combination of factors including sea and tidal conditions, rising sea levels and sinking land levels, the dependence on man-made defences, the low-lying nature of the land and the high quality agricultural land (EA 2007).

Figure 1 Lincolnshire coast

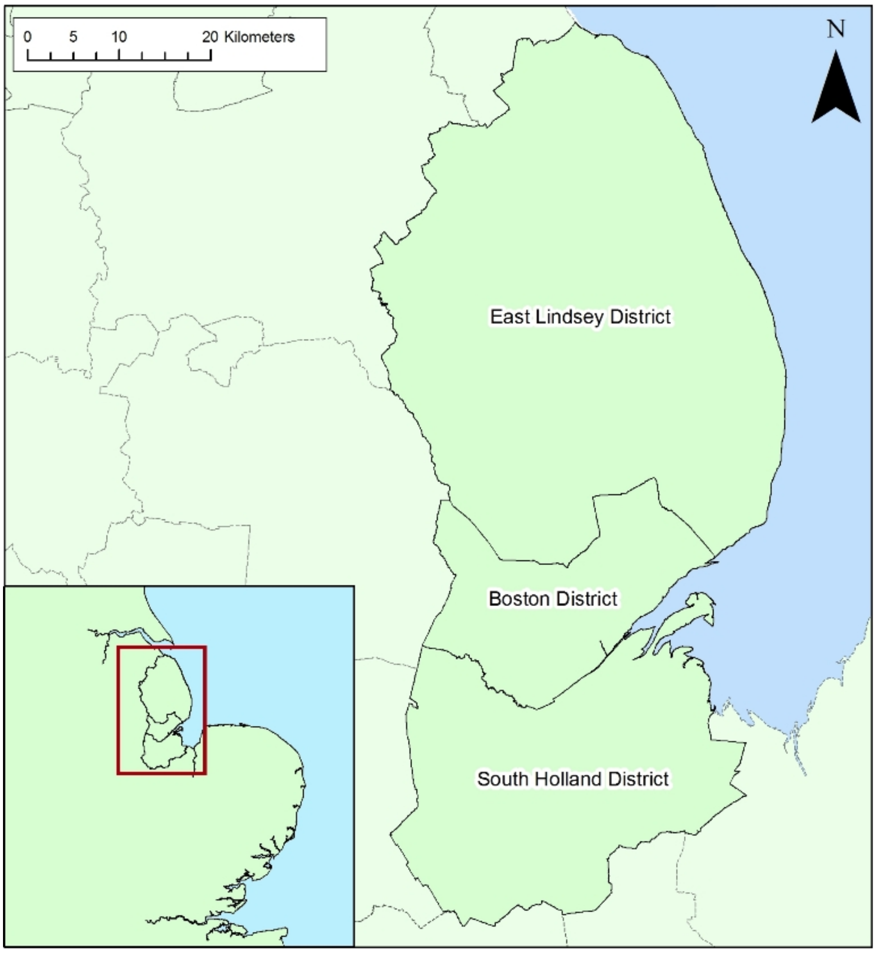
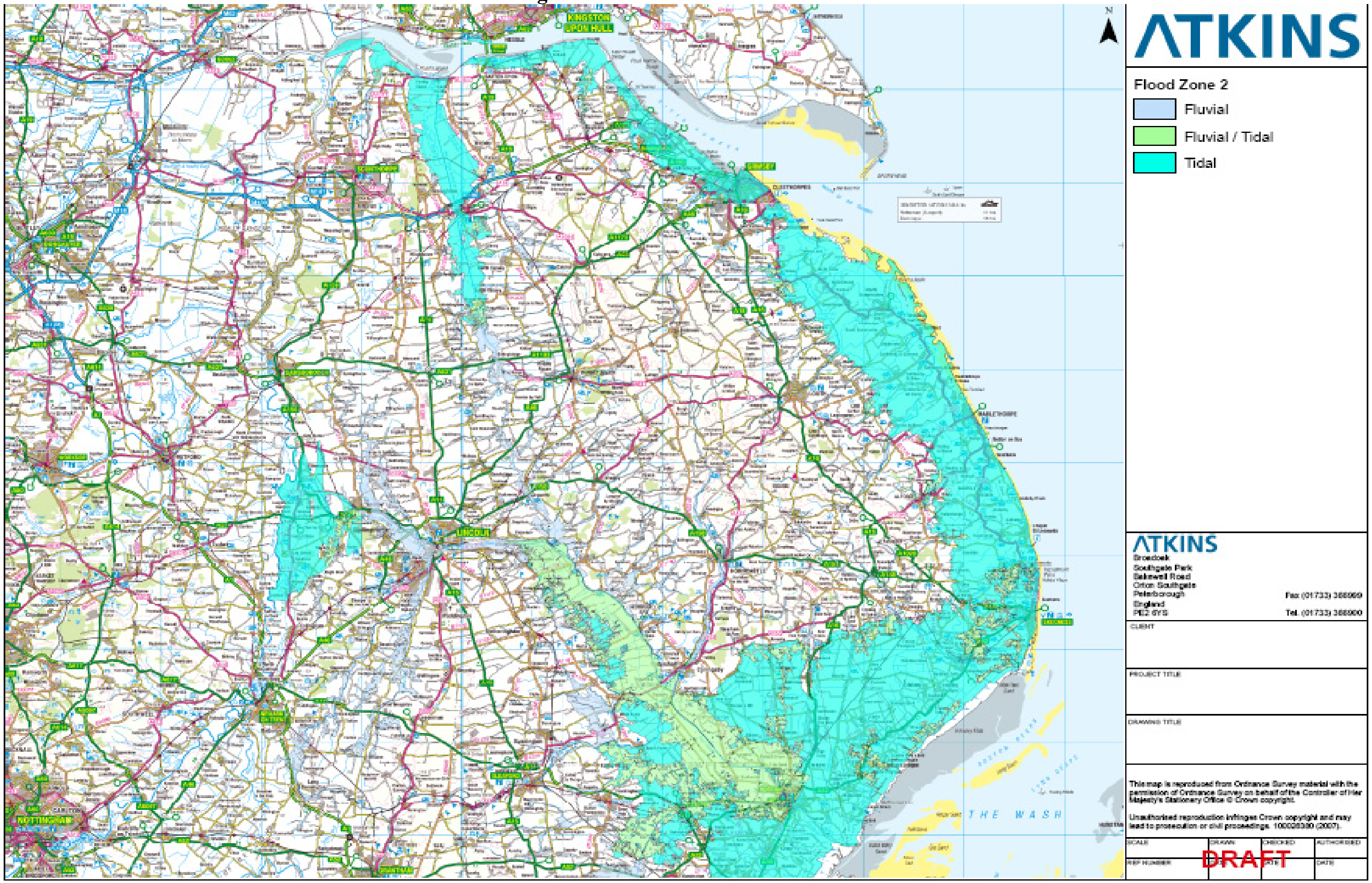


Figure 2 Current flood risk on the Lincolnshire coast

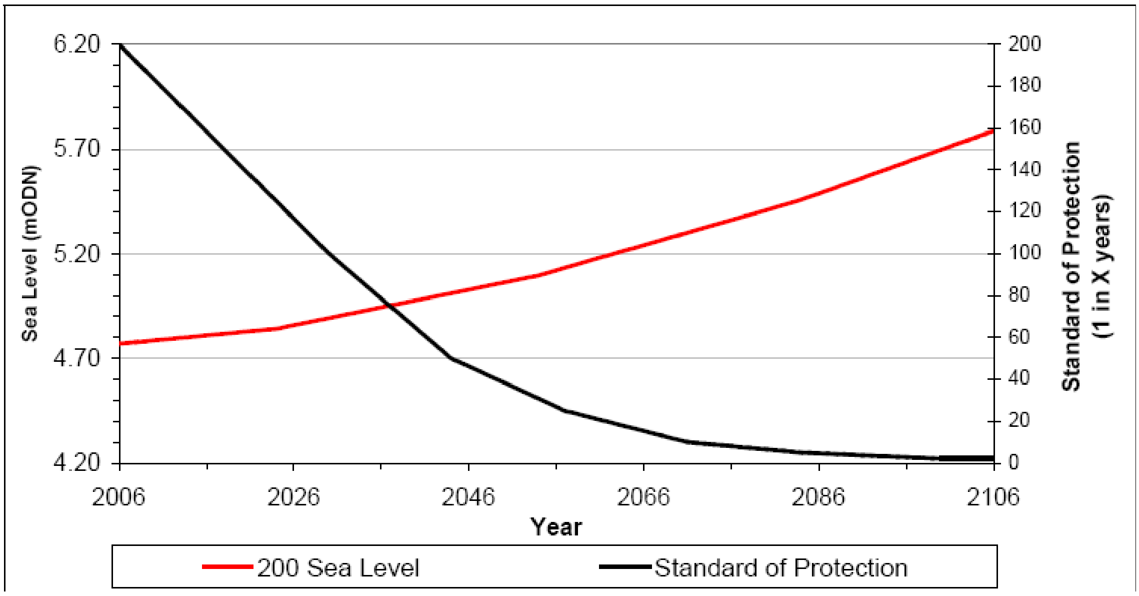


The risk of coastal flooding on the Lincolnshire coast is likely to increase due to climate change. In addition to mean relative sea level rise, climate change is likely to increase the frequency and magnitude of storm surge events. The UKCIP02 scenarios project that by the 2080s, the combined effect of sea level rise, vertical land movements and changes in storminess will result in a 50-year return period storm surge height off the Lincolnshire coast that will be 0.2 – 1m greater than at present (Hulme *et al*. 2002).

Defra guidance (based on UKCIP updated sea level rise projections) is for an allowance in the East of England of 4mm/year until 2025, 8.5mm/year between 2025 and 2055, 12mm/year between 2055 and 2085 and 15mm/year between 2085 and 2115 (Defra 2006).

The coastal zone is protected by an extensive network of raised engineered sea defences, which generally provide a standard of defence between 1 in 50 years and 1 in 200 years and are in fair to good condition (EA 2007). However, the standard of defence will decline significantly over the coming century as sea levels rise (see Figure 3). For example, a 200-year standard will decline to <10 year standard along the coastline between Mablethorpe and Skegness well before the end of the century, unless defence standards are raised (EA, 2007).

Figure 3 Reduction in Standard of Protection over time for the Lincolnshire coast



Source EA 2007

Scope of Case Study

The purpose of this case study is to investigate the economic impacts on the East Midlands agricultural sector of coastal impacts of climate change. In practice therefore the case study is focussed on the coastal area in Lincolnshire used in agricultural production. The quantitative analysis is centred on the flood risk to crops and livestock as a result of sea water inundation from changes in storm frequency. For this risk we identify the economic costs associated with loss of annual agricultural output that would result from a 1 in 200 year flood event, and interpolating the costs for less severe events that would occur with higher frequencies. The 1 in 200 year event is modelled now and under climate change (an assumption of a 1m change in sea level is included). To put a 1 in 200 year event into context, the return period of a 1.5m storm surge such as that experienced along the Lincolnshire coast during the 1953 storm, is 1 in 120 years (Sean Clarke, Met Office quoted in BBC 2003).

Other risks from climate change – such as coastal erosion (loss of land area), and soil salinisation (affecting crop productivity) are much harder to quantify at the local scale and so we describe these potential impacts in qualitative terms. Similarly, we indicate impacts on habitat changes, food security and biofuels qualitatively.

Analysis of Impact Risks

Physical Impact risks

<u>Method</u>

Our quantitative analysis is concerned with the impacts on agricultural production in the coastal region of Lincolnshire resulting from flooding from sea water inundation. The first element of this analysis is therefore to model the change in flood risk to this area as a result of climate change. This was undertaken by creating a new set of 1 in 200 year (0.5% annual probability) tidal flood outlines for current and future climate change scenarios for all areas at risk within the East Midlands Region. The climate change scenario used was the 2080s high emissions scenario which in terms of mean relative sea-level rise is 0.8m. However, given that the effect of storminess may add up to another 0.2m (on the 50-year return period storm), a gross figure of 1.0m has been used. The flood outlines were created using a combination of the GIS projection method and 2D hydrodynamic modelling. The latter was carried out during the creation of the original flood zones by Atkins on behalf of the Environment Agency in 2005. The flood risk modelling enables us to map the geographical area that would be inundated by sea flood water as a result of such an event under present-day (assumed to be non-climate change) conditions, and under climate change conditions in a 30-year time-slice centred on the 2080s. See Appendix 1 for further details of the data used and modelling method.

Results

Table 33, disaggregated by land use, with agricultural land categorised by its Agricultural Land Classification (ALC). They show that the total hectarage inundated by a 1 in 200 year flood event increases from just over 152,000 in 2007 to just over 172,000 in the 2080s – an increase of 12% (see Figure 4). Within this total it is notable that agricultural land is most vulnerable in both absolute and relative terms, with an increase of 17% in the area of agricultural land classified as Grade 2 inundated as a result of this flood event.

Table 33. Area of land within the EMDA NUTS1 Boundary inundated by a 1 in 200 year flood event for the present day and climate change scenarios, sub-divided by Agricultural Grade (ALC)

ALC Grade	2007	2080s	Difference (Ha)	% Increase
	Area (Ha)	Area (Ha)		
Grade 1	51,145	56,934	5,790	11
Grade 2	61,053	71,159	10,106	17
Grade 3	33,127	35,883	2,757	8
Grade 4	1,893	2,053	160	8
Non Agricultural	3,137	3,156	19	1
Urban	1,984	2,038	54	3
Total	152,339	171,223	18,885	12

Table 34 and Figure 4, disaggregated by Local Environmental Action Plan areas, (LEAPs), and by Agricultural Land Classification.

Table 34. Total Hectarages of Agricultural Land in coastal Lincolnshire, by LEAP and ALC

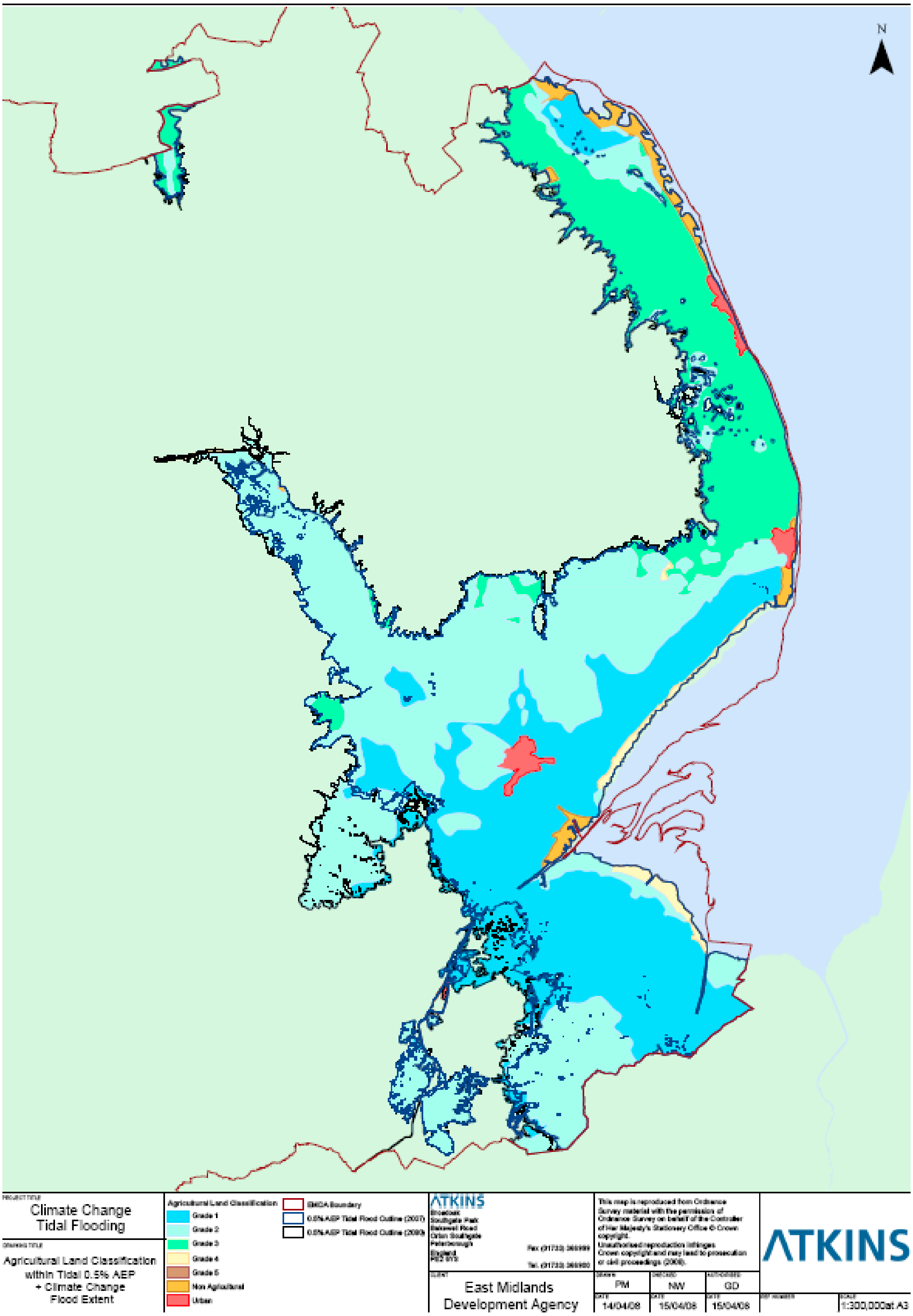
	ALC				
LEAP	**1**	**2**	**3**	**4**	**Total**
Welland	26,864	31,181	98,233	3,586	159,864
Witham	28,780	54,684	26,036	1,005	110,505
Upper Witham	179	55,877	132,628	1,971	190,655
Louth Coastal	4,366	25,510	69,784	784	100,444
Lower Trent and Erewash	6,170	29,159	118,566	5,156	159,051
Grimsby-Ancholme	2,187	38,456	57,432	2,353	100,428
Total	68,547	234,869	502,682	14,859	820,947

Combining the two tables allows us to estimate the inundation of land area, in percentage terms, resulting from a 1 in 200 year flood event in each ALC. These estimates are summarised in Table 3. The table shows that the total area of agricultural land inundated increases from a current 18% to 20% under a climate change scenario in the 2080s. The most striking result is that three-quarters of the most productive land – classified as ALC1 – would be inundated by this flood event at present, and this would increase to 83% in the 2080s under a climate change scenario.

Table 35. Area of land inundated by 1 in 200 yr flood event, as % of total area in each ALC in LEAPs

ALC	2007	2080s
1	75	83
2	26	30
3	7	7
4	13	14
Total	18	20

Figure 4 Area of land at risk of 1 in 200 year flood in 2007 and in 2080 (with climate change)



Economic Impact risks

Method

We wish to translate these estimates of physical flood inundation areas into estimates of economic loss. The principal way in which we do this is by modelling the productivity changes – in terms of change in economic output - to agricultural production in the sub-region. We assume that the modelled flood event occurs at a time of year that results in the complete loss of a crop, or that makes the land unusable for production for one year. We adopt the method for this impact suggested in Annex B to the chapter on Economic Appraisal in the Defra FCDPAG (Defra 1999). In this case, the Gross Margins approach to measuring the value of lost output is adopted. In this approach the loss is calculated by subtracting total variable costs (e.g. seeds, fertiliser, casual labour) from total revenue. The key methodological stages are as follows:

1. The flood events are modelled in order to derive the land area that is being directly impacted, apportioned to specific land uses. Thus, for each land use category, flood areas are estimated under a non-climate change baseline scenario, and a climate change scenario. The difference between these two areas equates to the net climate change flood impact, disaggregated according to its Agricultural Land Classification (ALC). We model a 1 in 200 year flood event and then carry out a linear interpolation across other, lower, return periods in order to estimate total climate change impact.

2. The net climate change flood impact expressed as land area, (from step 1), is then converted to loss of agricultural output. This is achieved by apportioning the output (in terms of crop type, livestock etc.) to the specific ALC by assuming that all horticultural crops are grown on ALC1 land or, if the acreage of horticultural crops exceeds the area of ALC1 land, that they are grown on ALC2 land. Other types of agricultural output are apportioned equally across the remaining ALC 1-4 areas. Data on the acreage of agricultural output in the area is derived from agricultural census data disaggregated by Local Environmental Action Plan (LEAP) areas. Losses from other land uses are ignored.

3. The value of the loss of agricultural output is derived by applying gross margins to the affected acreages calculated in step 2. We use the Gross Margins data

presented in the Agricultural Budgeting and Costing Book (ABCB) (Agro Business Consultants 2004) for each specific type of agricultural output. Since we do not have output data for the Lincolnshire coastal area disaggregated by crop or livestock type to the same degree as the ABCB we use relatively crude average values. These approximate to a value of £500 per hectare for livestock and non-horticultural crops and a value of £1,500 per hectare for horticultural crops.

Note that the method is necessarily simplified. There are a number of assumptions and limitations that should be borne in mind when viewing the results presented below. These are highlighted in the following bullet points:

- No socio-economic change is assumed; we therefore assume that there is no change in land use to the 2080s, and that the pattern of agricultural crop cultivation and livestock rearing remains unchanged from current patterns.
- Connected with the first point, we assume that farmers do not modify, or adapt, their agricultural production patterns in the face of a changing climate to the 2080s.
- We assume that occasional losses of output result from climate change induced coastal flooding. It is possible that these effects of climate change will be exacerbated by other climate change risks such as salinisation and coastal erosion, and that land is actually lost for agricultural purposes for the foreseeable future. In this case, the climate change impact costs presented here will be an under- estimate of the true costs. Conversely, we assume that the flood events act to destroy all of the agricultural output in the year within which it occurs. However, depending on the timing of the flood event relative to the seasonal sensitivity of agricultural production, we may be over-estimating the true costs.
- In this analysis we effectively ignore all other climate change impact costs apart from those of coastal flooding on agriculture. Thus, ecosystem values – for example - are not included in our cost estimates; suggesting that our estimates should be seen as a sub-total of impact costs only.
- A single climate change scenario is used, belying the fact that considerable uncertainty continues to exist in projections of future GHG emissions and on

resulting impacts. This uncertainty is likely to be exacerbated by the uncertainty pertaining to socio-economic futures, as mentioned above.

Results

The results of this estimation procedure are presented in Table 4 and Table 5. Table 4 shows the total flood impact on agricultural production over the ALC categories of a 1 in 200 year flood event in a no-climate change scenario whilst Table 5 shows the total flood impact for this flood frequency event in a climate change scenario. The flood impact is expressed in terms of the hectarage of agricultural land impacted and in terms of the value of agricultural output lost as a result of the hectarage impacted. Total impact costs increase form £98 million under the no-climate change scenario to £109 million under the climate change scenario – an increase of £11 million, equivalent to a 22 per cent increase. This increase is therefore the net cost of climate change for a flood event of this magnitude. The net costs of climate change of this flood event frequency are presented in Table 6.

Table 36. Costs (loss of Gross Margins) of a 1 in 200 year coastal flood event in the emda region – 2007, no climate change

	Hectares			Value (£ million)		
ALC	Hort. Crops	Other crops/ Livestock	Total	Hort. Crops	Other crops/ Livestock	Total
1	22,039	29,106	51,145	33	15	48
2	1,303	59,750	61,053	2	30	32
3		33,127	33,127		17	17
4		1,893	1,893		1	1
Total	23,342	123,875	147,217	35	63	98

Table 37. Costs (loss of Gross Margins) of a 1 in 200 year coastal flood event in the emda region – 2080s, climate change scenario

	Hectares			Value (£ million)		
ALC	Hort. Crops	Other crops/ Livestock	Total	Hort. Crops	Other crops/ Livestock	Total
1	24,534	32,400	56,934	37	16	53
2	1,519	69,640	71,159	2	35	37
3		35,883	35,883		18	18
4		2,053	2,053		1	1
Total	26,053	139,976	166,029	39	70	109

Table 38. Net costs of climate change for a 1 in 200 year coastal flood event in the emda region

	Hectares			Value (£ million)			
ALC	Hort. Crops	Other crops/ Livestock	Total		Hort. Crops	Other crops/ Livestock	Total
1	2,495	3,295	5,791		3.7	1.7	5.4
2	216	9,890	10,108		0.3	4.9	5.3
3		2,757	2,760			1.4	1.4
4		160	164			0.08	0.08
Total	2,711	16,101	18,812	Total	4	8	12.1

It is important to note that the climate change impact costs presented in Table 6 are associated with one coastal flood event frequency only. There are, however, likely to be additional impact costs associated with coastal flood events of other (higher) frequencies; if the derived costs, above, are to be utilised as an input to a decision-making process that determines an appropriate adaptation response to the increased flood risk, they need to be seen as a part of the total cost associated with climate change coastal flood risk. In order to provide an indication of the magnitude of these total costs we assume a linear negative relationship between flood frequency and cost that assumes that for a doubling of flood frequency (e.g. from 1:200 to 1:100) the cost halves as a consequence (e.g. from 12.1m to 6.1m). In turn, this type of linear relationship between flood frequency and cost implies a constant annualised cost associated with each flood frequency event, in this case, of £60,000. Summing these annualised costs across the range of flood frequencies gives a lower bound total annual cost – here £420,000 - associated with climate change induced coastal flooding in Lincolnshire under the climate change scenario adopted for the time-slice centred on the 2080s.

Table 39. Annualised net climate change costs (£m) for alternative coastal flood event frequencies in Lincolnshire, 2080s

Return period (years)	2	5	10	20	50	100	200	Total
Exceedance probability	0.5	0.2	0.1	0.05	0.02	0.01	0.005	
Cost of event	0.12	0.3	0.6	1.2	3	6.1	12.1	23.42
Annualised	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.42

Discussion

In the sections above we have made estimates of the coastal area in Lincolnshire that would be inundated by flood water as a consequence of a 1 in 200 year flood event under a non-climate change scenario and under a climate change scenario for the 2080s. We have then made estimates of the loss in value of agricultural production resulting from these flood events; the difference in the losses of value in the two scenarios is attributed as the net climate change impact. For the 1 in 200 year flood event, the net climate change impact is estimated to be £12.1 million, equivalent to £60,000 per year over 200 years – the annualised impact cost. This climate change impact is equivalent to a 12% increase in costs of a 1 in 200 year flood event that would be £98 million, in the absence of climate change.

Under certain assumptions we then estimate the net climate change impact over a number of other flood event frequencies and sum these to £23.42 million, equivalent to an annualised cost of £420,000. Since this latter estimate does not consider all flood event frequencies we may reasonably round this annualised total cost up to £500,000.

This annualised impact costs can be expressed in terms of lost jobs. If we assume that the annual marginal productivity of agricultural labour is equivalent to an output valued at £30,000, the climate change impact cost implies a direct loss of some 16 full-time jobs. Additionally, the resulting fall in income will result in less expenditure in the regional economy. Thus, applying an employment multiplier of two[27], the total employment effect is a loss of 32 jobs that can be attributed solely to climate change.

As identified when discussing limitations to the methodology above, the analysis does not take into account any changes in land use that might arise from socio-economic development over time or any responses that farmers or others might instigate in order to reduce such climate change impacts. In this respect these estimates may be seen to represent a worst-case scenario. At the same time, it should be recalled that there are additional climate change impacts expected to occur that may exacerbate the size of these estimates. Principal amongst these risks are those from coastal erosion resulting

[27] Derived from http://openscotland.gov.uk/Topics/Statistics/Browse/Economy/Input-Output/Tables2004Multipliers

from both sea level rise, storm surges, and enhanced wave action, together with the effects of increased soil and water salinisation, and increased water scarcity - with its implications particularly for irrigation in the sub-region. Quantitative estimates of these impacts do not currently exist at the sub-regional scale in which we are interested. However, estimates of coastal erosion in East Anglia by Evans *et al*. (2004) for the Foresight research initiative show a range of annual costs of £4 million - £13 million in the 2080s, compared to £1.2 million in the present day, and suggest that there may also be significant effects in Lincolnshire.

Other impacts of climate change on agriculture – qualitative commentary

<u>Salinisation</u>

Currently salinisation is not a widespread problem in the UK but sea level rise as a result of climate change may increase its occurrence. A rise in sea level leads to contamination of groundwater as salt water rises through the subsoil due to the hydrostatic pressure exerted by sea water.

Groundwater in low-lying coastal areas is considered to be very sensitive to climate change (Hiscock and Tanaka 2006) and as a result, salinisation is a potentially significant risk for agriculture along the Lincolnshire coast. As well as its topography, the nature of the crops grown in Lincolnshire make it vulnerable to salinisation. Horticultural crops are particularly vulnerable as yield quality is especially sensitive to stressed conditions (Spedding 2006).

A recent study into salinisation in Norfolk reported that a rise in sea-level in the 2080s to an elevation of 57cm and a 60% decrease in annual actual groundwater recharge under a Medium-High gas emissions scenario will potentially cause saline water to advance 1700m further inland into the coastal sand and gravel aquifer. As a consequence of the shallow depth of saline water in the coastal aquifer, the chloride concentration in coastal drains may increase to about 4000 mg/l in the 2080s (Hiscock and Tanaka 2006).

It is important to consider possible adaptation strategies to tackle salinisation of agricultural soils at the coast. Hiscock and Tanaka (2006) suggest a possible approach whereby the water level in coastal drains is maintained at a lower elevation than the inland drain elevation. Furthermore, there are methods to adapt involving changing land use. The Lincolnshire Coastal Grazing Marsh project is attempting to return arable land back to a pastoral system, which may increase resilience to climate change. Farmers are already changing land use to grazing in response to consumer demand for local, organic, rare breed meat. This change is highly compatible with adaptation, including flood risk management schemes involving managed realignment and habitat recreation.

The EU has recognised the threat posed by salinisation to Europe's soil resource and is currently consulting on a Soil Framework Directive. Under the Directive, Member States would be responsible for identifying risk areas with regard to salinisation, setting risk reduction targets and drawing up a programme of measures for reaching those targets.

Habitat creation

The Environment Agency (EA) is responsible for flood defence in the UK. Where flood defence activities result in loss or degradation of Special Protection Areas (SPAs) or Special Areas of Conservation (SACs), the EA is obliged under the Habitats and Birds Directives to re-create an equal amount of compensatory habitat. Defra/Natural England have a preference for providing compensatory habitat in close proximity to that being lost and as a result, habitat creation works are often located on coastal sites. This results in permanent conversion of agricultural land to conservation land and is a potential driver of loss of agricultural land in Lincolnshire.

Currently flood defence schemes are being progressed in Lincolnshire which require provision of compensatory habitat, including work on the Humber estuary. In addition to habitat lost as a result of the flood defence strategy, coastal squeeze (in part due to sea level rise) will lead to further loss. As a result, 720ha of new habitat will be required to compensate for the scheme (Environment Agency 2005).

One of the approaches to flood defence included in the Humber Strategy is managed realignment. Managed realignment involves identifying a new (inland) line of defence and, where appropriate, constructing new defences landward of the existing ones. As a result, new inter-tidal habitat is created and acts as a buffer, providing defence against flooding to the land behind it. Whilst managed realignment has benefits in terms of flood defence, it is another source of potential loss of agricultural land. In addition to the land lost to the sea, additional freshwater habitat must often be created to compensate for that lost due to managed realignment.

Alkborough Flats in North Lincolnshire is the first coastal managed realignment site to be developed as part of the Humber Shoreline Management Plan. The project delivers a combination of habitats, including lagoons, islands, reedbeds and grazing marsh and has been successful at attracting large number of birds. However, as a result of the habitat creation, 440ha of low-lying agricultural land has been lost.

The Lincolnshire coast between Saltfleetby and Theddlethorpe Dunes and at Gibraltar Point is a candidate SAC. All of the saltmarsh areas in Lincolnshire have been notified as Sites of Special Scientific Interest (SSSIs). In addition, all Lincolnshire saltmarshes are also within Special Protection Areas (SPAs) and the saltmarshes within The Wash also carry the Ramsar designation (Lincolnshire Wildlife Trust 2006). Whilst the current position on coastal flood defences on the Lincolnshire North Sea coast is 'Hold the Line' i.e. maintain the existing defence in its current position, there is little threat to agricultural land from habitat creation schemes. If in future this position was to change, potentially due to increased flood risk from climate change and sea level rise, it is possible that significant amounts of agricultural land would have to be converted to habitat creation land.

Biofuels and Food Security

Whilst no socio-economic changes are included in the modelling above, it should be noted that two issues of national strategic importance – food security and the production of biofuels – may have a bearing on land use in coastal Lincolnshire in future decades. A companion case study – Case Study 5 Food and Drink sector – demonstrated that climate change impacts in other parts of the world – as well as multiple other factors relating to the global supply and demand of foodstuffs – are projected to result in increasing prices of foodstuffs, either as inputs to processed food products or as unprocessed foodstuffs. One response to this upward price profile is likely to be a shift towards domestically produced food as its relative price falls. This may occur at the same time as land comes under increasing pressure as a resource for growing biofuels to mitigate climate change. Consequently, one might expect the value of domestic agricultural production to rise; the corollary of this is that the value of output loss from coastal flooding estimated in the preceding section will represent an under-estimate, as agricultural output prices rise over time. However, reform of the EU CAP and existing associated protectionist measures may also be expected to evolve over time, perhaps acting to lower agricultural output prices.

Deriving energy from biofuels is increasingly being seen as a potential strategy for mitigating climate change. Biofuels can be solid (for combined heat and power, CHP), and liquid for biodiesel and bioethanol. Solid biofuels include short rotation coppice, miscanthus and the use of agricultural and forestry wastes, which can be burned, gasified or pyrolysed for energy production. Liquid biofuels can be derived from existing crops such as oilseed rape, wheat and short rotation coppice.

There is already significant interest in the potential to grow energy crops in Lincolnshire with a number of conferences and meetings on the subject. It has been suggested that Lincolnshire could follow the Danish example and establish itself as a hub for rural biofuel production (Energy Saving Trust 2007). However, there are a number of economic and environmental costs and benefits associated with a move towards growing biofuels in Lincolnshire.

Costs

A major cost of switching from traditional crops to growing biofuels is the reduction in local food production. Currently agriculture in the East Midlands is estimated to supply the food and drink industry with a third of its raw materials (emda 2005). A recent survey has shown that the majority of food companies would prefer to purchase more of their raw materials from producers in the Region (emda 2005). It thus appears that demand for locally grown food products already outstrips supply; a switch to energy crop production in Lincolnshire would widen this gap further.

There is also a possibility that an increase in biofuels cultivation will increase food prices. In 2007 wheat prices hit a 10-year high, partly due to the growing demand for biofuels (Flood 2007). Biofuels are gradually taking over as the main growth driver of agriculture demand and analysts Goldman Sachs have calculated that if government policies are adopted in full, global demand for biofuels could increase from 10bn gallons a year to 25bn gallons by 2010 (Flood 2007). An increase in grain prices will have negative effects on consumers including food and drink manufacturers and individuals. However, for farmers, an increase in wheat prices is an attractive prospect.

Reducing the area cultivated for food crops will increase the volume of goods imported to the Region, thus increasing greenhouse gas emissions associated with transport. In this respect, switching to energy crops can be seen as a mal-mitigation whilst on the one hand, GHG emissions from energy production can be reduced, emissions from transport of food may increase.

As well as potential negative impacts on GHG emissions, reducing the area cultivated for food raises an issue over food security and self-sufficiency. In the UK, the self-sufficiency ratio of domestic production to consumption has been in noticeable decline over the last decade (Defra 2006d) and this is expected to continue, in part due to an increase in biofuels but also due to reform of the CAP and other drivers. There is a growing sense that food supplies could be disrupted in the future due to climate change, international energy concerns, geopolitical tensions and international terrorism (Defra 2006) and that securing adequate domestic food resources should become a political priority. Converting large areas of food producing land to biofuels may put further pressure on the nation's food supply. It could also lead to a greater demand for water. Growing biofuels could be seen as another example of mal-mitigation; whilst growing biofuels could contribute to climate change mitigation, it may make adapting to the impacts of climate change in the UK more difficult.

Benefits

In order to remain economically viable, farms increasingly have to diversify their products and services. One of the diversification ideas listed on the Welland Rural Diversification website, set up by emda, is energy crops. There are significant economic benefits to farmers from switching to energy crops.

There is an increasing market for energy crops due to Government targets and legislation to encourage the uptake of renewable energy. The Renewables Obligation (RO) is a market mechanism to increase installation of renewable energy such that 10% of grid-generated energy is provided by renewable energy by 2010. Coupled with the Renewable Transport Fuel Obligation (RTFO) due to begin in April 2008, this creates a market for energy crops in the UK.

The local market in Lincolnshire is also growing. A new straw fired power station to be built near Sleaford was announced in July 2007 (BBC 2007). Lincolnshire County Council has recognised the potential for biomass in Lincolnshire and has set up

Lincolnshire Green Heat scheme (LIGHT). Through LIGHT the Council provides advice and grant support to organisations wishing to install a biomass heating plant, with the additional benefit of kick-starting a market for energy crops in the county.

There are also financial incentives for farmers to switch to growing energy crops. Energy crops can be grown on set-aside land or if not on set-aside land, farmers receive a €45 per hectare payment under the Energy Aid Payment. Establishment grants are also available for short rotation coppice and miscanthus.

There is potential for farmers to gain a first-mover advantage by moving into the energy crop market early. There is an establishment period of approximately 4 years for short rotation coppice and miscanthus, so by establishing themselves as energy crop growers early, farmers will be well placed to take advantage of the growing market.

Conclusions and Policy Implications

The quantitative analysis in this case study has shown that climate change may increase the costs of coastal floods in the agricultural sector in Lincolnshire, East Midlands in the region of 12% by the 2080s. An annualised cost of around £500,000 has been estimated but a number of assumptions and possible land use changes identified above suggest that this cost may be an under-estimate of the real cost. It is recommended that emda work with GOEM, Defra, the Environment Agency and others to fully evaluate the consequences of changes to the value of agricultural production under various future scenarios. This should build on the Foresight Future Flooding Study (Evans *et al*. 2004) and ongoing Foresight work on land use change.

On the assumptions made in this study, the damage cost is small compared to the cost of coastal floods to other areas, particularly urban areas. The Foresight Future Flooding Study (Evans *et al.* 2004) found that future agricultural damages were less than 1% of total damages, except in the Local Stewardship scenario (15%), in which production costs significantly increase, while other risks decrease. However, the total damage costs of an event as assessed in this study are significant and may justify ongoing protection. Providing additional protection to deal with climate change will be easier to justify where existing defences are being replaced or upgraded. It is also important to consider the longer-term implications of climate change; sea-level rise will continue for several centuries and therefore economic damages are likely to increase, so precaution, or flexibility in policy and design will be prudent.

Action will also depend on non-agricultural reasons for protection including settlement, infrastructure, industry and biodiversity. Some loss of traditional agricultural land may be beneficial if overall risk is reduced, including to agricultural land further away from the coast. The Lincolnshire Coastal Grazing Marsh project, and existing changes to agricultural practices mean that agriculture and flood risk management measures may be highly compatible and opportunities such as this should be encouraged and supported.

The results of this study should be fed into ongoing coastal flood risk management processes. This includes the second round of Shoreline Management Plans (SMPs) and the Lincolnshire Coastal Study. Second generation SMPs for sub-cells 2c (Lincolnshire) and 2d (The Wash) are currently in production and will assess the impacts of climate change on the future strategic management of the coast. The Lincolnshire Coastal Study has been established following the Panel's review of the Regional Spatial Strategy and will evaluate how climate change will affect flood risk management and development issues along the Lincolnshire Coast. The study will also incorporate other social, economic and environmental considerations, including agriculture and the rural economy, and will contribute to a vision for sustainable development along the coast. Emda should be able to use its position on the project steering group to represent the economic interests of the coastal communities. It should continue the integrated delivery of economic development in the coastal zone working with other bodies including Lincolnshire Enterprise, East Midlands Tourism, Lincolnshire Tourism, the Coastal Communities Alliance, the Lincolnshire Forum for Agricultural and Horticulture, and local authorities.

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CASE STUDY 5: FOOD & DRINK SECTOR

Introduction

Food & Drink is identified as a priority economic growth sector in the East Midlands Regional Economic Strategy (RES) (emda 2006). As such, it is important to assess the extent to which climate change – the impacts associated with its physical effects, as well as regulation of greenhouse gases – may affect the operations and activities of the sector, and its projected economic performance.

This case study explores the effect of greenhouse gas mitigation strategies on the energy use of the Food and Drink sector and the costs that are potentially incurred as a result. The case study also explores the extent to which the domestic and imported foodstuffs that are used as an input to the region's Food and Drink sector's activities may be affected by climate change in their source countries, and the effects that this may have on sectoral costs.

Overview of Sector

Food and Drink is one of the four key sectors identified in the RES as priorities for economic growth (emda 2006). The sector is diverse with a mixture of agriculture (and related services) and food processing whilst East Midlands is home to a number of well known companies manufacturing food and drink products. The sector is a highly significant contributor to the Region's economy and contributes 17.5% to the regions Gross Domestic Product (GDP) employing 82,000 people, equivalent to 4.7% of regional employment and representing 11% of the UK's employment within this sector (Eurostat 2007).

The Region is also a hub for the import and export of food and drink products and the freight distribution sector contributes significantly to the regional economy: Thirty-three thousand tonnes of food and drink products are currently moved into, out of, or within, the Region by road freight annually (Sinclair Knight Merz 2002).

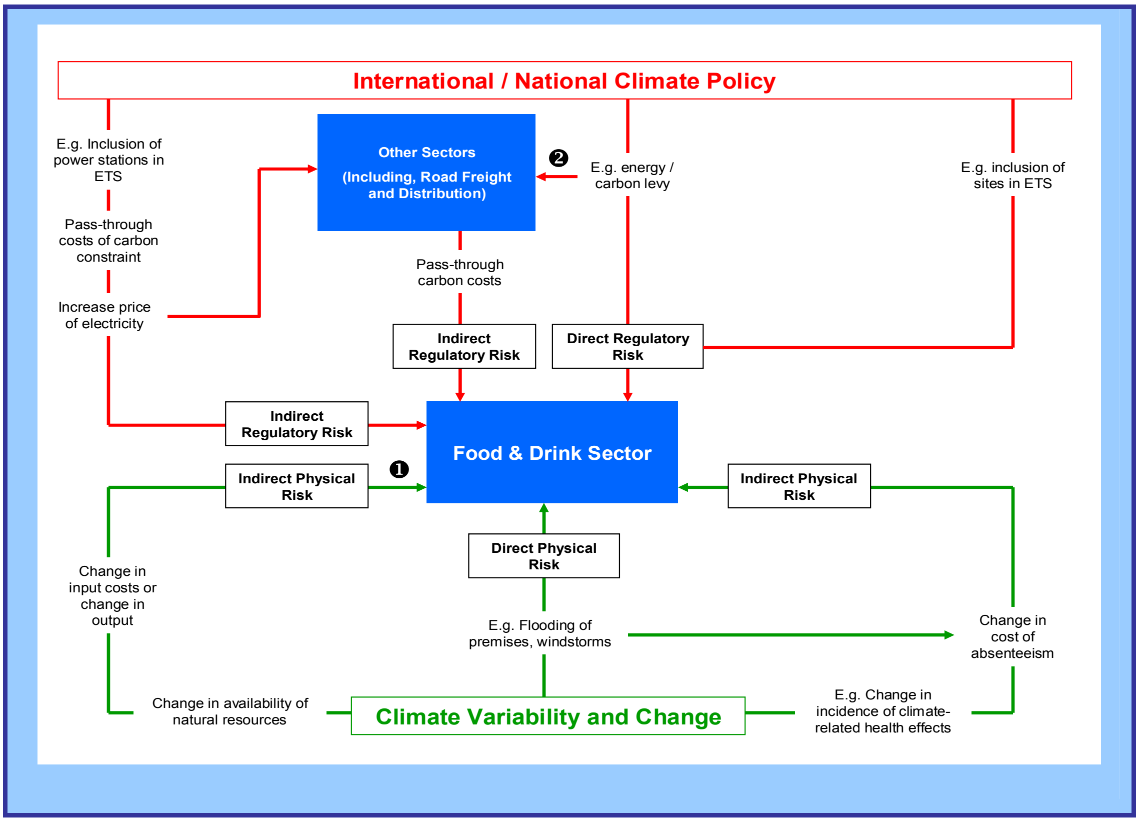
Scope of Case Study

There are many 'pathways' through which climate variability and change, and international and national responses to climate change, may directly or indirectly affect the Food & Drink sector in the East Midlands. Some of the key 'physical risk' (green arrows) and 'regulatory risk' (red arrows) pathways are highlighted in Figure 1. This case study analyses one regulatory risk and one physical risk pathway. With reference to Figure 1, we first quantify the economic impact on the sector associated with changes in the price of key inputs (specifically, agricultural products), where the price changes are the result of climate-induced reductions / increases in the supply of agricultural products (impact pathway ❶). Second, we quantify the regulatory risks associated with direct carbon emissions from the distribution of Food & Drink output by road (impact pathway ❷). In the latter case, we consider the economic impacts of regulatory risks to both the road haulage industry and the Food & Drink sector, if the carbon costs incurred by haulage operators are passed on to their customers in the form of higher freight rates.

The purpose of the case study is therefore two-fold. It is:

- To identify the threats and opportunities to the Food & Drink sector from changes in supplies of raw material inputs (foodstuffs) resulting from climate change impacts inside and outside the UK.
- To identify the economic impacts of greenhouse gas (GHG) mitigation in the Food & Drink sector, as a result of regulatory risk to sectoral freight and distribution.

Figure 25: Potential Climate Change-related Impact and Regulatory Risks to the Food & Drink Sector in the East Midlands

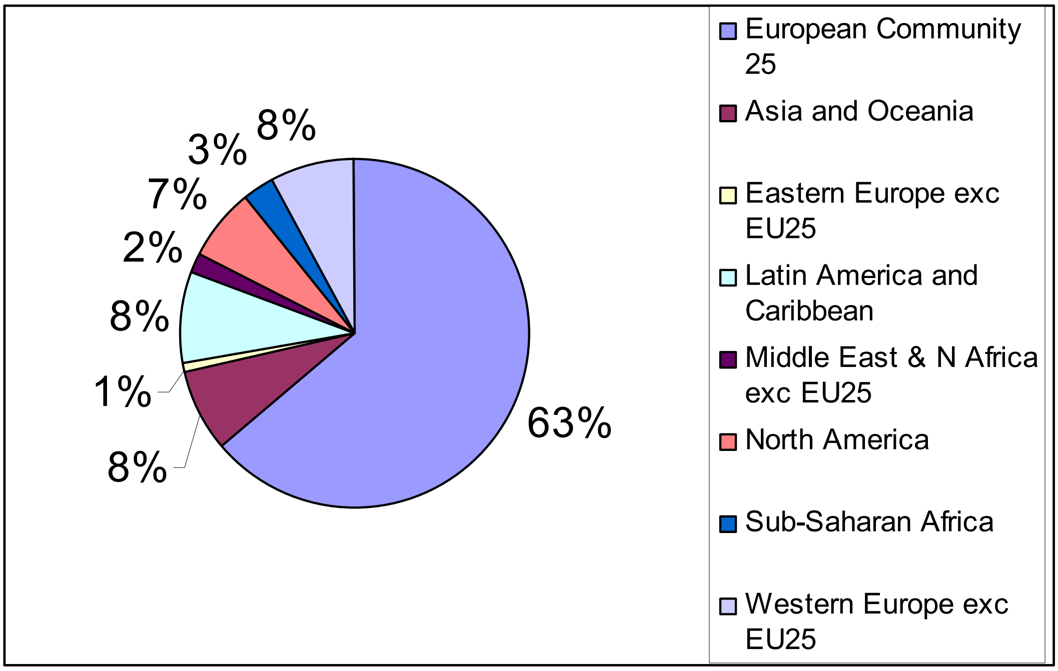


Analysis of Impact Risks to Agricultural Products

The food and drink sector is already vulnerable to adverse weather. In 2007, corn and wheat prices reached their highest levels for a more than a decade, while coffee prices hit an eight-year high and cocoa rose to a four-year high (Flood 2007). The strength of the coffee price was driven by adverse weather affecting production in Vietnam and Brazil, the two largest producers. Closer to home, the summer 2007 floods across the UK significantly affected agricultural yields, thus driving up prices. Crops in Lincolnshire were badly damaged by heavy rainfall resulting in a pea harvest of 90,000 tonnes compared with a normal yield of 150,000 (Rozenberg 2007).

Both the impacts of climate change and mitigation policy have the potential to negatively affect the food and drink sector in the East Midlands. The food and drink sector in the East Midlands has a sizeable international dimension; as is shown in Figure 2. Raw materials and food stuffs are sourced from a number of world regions, the European Union being dominant. Of the total supplies of raw materials and food stuffs for the East Midlands Food and Drink sector around 16% are sourced from overseas, with a value of £132 million in 2006. The remainder is sourced domestically, with 30% sourced from within the region and 54% sourced from elsewhere in the UK (emda 2005).

Figure 26. Origin of all food and drink products imported into the East Midlands, shares by value (2006)

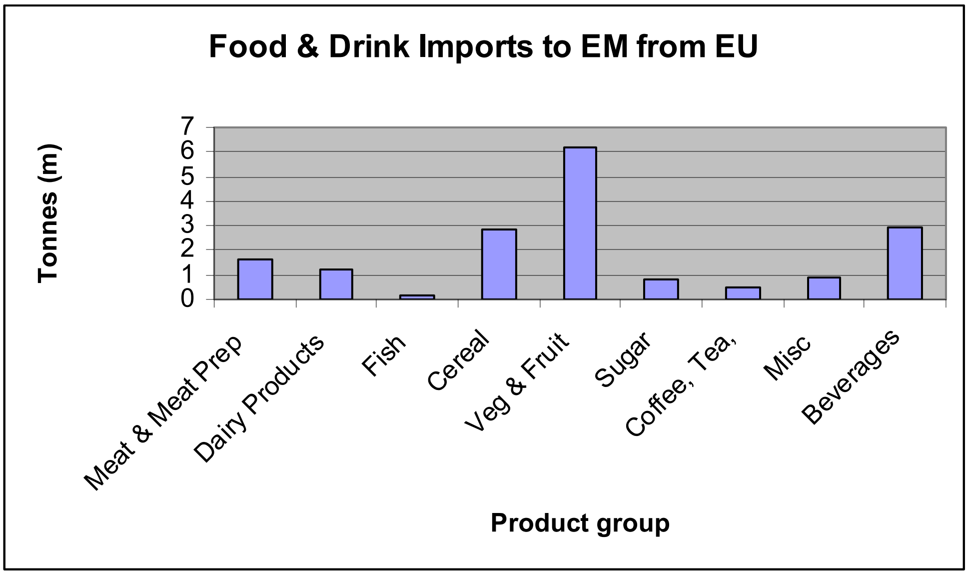


Source HM Customs and Revenue 2007

The impacts of climate change on the East Midlands food and drink sector will then, to some extent, be a consequence of changes in the supply of raw materials within the UK and from overseas. For example, we may expect to see changing patterns of global and regional crop distribution and yields. Consequently, the pattern of imports of food and drink products to the East Midlands may change.

More detail is provided on food import quantities for the EU as dominant export region to the East Midlands in Figure 27. The units are expressed in tonnes rather than in terms of value; nevertheless the figure shows that cereals and fruit & vegetables are significant product areas as inputs to the East Midlands. Current climate science from the IPCC Fourth Assessment Report suggests that a climatic warming will expand the area of all cereals northwards in Europe. However, warmer temperatures will also lead to an earlier start of growth in the spring and a shorter grain filling period, resulting in reduced yield if management is not altered. Drier conditions in the Mediterranean region may also lead to lower yields there and the need for adoption of new varieties and different crop management schemes. For many vegetable crops, increasing temperature will also generally be beneficial, with production similarly expanding northwards. A temperature increase will in some areas offer possibilities of a larger span of harvesting dates thus giving continuous market supply during a larger period of the year. For cool season vegetables such as cauliflower, large temperature increases may decrease production during the summer period in southern Europe. In relation to meat, heat stress has several negative effects on animal production, including reduced reproduction and milk production in dairy cows and reduced fertility in pigs. This may negatively affect livestock production in the warm months in the currently warm regions of Europe. Warming during the cold period for cooler regions may on the other hand be beneficial due to reduced feed requirements, increased survival, and lower energy costs. Impacts will probably be minor for intensive livestock systems because climate is regulated to some degree, though requirements for insulation and air-conditioning may change.

Figure 27. Quantities of food imports to the East Midlands from EU25 countries



It should be noted that these types of change do not necessarily present risk to the food and drink sector, only; there is an opportunity to profit from new products and new markets if firms are willing and able to adapt to this new world order in agricultural production. Root crops, such as sugar beet and potato, for example, are likely to be able to increase their geographical range, leading to lower prices as inputs to many ready prepared meals. However, firms that are unwilling or unable to adapt their production processes and patterns of imports may be threatened by such climate change impacts.

Overview of Approach

In order to assess the risks to the East Midlands Food and Drink sector from climate change it is useful to explore the extent to which raw materials and foodstuffs used in the sector may be impacted upon in their source country or region. More specifically, the agricultural production of these sectoral inputs may be impacted by climate change, e.g. through changes in mean temperature, CO_2 fertilisation, changes in precipitation patterns and subsequent water availability, changes in pest and weed incidence, and changes in the frequency and intensity of extreme events. It is suggested (see e.g. Parry, (ed.) 2000), that such impacts may affect agricultural yields and their subsequent supply price. This section in the case study investigates this possibility and traces through the likely implications for the Food and Drink sector in the East Midlands.

In undertaking this analysis, the overall method we initially adopt is comprised of the following elements:

a) Disaggregate current raw material imports to the East Midlands by country/world region of origin and by food type

b) Review the climate change impact literature in order to identify changes in yields and production for the countries/regions and food types described in a)

c) Map the climate change impacts identified in b) on to the current disaggregated categories of foodstuff imports to the East Midlands

d) Model the climate change impacts in terms of potential quantitative effects on supply price

e) Model the supply price effects identified in d) in terms of potential input cost changes for the East Midlands Food and Drink sector and subsequent effects on profitability.

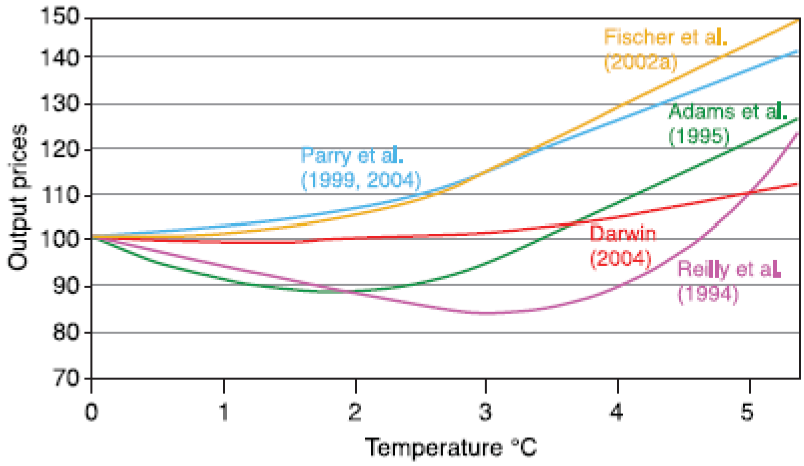
Note that this methodology assumes that today's pattern of composition and geographical sources of inputs into the operations of the Food and Drink sector in the East Midlands remains unchanged over the future time periods in which climate change impacts are projected. In other words, consumption patterns relating to the Food and Drink sector are assumed to be constant; no socio-economic change is included in the analysis. In reality, this will be a further complicating factor with an uncertain influence on product prices.

Our analysis requires us to identify the changes in costs of the foodstuffs input into the East Midlands Food and Drink sector. Since there are effectively global international markets for foodstuffs we therefore need to identify changes in world prices resulting from climate change; analysis at the individual source country scale is not necessary. An overview of price profiles to 2100 is compiled by Easterling et al. (2007), and presented here in e.g. pastureland productivity.

Figure 28. Note that cereal price changes are used as a proxy for all foodstuffs principally because impact studies of cereals have dominated sectoral studies and are, in

any case, likely to be representative of other impacts in the sector e.g. pastureland productivity.

Figure 28. Cereal prices versus temperature increases in global studies



In our analysis we adopt the results from the Parry et al. (2004) study. Not only is this one of the most recent studies, its results also constitute a high-end estimate of the possible climate change impacts on commodity prices. The study includes carbon fertilization effects[28] and incorporates the effect of changing trade flows consequent on the climate change impacts on productivity. Inter-governmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) socio-economic change (population and economic growth) (Nakicenovic and Swart, (Eds). (2000)). are also built into the trade models, whilst a variety of adaptation responses are also included. The results for the A2 (medium-high) emissions scenario are adopted. Note that a lower-end estimate e.g. from Darwin (2004) is likely to lead to insignificant impacts over the time period considered.[29]

The changes in food prices identified by Parry et al. (2004) are interpreted in our

[28] The enhancement of plant productivity due to higher atmospheric carbon dioxide levels.

[29] Note that whilst the two earlier studies – Darwin et al. (1994), Adams et al. (1995) – project price falls for low levels of global mean temperature increases, and suggest possible commercial opportunities deriving from lower input costs, their results are based on what are now considered to be unrealistically high levels of carbon enrichment. Consequently, we suggest less weight be given to the lower end results.

analysis in terms of changes in input costs to the Food and Drink sub-sectors. An own price elasticity – assumed to be of 0.5 – dictates the extent to which the cost increases can be passed on to consumers. The resulting changes in input costs borne by the firms within the sub-sectors are then expressed in terms of the percentage by which they reduce the Gross Operating Surplus (GOS), adopted as a proxy for profit levels.

Results

The estimated changes in costs, as a percentage of the GOS, are presented in Table 1 alongside the GOS estimated for the East Midlands for 2004 (from Eurostat data). The four sub-sectors whose profitability is most vulnerable under the future climate change-induced price scenarios are highlighted in the table, in bold italics: Production and preserving of Meat and Poultry Meat, Operation of dairies and cheese making, and Manufacture of prepared feeds for farm animals. In these sectors, profitability is reduced by 10-20% in the 2020s and by 20-40% in the 2080s. As the GOS totals imply, their relatively high profit vulnerability principally results from their having relatively low GOS levels, as well as a relatively high proportion of raw material inputs in total costs. Other sub-sectors' profitability is generally negatively impacted by under 5%.

Table 40. Cost increases expressed as % of East Midlands Food & Drink sub-sector GOS in future time-periods, and GOS (£m) in 2004

Sub-sector	GOS	2020s	2050s	2080s
Production and preserving of meat	***36***	***12.4***	***14.3***	***24.8***
Production and preserving of poultrymeat	***28***	***11.1***	***12.9***	***22.3***
Production of meat and poultrymeat products	98	7.4	8.6	14.8
Processing and preserving of potatoes	63	1.8	2.1	3.6
Processing and preserving of fruit and vegetables	67	4.6	5.3	9.3
Operation of dairies and cheese making	***36***	***19.5***	***22.5***	***39.0***
Manufacture of ice cream	7	2.4	2.8	4.9
Manufacture of prepared feeds for farm animals	***16***	***19.5***	***22.5***	***39.1***
Manufacture of bread, cakes etc	126	2.9	3.4	5.9
Manufacture of rusks and biscuits	50	3.4	4.0	6.9
Manufacture of cocoa; chocolate and confection	170	1.6	1.8	3.2
Processing of tea and coffee	51	2.0	2.3	3.9
Manufacture of condiments and seasonings	35	3.9	4.5	7.9
Manufacture of other food products	124	3.2	3.7	6.4
Manufacture of beverages	668	1.6	1.8	3.2

Table 41 below, presents the results in absolute monetary terms for each sub-sector and for the Food and Drink sector as a whole. The results are based on current (2004) GOS data. They suggest that just under £2 million of GOS may be lost in the sector each year as a whole as a result of climate change in the 2020s. In absolute terms, the four sectors that suffer an annual loss of more than £200,000, highlighted in bold italics, are: Production and preserving of poultry meat; Processing and preserving of potatoes; Dairy and cheese, and; Processing of tea and coffee. Combined with the results from Table 40, it serves to emphasise the relative vulnerability of the dairy and cheese sector, and the possible need for policy support action to be targeted towards this sector.

Table 41. Modelled annual losses in East Mids. Food & Drink sub-sector GOS (£M, 2005 prices)

Sub-sector	**2020s**
Production and preserving of meat	0.15
Production and preserving of poultrymeat	***0.21***
Production of meat and poultrymeat products	0.13
Processing and preserving of potatoes	***0.23***
Processing and preserving of fruit and vegetables	0.07
Operation of dairies and cheese making	***0.23***
Manufacture of ice cream	0.01
Manufacture of prepared feeds for farm animals	0.10
Manufacture of bread, cakes etc	0.03
Manufacture of rusks and biscuits	0.09
Manufacture of cocoa; chocolate and confection	0.14
Processing of tea and coffee	***0.20***
Manufacture of condiments and seasonings	0.14
Manufacture of other food products	0.05
Manufacture of beverages	0.16
Total: Food and Drink sector	**1.93**

Clearly, these estimates hide significant uncertainties, not only due to the assumptions adopted but also in the climate change scenarios and climate impact (price change) modelling. It should also be remembered that these estimates are likely to constitute the high end of estimates since the price changes adopted are from a medium-high climate change scenario within a study that gives larger adverse price changes than other similarly designed studies. A lower end to the price range is provided by the Darwin et al. (2004) study which effectively projects unchanged prices at lower global mean temperature increases. For reasons given above, however, we place less weight on these lower end results.

Additionally, we assume that all foodstuff inputs to the Food and Drink sector are affected by the projected price increases. However, the UK is a temperate country which, is not expected to be as adversely affected as some other source countries. To the extent that there are domestic markets in foodstuffs not impacted by changes in global markets, this suggests that – since imports constitute only 16% of total foodstuffs used in the UK – the negative impact may be much reduced. The same percentage applies to the East Midlands; for this reason we do not expect this region to be differentially impacted.

Analysis of Regulatory Risks to Road Haulage

The freight sector in the East Midlands is unlikely to be directly affected by a changing climate but may be impacted by mitigation legislation in response to climate change. The impact will be felt mainly through changes in UK and international legislation. Until recently, firms have not had to pay for damage done as a result of GHG emissions; these costs have been externalised. This case study assesses the mitigation risk posed to the freight sector in the East Midlands by regulatory regimes that aim to internalise the cost of carbon. The knock-on effects for the food and drink industry, one of the major sources of freight in the Region, will also be assessed. Mitigation policies likely to affect the freight and distribution sector include:

- Renewable Transport Fuel Obligation (RTFO);
- National road pricing.

The RTFO Programme will, from April 2008, place an obligation on fuel suppliers to ensure that biofuels constitute a certain percentage of their aggregate sales. The effect of this will be to require 5% of all UK vehicle fuel sold on UK forecourts to be derived from a renewable source by 2010. Bio-fuels are currently more expensive to supply than fossil fuels so there is a risk of increased fuel prices, directly affecting the road freight/distribution sector and the industries it serves.

The LRUC was a proposed charge that would be levied on all lorries, regardless of nationality, using UK roads. Off-setting tax reductions were to be provided by a reduction in fuel duty for lorries using UK duty-paid fuel. However, after further studies into the feasibility of the LRUC it was scrapped in 2005. The DfT is still considering various forms of road pricing in an attempt to reduce congestion and greenhouse gas emissions from transport. The principal sector affected by these policies would be the road freight industry. The East Midlands freight operations may be particularly vulnerable since road freight is a significant contributor to the regional economy.

Overview of Approach

The regulatory risk analysis is based on the following steps:

7. Relevant road freight data sets are obtained from various sources published by the Department for Transport (DfT), including:

    - The total stock of light goods vehicles (LGVs) and heavy goods vehicles (HGVs)[30] licensed in the Great Britain (GB) in 2005. The HGV stock is disaggregated by vehicle type and size, and by fuel.
    - The total goods lifted (measured in tonnes, t) and moved (measured in tonne-kilometres, t-km)[31] by LGVs and HGVs in GB in 2005, disaggregated by vehicle type (HGVs only) and NST Code[32].
    - The total distanced travelled (measured in vehicle-kilometres, v-km) by LGVs (business use only) and HGVs in GB in 2005, disaggregated by NST Code.
    - The average speed (measured in miles per hour, mph) of LGVs (petrol and diesel) and HGVs (articulated and rigid) by road class.
    - Goods vehicle traffic (measured in v-km) by road class in GB in 2005, disaggregated by GO Region.

[30] Goods vehicles of more than 3.5 tonnes gross plated weight.

[31] A measure of freight moved, which takes account of the weight of the load and the distance through which it is hauled.

[32] Nomenclature Statistique de Transport (NST) - the classification of commodities for transport statistics used in the European Communities.

- Goods lifted and moved by origin and destination GO Regions of goods in 2005, disaggregated by the following commodity groups: "Agricultural Products" (e.g. bulk cereals, potatoes, other fresh and frozen fruit and vegetables, sugar (including beet), live animals and animal foods) (NST Codes 01-03, 06, 08, 11 and 17); "Beverages" (alcoholic and non-alcoholic drinks, except tea, coffee and milk) (NST Code 12); and "Other Foodstuffs" (meat, fish, dairy products, fruit cereals, other foods, including tea and coffee) (NST Codes 13, 14 and 16). Regulatory risks are analysed for each of these three broad commodity groups, which encompass those goods most relevant to the Foods & Drink sector.

8. Speed-emission functions, relating emission factors for CO_2-eq (in grams per kilometre) to average speed (in kilometres per hour, kph), for (i) petrol LGV (ii) diesel LGV (iii) articulated HGV and (iv) rigid HGV are obtained from the National Air Emissions Inventory database (www.naei.org.uk). Speed-emission functions are available for a range of Euro (I, II, etc.) emission standards; we use the functions corresponding to the most stringent standard, thus assuming that by 2020 the entire goods vehicle fleet in the UK will comply with this standard.

9. Using the speed-emission functions, we calculate the CO_2-eq emission factor (g per km) for each type of goods vehicle (i – iv) travelling on each road class (since vehicle speeds vary by road class). Weighted average emission factors are then calculated for the distribution of each of our three commodity groups, where the weights are based on the total goods moved in GB in 2005 by NST Code and vehicle type, and the total goods vehicle traffic by road class in GB in 2005. The weighted average emission factor across all three commodity groups is 1,050 g CO_2-eq per km (with a range of 1,045 g CO_2-eq per km for Agricultural Products to 1,090 g CO_2-eq per km for Beverages).

10. Weighted average CO_2-eq emissions per km are next multiplied by the price of carbon (2005 £ per t CO_2-eq) corresponding to each of our six Regulatory Risk Scenarios[33] (RRS), to estimate potential carbon costs per km, by commodity

[33] See (common) Appendix to Case Study 1.

group.

11. Next, total CO_2-eq emissions and carbon costs, by commodity group, are computed for three types of distribution journey involving the East Midlands: **journey 1** - estimated total v-km travelled moving goods from other GO Regions to the East Midlands; **journey 2** - estimated total v-km travelled moving goods from the East Midlands to other GO Regions; and **journey 3** - estimated total v-km travelled moving goods within the East Midlands. The estimated total annual emissions and carbon costs are representative of 2005.

12. The State of Freight in the East Midlands (EMRA, 2005) contains forecasts for road freight volumes through to 2020. This suggests that if the Government's target of an 80% increase in rail freight is achieved, road freight is forecast to increase by 48% relative to 2000; if there is no growth in rail freight, road freight is forecast to increase by 58% relative to 2000. Growth rates are provided for intervening years – 2005, 2010 and 2015. We assume that the Government's target for rail freight is met, and re-base the forecast growth rates to cover the period 2005-2020. Over this period road freight is forecast to increase by about 31% (EMRA, 2005). On the basis of this growth rate, we estimate total annual emissions and carbon costs, by commodity group, for 2020. It is implicitly assumed that road freight in each commodity group grows at the forecast rate of 31% between 2005 and 2020.

13. We next analyse the effect of the additional carbon costs on the road haulage industry, in terms of impacts on (a) profitability, (b) employment and (c) wider household income. Impacts are measured for our 'best guess' regulatory risk scenario (RRS 4) only. Employment and income effects include those arising directly as a result of (a), as well as indirect and induced effects. Impacts on (a) are estimated assuming carbon cost pass through by road haulage operators of 0%, 50% and 100%, and assuming a price elasticity of demand for road freight of negative 1.05[34]. As noted elsewhere, the lowest impact on the profitability of

[34] This is the median value for road freight services reported in Graham, D. and Glaister, S. (2002) "Review of Income and Price Elasticities of Demand for Road Traffic", Contract number PPAD 9/65/93, Centre for Transport Studies, Imperial College of Science, Technology and Medicine, London.

haulage operators is likely to occur with 100% cost pass through, while the largest impact on profitability is likely to occur with no cost pass through.

14. A weighted average haulage charge (2005 £) per km, by commodity group, is calculated on the basis of data reported in Road Haulage Association (2007)[35]. First, a haulage charge is computed for each type of goods vehicle, comprising time-costs, mileage-costs and an assumed mark-up of 10% (equivalent to the net profit margin). Average charges per vehicle type are weighted by the total freight in a commodity group moved by each type of goods vehicle. The weighted average haulage charge across all three commodity groups is roughly £0.75 per km; it varies by 1-2 pence per km depending on the commodity group.

15. The weighted average haulage charge, by commodity group, is increased by the average regulatory cost per km (under RRS 4), adjusted for the assumed level of cost pass through, and the new level of demand is determined as a function of the assumed elasticity of demand for road freight services, the estimated change in haulage charge, and projected road freight volumes prior to internalisation of the carbon cost. The resulting impacts on turnover and gross profit and calculated, and the additional regulatory cost burden is expressed as a percentage of baseline gross profit (i.e. projected gross profit prior to internalisation of the carbon costs). For consistency with the other case studies we use gross profit as opposed to net profit. (Of course, if additional haulage costs are not passed on to customers, turnover will be unaffected; however, gross profit will be more adversely affected than it would have otherwise been with some positive level of cost pass-through).

16. It should be noted that the estimated impacts on road haulage operators are not specific to the East Midlands; it is not possible to identify the location of affected operators. Rather, the impacts relate to haulage operators moving goods (i.e. Agricultural Products, Beverages and Other Foodstuffs) (a) from other GO Regions to the East Midlands (b) from the East Midlands to other GO Regions and (c) within the East Midlands. These operators could, in principle, be based

[35] Road Haulage Association (2007) Goods Vehicles Operating Costs 2007, prepared for the Road Haulage Association by DFF International, Bristol.

anywhere in the UK. The estimated impacts must therefore be interpreted as national-level effects arising through the internalisation of carbon costs into the price of distributing (by road) goods prepared by / for the Food & Drinks sector in the East Midlands.

17. Nonetheless, if we assume that: (a) 50% of goods hauled from other GO Regions to the East Midlands are by operators based in the East Midlands (i.e. vehicles shipping goods from the East Midlands to other GO Regions return full) (b) 50% of goods hauled from the East Midlands to other GO Regions are by operators based in the East Midlands (i.e. vehicles shipping goods from other GO Regions to the East Midlands return full) and (c) 100% of goods hauled within the East Midlands are by operators based in the region, then approximately 60% of the reported impacts on road haulage operators may be attributable to operators based in the East Midlands.

18. Finally, we consider the potential impacts on the Food & Drinks sector in the East Midlands (specifically, NACE DA 15.1 to 15.9)[36]. This involves, for our 'best guess' risk scenario (RRS 4):

    a) Collating data on the financial performance of these sectors from EUROSTAT – e.g. number of enterprises, turnover, value added, gross operating surplus, total purchases of goods and services, and personnel costs. An annual average is calculated for the period 2001-05. As noted in CCS 1, this data is only available for the UK as a whole. We therefore normalise the financial statistics to the number of enterprises, and subsequently multiply these values for an average enterprise in the UK by the total number of enterprises registered in each sector in the East Midlands (the latter is again calculated as an annual average over the period 2001-05, based on data from EUROSTAT and the ONS ABI).

    b) Using the (output and employment) growth forecasts for the Food & Drinks sector from the RES, we project the annual average financial data for the period 2001-05 to 2020, assuming the annualised growth rate

[36] We assume that: "Agricultural Products" comprises NACE DA 15.3, 15.6 and 15.7; "Beverages" comprises NACE DA 15.9; and "Other Foodstuffs" comprises NACE DA 15.1, 15.2, 15.4, 15.5 and 15.8.

between 2004 and 2014 is maintained through to 2020. It is further assumed that an average enterprise in 2001-05 has identical financial performance to an average enterprise in 2020, except for the forecast improvement in labour productivity reported in the RES. Total turnover and gross value added for the sector as whole in the East Midlands by 2020 is estimated at about £16.6 billion and £5.6 billion, respectively (2005 prices).

c) Calculating the additional freight costs likely to be faced by each sub-sector if haulage operators pass on the additional costs of carbon (assuming 100% and 50% cost pass through), allowing for reductions in demand in response to higher freight rates. To provide an indication of the relative size of the carbon cost burden, the additional haulage costs are presented as a percentage of gross operating surplus (GOS) and variable production costs (assumed equivalent to the "total purchases of goods and services").

Results

By 2020 an estimated 64.1 million tonnes of goods per year will be shipped by road freight for the Foods & Drinks sector in the East Midlands (see Table 3 for breakdown by commodity group). Total goods moved by road[37] for the Foods & Drinks sector in the East Midlands by 2020 are estimated at close to 9.5 billion t-km per year (see Table 3 for breakdown by commodity group). Total annual CO_2-eq emissions from road freight across all commodity groups (i.e. for the Food & Drinks sector as a whole) amount to about 9.7 million t CO_2-eq by 2020 (see Table 3 for breakdown by commodity group).

The distribution of CO_2-eq emissions by origin / destination, for each commodity group, is shown in Figure 29.

Table 174 shows the estimated annual regulatory risk costs associated with moving

[37] Total goods moved = is total distance all freight travels (i.e. t-km); total goods lifted = total weight of all goods loaded (i.e. t). These are standard DFT terms

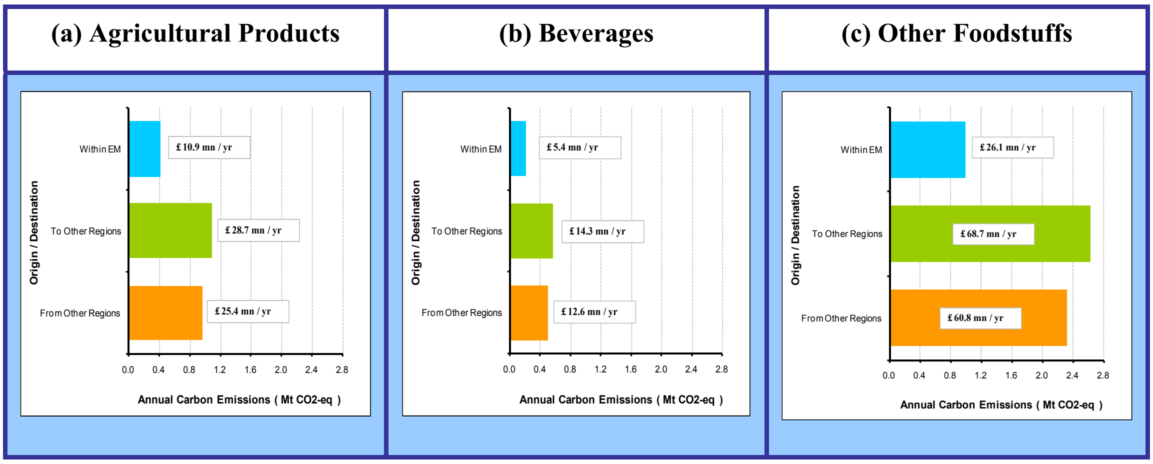
goods for the Food & Dinks sector of the East Midlands by road in 2020 (i.e. from impact pathway ❷). Under our 'best guess' regulatory risk scenario (RRS 4) total annual costs for the sector as a whole are £253.0 million per year by 2020 – by commodity group:

- Agricultural Products = £65.0 million per year by 2020;
- Beverages = £32.4 million per year by 2020; and
- Other Foodstuffs = £155.6 million per year by 2020.

Table 3: Goods shipped by road freight by 2020, total goods moved by road and estimated annual CO_2-eq emissions from the Food and Drink sector in the East Midlands by commodity group

	Goods shipped by road freight by 2020 (million tonnes)	Total goods moved by road[8] (billion t-km)	Estimated annual CO_2-eq emissions (million tonnes CO_2-eq)
Agricultural products	20.9	2.7	2.5
Beverages	8.5	1.4	1.3
Other food stuffs	34.7	5.4	5.9

Figure 29: Distribution of Total Annual Carbon Emissions and Total Annual Regulatory Risk Costs by Origin / Destination of Goods in 2020, by Commodity Group (RSS 4) (million t CO_2-eq per year) (2005 £ million per year)



Source: Own calculations.

Table 4: Total Annual Regulatory Risk Costs in 2020 from Impact Pathway ❷, by Commodity Group and by Regulatory Risk Scenario (2005 £ million per year)

(a) Agricultural Products		(b) Beverages		(c) Other Foodstuffs	
Regulatory risk (RRS1)	12.4	Regulatory risk (RRS1)	6.2	Regulatory risk (RRS1)	29.8
Regulatory risk (RRS2)	19.9	Regulatory risk (RRS2)	9.9	Regulatory risk (RRS2)	47.6
Regulatory risk (RRS3)	35.3	Regulatory risk (RRS3)	17.6	Regulatory risk (RRS3)	84.6
Regulatory risk (RRS4)	65.0	Regulatory risk (RRS4)	32.4	Regulatory risk (RRS4)	155.6
Regulatory risk (RRS5)	106.5	Regulatory risk (RRS5)	53.0	Regulatory risk (RRS5)	254.9
Regulatory risk (RRS6)	148.3	Regulatory risk (RRS6)	73.9	Regulatory risk (RRS6)	355.0

Source: Own calculations.

Looking at the additional carbon costs per tonne of freight lifted, under our 'best guess' regulatory risk scenario (RRS 4), we find:

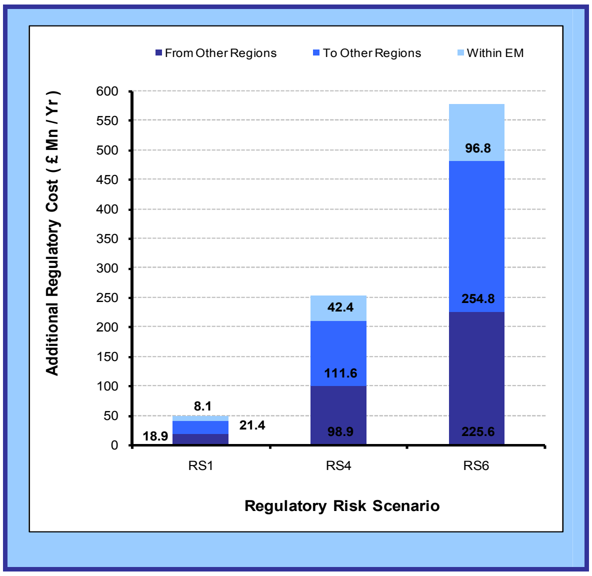
- Agricultural Products = £3.80 per tonne lifted by 2020;
- Beverages = £3.10 per tonne lifted by 2020; and
- Other Foodstuffs = £4.45 per tonne lifted by 2020.

The average additional carbon cost across all goods lifted for the Food & Drinks sector is about £3.95 per tonne of freight by 2020 (under RRS 4). Figure 30 shows the distribution of total annual regulatory costs faced by the Food & Drinks sector in 2020 under RRS 1, 4 and 6 by the origin / destination of the freight.

Impacts on Road Haulage Operators

We next consider the economic impacts of the additional carbon costs on road haulage operators. Across all commodity groups, as expected, the greatest loss of gross profit is experienced with no cost pass-through, in which case gross profits are estimated to decline by about £253 million per year by 2020, as the additional carbon costs under RRS 4 are absorbed fully by operators. With no cost pass-through, there is no reduction in turnover – and as we will see below – no impact on customers in the Food & Drinks sector in the East Midlands. If, however, 100% of the costs are passed through to customers, sales are projected to decline by about £13 million per year, but the reduction in gross profit declines by only £113 million per year.

Figure 30: Distribution of Total Annual Regulatory Risk Costs Faced by Food & Drinks Sector by Origin / Destination in 2020 (RSS 1, 4 and 6) (2005 £)



Source: Own calculations.

The overall regulatory cost burden to haulage operators is summarised by the 'cost burden-to-baseline (gross) profit ratio'. Under the worst-case scenario for haulage operators, whereby no additional costs are passed onto customers, the ratios are high – by commodity group:

- Agricultural Products = 8.5% by 2020;
- Beverages = 8.6% by 2020; and
- Other Foodstuffs = 8.8% by 2020.

Taking Agricultural Products, for example, this means that the additional carbon costs will reduce the funds available to remunerate labour and owners, and pay other fixed expenses and taxes will be reduced by 8.5%.

As output is reduced, with higher haulage charges, employment is adversely affected. Over all commodity groups, we estimate total job losses (i.e. direct + indirect + induced) with 50% and 100% cost pass-through at 140 and 270 FTEs, respectively. The corresponding total loss of household income is £4 million (50% cost pass-through) and £7 million (100% cost pass-through). Of course, with no cost pass-through, demand is unaffected and consequently there are no short-term adverse effects on employment and household incomes. However, it is important to note that the greatest threat to the economic viability of haulage operators occurs with no cost pass-through, which may lead operators to exit the sector in the long-term, with associated job and income losses.

As noted above, a reasonable assumption is that about 60% of these impacts to road haulage operators will be felt in the East Midlands. Table 6 summarises some of the impacts on road haulage operators of the estimated carbon costs under RRS 4, assuming 100%, 50% and 0% cost pass through, by commodity group.

Impacts on the Food & Drinks Sector

We now consider the economic impacts on the Food & Drink sector in the East Midlands if haulage operators were to pass on some (specifically, 50%) or all of the additional carbon costs. Table 7 summarises these impacts under RRS 4, by commodity group. After allowing for demand effects in response to higher haulage rates, the additional freight costs faced by the Food & Drinks sector in the East Midlands by 2020 range from £124 million (with 50% cost pass-through) to £244 million per year (with 100% cost pass-through). By far the largest additional costs are incurred by those sub-sectors involved in the preparation of Other Foodstuffs (just over 60% of total additional annual costs). To put these additional costs in the context of the projected financial performance of the sector by 2020 by commodity group see Table 5.

The additional carbon costs under this worst-case scenario thus represent a significant burden to sub-sectors involved in preparing Agricultural Products and Other Foodstuffs, which collectively we project to account for 75% of total turnover and 65% of value added from the Food & Drinks sector in the East Midlands by 2020. We can therefore conclude, first, that the impacts on those two sub-sectors is large; and second, these sectors are projected to play a significant role in the total sector's output by 2020. As a consequence, the clear policy/business support priorities for the region in this sector should focus upon agricultural products and other foodstuffs, and specifically the impact of carbon pricing regimes in their transportation.

Table 5: Additional costs in context of projected financial performance by commodity group in the East Midlands Food and Drink sector

	Percentage of variable costs and gross operating surplus (RSS4)	
	50% cost pass through	**100% cost pass through**
Agricultural products	4.5	22.7
Beverages	1.4	2.1
Other foodstuffs	4.3	21.2

Notes: "Agricultural Products" (e.g. bulk cereals, potatoes, other fresh and frozen fruit and vegetables, sugar (including beet), live animals and animal foods) (NST Codes 01-03, 06, 08, 11 and 17); "Beverages" (alcoholic and non-alcoholic drinks, except tea, coffee and milk) (NST Code 12); and "Other Foodstuffs" (meat, fish, dairy products, fruit cereals, other foods, including tea and coffee) (NST Codes 13, 14 and 16).

Table 6: Summary of Impacts on Road Haulage Operators and Wider Economy in 2020 from Impact Pathway ❶ under RSS 4

(a) Agricultural Products

	100% Cost Transfer	50% Cost Transfer	0% Cost Transfer
	(£ mn / yr)	(£ mn / yr)	(£ mn / yr)
Reduction in turnover	3.2	1.6	-
Reduction in gross profit	29.0	46.4	65.0
Cost burden-to-baseline profit ratio	3.8%	6.1%	8.5%
Total loss of household income from job losses	1.9	0.9	-
	(FTE)	(FTE)	(FTE)
Direct job losses to haulage operators	50	20	-
Total job losses (direct, indirect and induced)	70	40	-

(b) Beverages

	100% Cost Transfer	50% Cost Transfer	0% Cost Transfer
	(£ mn / yr)	(£ mn / yr)	(£ mn / yr)
Reduction in turnover	1.6	0.8	-
Reduction in gross profit	14.4	23.1	32.4
Cost burden-to-baseline profit ratio	3.8%	6.1%	8.6%
Total loss of household income from job losses	0.9	0.5	-
	(FTE)	(FTE)	(FTE)
Direct job losses to haulage operators	20	10	-
Total job losses (direct, indirect and induced)	30	20	-

(c) Other Foodstuffs

	100% Cost Transfer	50% Cost Transfer	0% Cost Transfer
	(£ mn / yr)	(£ mn / yr)	(£ mn / yr)
Reduction in turnover	7.8	3.9	-
Reduction in gross profit	69.3	110.9	155.6
Cost burden-to-baseline profit ratio	3.9%	6.3%	8.8%
Total loss of household income from job losses	4.5	2.3	-
	(FTE)	(FTE)	(FTE)
Direct job losses to haulage operators	110	60	-
Total job losses (direct, indirect and induced)	170	80	-

Source: Own calculations.

Note: Total effects include direct + indirect + induced effects. FTE = full-time equivalents.

Table 7: Summary of Impacts on the Food & Drinks Sector in the East Midlands in 2020 from Impact Pathway ❶ under RSS 4

(a) Agricultural Products

	100% Cost Transfer (£ mn / yr)	50% Cost Transfer (£ mn / yr)
Additional freight costs	62.6	31.9
As a % of gross operating surplus	22.7%	11.5%
As a % of variable production costs	4.5%	2.3%

(b) Beverages

	100% Cost Transfer (£ mn / yr)	50% Cost Transfer (£ mn / yr)
Additional freight costs	31.2	15.9
As a % of gross operating surplus	2.1%	1.1%
As a % of variable production costs	1.4%	0.7%

(c) Other Foodstuffs

	100% Cost Transfer (£ mn / yr)	50% Cost Transfer (£ mn / yr)
Additional freight costs	149.7	76.3
As a % of gross operating surplus	21.2%	10.8%
As a % of variable production costs	4.3%	2.2%

Source: Own calculations.

Notes: Obviously, there are no impacts on the Food & Drinks sector with no cost pass-through by road haulage operators, so it is not considered.

Conclusions

Summary of Economic Analysis

The Food and Drink sector is identified in the RES as one of four priority sectors likely to make the greatest contribution to the East Midlands' economy over the lifetime of the RES.

The analysis of potential impacts of climate change on raw materials (foodstuffs) used by the East Midlands Food and Drink sector highlights that where individual sub-sectors have high raw material input costs as a proportion of total production costs, or where profit margins, measured by Gross Operating Surplus, are small at present, the effect may be to reduce GOS by up to 20% by 2020. On this basis four sub-sectors were identified as being particularly vulnerable. These are: Production and preserving of Meat; Production and preserving of Poultry Meat, Operation of Dairies and Cheese making, and Manufacture of Prepared Feeds for Farm Animals.

However, the results should be seen as indicative only. The analysis is artificial to the extent that we impose foodstuff price increases derived from future climate and socio-economic conditions on current (recent past) sectoral financial conditions. Additionally, the analysis is undertaken using climate change scenarios and impact studies at the high end of the impact range (e.g. high emissions); our results are therefore illustrative of the upper bound potential impacts. The single set of results for each sub-sector also masks the large uncertainties hidden in the range of assumptions necessarily built into the analysis.

The climate change-related regulatory risks faced by freight enterprises derive specifically from direct carbon emissions by the sector. By 2020 an estimated 64.1 million tonnes of goods will be shipped by road freight for the Food and Drink sector in the East Midlands. The estimated annual CO_2-eq. emissions associated with this are 9.7 million tonnes.

Under the 'best guess' regulatory risk scenario (RRS4) total annual costs for the sector as a whole are £253 million per year by 2020. The average additional carbon costs across all goods lifted for the Food and Drink sector is about £3.95 per tonne of freight by 2020.

The impact of this increase on haulage operators depends on the level of cost pass-through. The greatest loss of profit is experienced with no cost pass-through in which case gross profits are estimated to decline by about £253 million per year by 2020. If 100% of costs are passed through, sales will decline by £13 million per year but the reduction in gross profit declines by only £113 million per year. As output is reduced, employment is adversely affected. Total job losses are estimated at 140 FTEs (with 50% cost pass-through) or 270 FTEs (with 100% cost pass-through). However, the greatest threat to the economic viability of hauliers occurs with no cost pass-through which may lead to operators exiting the sector in the long term with associated job losses.

The impact on the Food and Drink industry also depends on the level of cost pass-through of additional carbon costs from haulage operators. After allowing for demand effects in response to higher haulage rates, the additional freight costs faced by the Food and Drink sector in the East Midlands by 2020 range from £124 million per year (50% cost pass-through) to £244 million per year (100% cost pass-through).

Clearly, the two areas of analysis are best viewed as elements of a common climate change challenge; the regulatory risk is being imposed in order to limit the extent of future climate change impacts, including those on global agricultural production. Thus, the outputs of our analysis should be combined: increased unit feedstock costs + increased unit haulage costs. Ultimately, the economic burden on the sector and region is mainly about what consumers (wholesale and retail) are willing to accept in extra costs without significant changes in consumption – how elastic is demand given that the cost of all products is going to go up, other things being equal? Given that we have no historical analogue of the types of costs and socio-economic conditions likely to face the region in the future, we are obliged to use a range of assumptions to reflect this uncertainty, but develop policy responses that embodies society's attitudes to risk.

Policy Implications

The impact of climate change will be felt in the East Midlands food and drink sector through an increase in raw material and fuel costs. In turn this will reduce profitability, thus posing a risk to the growth of the sector. This may alter the relative competitiveness of the East Midlands, for example compared with enterprises that source a higher proportion of their raw materials from within the UK. The significance of this will partly depend on demand and the ability and willingness of enterprises to pass through additional costs and partly on their ability to source more raw materials from within the UK.

The actual outcome will depend strongly on adaptation measures employed by the suppliers of raw materials to the East Midlands (and elsewhere). These measures are not likely to be costless but vary from relatively low-cost options such as crop switching to high-cost options such as growing crops under controlled environments in greenhouses.

The impact of climate change on the East Midlands food and drink industry will also depend on the ability of enterprises to source raw materials from within the UK. The most cost-effective policy may be for the region to invest in and encourage adaptation by key regional foodstuff suppliers. Switching suppliers to those within the UK, whilst primarily an adaptation action, will also have benefits in terms of climate change mitigation through reducing the distance travelled and hence greenhouse gas emissions. This is an example of a win-win adaptation measure, for which the opportunity should be further investigated. This also links to the Regional Environment Strategy which includes a policy "To ensure that all elements that underpin the concept of local distinctiveness are conserved and managed" (Emra 2002). The clear policy implication is to encourage a wider range of agricultural outputs to be produced locally through agricultural support schemes.

If more raw materials are to be sourced locally, producers need to adapt to climate change. The results of Case Study 4: Agriculture show that a significant amount of agricultural land in the East Midlands is at risk of flooding due to sea level rise. Other risks associated with climate change include salinisation and drought. Measures to adapt agriculture in the East Midlands will be essential if the food and drink industry is to source more raw materials locally. Adaptation options include defending land from the sea and crop switching to more drought tolerant species. In addition to securing raw materials for the food and drink industry, enterprises that are willing and able to change suppliers may be able to realise cost benefits. There will also be a first mover advantage for enterprises able to switch production to new products, based on raw materials likely to benefit from climate change. For further discussion of adaptation of agriculture in the East Midlands, see Case Study 4.

Mitigation policy primarily represents a risk to the Food and Drink sector in the East Midlands through an increase in road freight costs. The significance of this will partly depend on the extent to which haulage operators pass on additional costs.

There are potential opportunities for the freight sector, for example, in relation to fuel efficiencies. Opportunities may also be realised by switching to alternative modes of transport; rail and waterways. This links to the Regional Freight Strategy which includes a target to double the tonnage (from 2000 levels) of freight carried on inland waterways by 2010 (Emra 2006) and the Regional Environmental Strategy which includes a policy "to encourage the use of environmentally friendly methods of travel" (Emra 2002). There is scope for further research into the potential for modal shift in the freight sector to identify where the freight to be shifted might come from and what the realistic opportunities for switching freight mode are. This would be a separate piece of work which would cross-cut the analysis of risks / opportunities and addressing material risks / opportunities presented here.

Significant uncertainties remain regarding future climate change impacts at a local and regional scale and it will be prudent for emda to maintain a watching brief on these. In the UK, new climate change projections will be published by the United Kingdom Climate Impacts Programme (UKCIP) next year (2008). These projections will allow results to be presented on a probability basis and with a specified level of confidence.

A number of initial recommendations can be drawn for emda to consider:

- Research into the ability and likelihood of companies passing on additional costs and the relationship with net effects on the regional economy;
- Research into the ability and likelihood of companies switching suppliers of raw materials or producing new products with raw materials likely to benefit from the impacts of climate change and the net effects on the regional economy;
- Encourage more collaboration between food and drink enterprises and suppliers in the Region and the UK;
- Development of an impact identification and adaptation toolkit to help

enterprises consider how climate change may affect their supply chains and how much this may cost;

- Encourage freight movement by alternative modes of transport to road through emda's planning role.

Emda's support in climate change mitigation for this sector will also help achieve other Priority Actions set out in the RES including:

- Supporting Innovation and Diversification in Manufacturing.
- Providing Business Support on Resource Efficiency.
- Adaptation to Climate Change.
- New Markets and Enterprise Opportunities.
- Improve Transport Connectivity and Accessibility.

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CASE STUDY 6: CARGO AND EXPRESS FREIGHT AT EMA

Introduction

The issue of air travel is an emotive one in climate change policy; the continued growth and expansion of UK airports and passenger numbers contradicts the necessary reduction in emissions to stabilise the carbon content of the atmosphere. Phase 1 of this study identified the need to identify direct and indirect regulatory risk related to energy use and GHG emissions associated with expansion of the East Midlands Airport.

The East Midlands Airport: Nottingham, Derby, Leicester (EMA) is situated at Castle Donnington in Leicestershire, with Derby as its closest city. EMA has one terminal and is a hub for over 20 airlines, serving more than 40 countries worldwide. EMA is also a base for Royal Mail and is the second busiest UK airport for freight, after Heathrow. The airport is a key feature for the economy of the East Midlands; as a hub for tourists, business and freight; it contributes to the success of many different sectors in the Region.

In 2006, 235 million passengers passed through UK airports, an increase in 3% on the previous year, a figure that the government predicts to double in the next 25 years (CAA, 2007). EMA has been no exception to this pattern of growth, with the recent addition of the low-cost airlines easyJet, Ryanair and bmi baby, the airport now deals with over 4 million passengers and over 250,000 tonnes of freight per annum (CAA, 2007).

Recent research by the Tyndall Centre for Climate Change Research has predicted that if aviation growth continued at the current rate, and safe carbon limits were to be met (as defined by the EU target to limit warming to 2ºC), air travel would take up the entire carbon emissions budget for all sectors of the UK economy by 2037 (Bows *et al.*, 2005).

The recent government Aviation White Paper published in December 2003 supported expansion of EMA in principle, but it must include rigorous assessment of noise, air quality and economic and social impacts (GOEM, 2006). The airport itself produced a Master Plan in 2006, which includes measures that the airport intends to implement up to 2030. These include plans to make airport ground operations carbon neutral by 2012, while at the same time increasing provision for long-haul flights to such destinations as India and USA.

This case study will consider the mitigation risk associated with future expansion of EMA under various scenarios of regulatory risk associated with climate change policy. First, an overview of the EMA is given, before the scope of the case study is established. The methodology to assess regulatory risk is then presented before the results. The conclusions include a summary of the economic analysis and the policy implications of this analysis.

Overview of EMA

Operations at EMA began in 1916 when the present site was used as a base for aerial defence against Zeppelin attacks. The end of the Second World War marked the end of military use of the site, but it was not until 1965 that the airport - as it is known today - opened. In its first year of operations the airport handled over 118 thousand passengers, and in 1985 annual passenger throughput surpassed the one million mark. By 2006, over 4.7 million passengers a year were using the airport and total air transport movements had reached 56,305 (CAA, 2007)[38].

The location of EMA - in the centre of England and adjacent to the national motorway network - has not only been a significant determinant of passenger growth, but also the amount of cargo handled by the airport. The connectivity of the airport with one of the largest catchments of any airports in the UK, creates significant opportunities for regional businesses to serve a range of domestic and foreign markets (and for foreign

[38] Civil Aviation Authority, UK Airport Statistics – 2006 Annual (www.caa.co.uk), accessed 14th October 2007.

businesses to serve a range of markets in the East Midlands and the rest of the UK); especially in relation to express freight[39]. EMA handled just over 272 thousand tonnes of pure freight[40] in 2006 (or close to 33% by weight of the total pure freight of all UK airports), making it the largest single pure freight airport in the UK (CAA, 2007). In fact, only Heathrow handled more total freight (i.e. pure plus belly hold freight) than EMA in 2006.

Just over 85% of the pure freight handled at EMA is express freight; indeed, the airport's location and transport connectivity have made it the UK's leading hub for express freight[41]. The express sector is essentially concerned with the door-to-door transport and delivery of next-day or time-definite shipments (between 2-3 days), including documents and parcels. Typically, express freight services are used for business-to-business transport of high-value / low-weight items, such as electronic components, pharmaceuticals / biotechnology, business and financial services, and IT.

The global express sector is dominated by four 'Integrated Carriers' - DHL, FedEx, TNT and UPS. These companies are 'integrated' in the sense that they control every part of the process from collection from a customer, through shipment by a variety of different modes (including lorries, vans, trains, passenger aircraft and dedicated freight aircraft), to the delivery to the end user (see Figure 31). Where necessary, express service provides also handle customs clearance, as well as the payment of any required duties and taxes. With the exception of FedEx, each of the main integrated operators has operations at EMA, and for DHL and UPS, the airport is their main centre for UK operations.

EMA is also the Royal Mail's largest UK hub for transporting mail by air within the UK, as part of a network of integrated road and air services designed to meet its next day delivery targets for first class mail. The airport handled close to 26 thousand tonnes of mail in 2006 (CAA, 2007).

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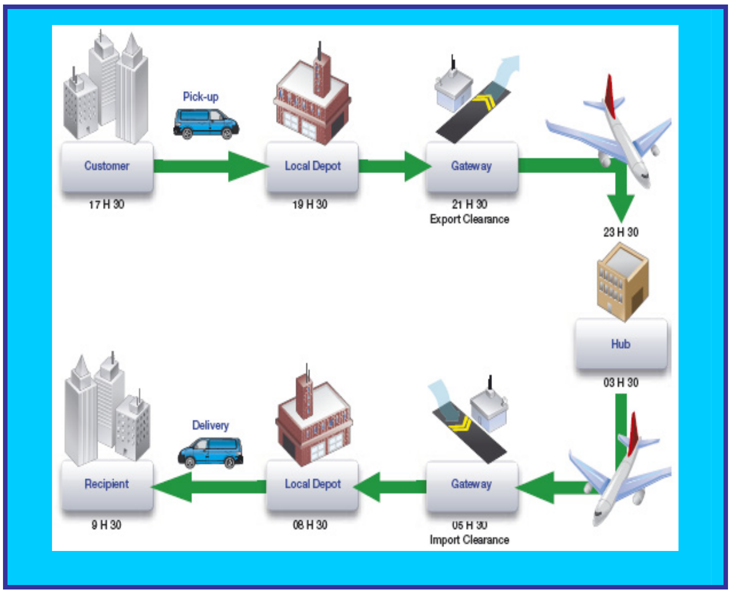
[39] EMA is within 4 hours driving time of close to 90% of mainland England and Wales.

[40] Pure freight is carried in dedicated cargo aircraft. In contrast, bellyhold freight is carried under the passenger compartment of (mainly long-haul) passenger aircraft, using airports such as Heathrow and Gatwick.

[41] A freight 'hub' is where aircraft from smaller airports on the periphery of an freight provider's network (the 'gateways' or 'spokes') meet and transfer shipments, both for domestic and onward international travel.

Figure 31: Main Stages in Express Freight Delivery Cycle



Source: EMA Master Plan 2006-2030, Section 2, p. 16.

The express freight sector is not identified as a separate sub-sector in the SIC (2003) or reported separately in the National Accounts produced by the UK Office for National Statistics. It is therefore difficult to collate data on the sector's economic performance, and its contribution to total regional or UK output and employment. On the basis of a detailed survey of the four main 'Integrated Carriers', Oxford Economic Forecasting put the total turnover and gross value added (GCA) of the express freight sector in the UK at around £2.1 billion and £0.9 billion, respectively, in 2004 (OEF, 2006)[42]. The value of intermediate purchases from suppliers (i.e. the cost of goods and services sold) is thus about £1.2 billion.

In terms of employment, Table 1 gives an overview of jobs generated by the express freight sector in the East Midlands. Taking into account the indirect and induced employment effects resulting from express sector activities elsewhere in the UK, the express sector, overall, supports about 10,200 jobs in the East Midlands.

[42] OEF (2006) The Importance of the Express Deliver Industry for the East Midlands Economy, a report prepared by Oxford Economic Forecasting (OEF) for EMDA and EMA, January 2006.

Table 42:Employment generated by Express Freight in East Midlands (2004)

Type	Number of jobs
Direct	4,740
Of which	
- EMA[43]	1,550
East Midlands Indirect (i.e. supplying goods and services to freight sector)	2,560
Other UK Indirect	1360
East Midlands Induced (i.e. resulting from purchases of employees in freight sector)	950
Other UK Induced	600
Total	10,210

Source: OEF,2006

The direct contribution of the sector to regional GVA can be estimated at about £135 million in 2004[44]. Looking ahead, OEF (2006) predict the UK express freight sector to grow by an average of 6.7% per year in real terms between 2004 and 2014, which is substantially above forecast growth for the UK economy as a whole. By 2014, the direct contribution of the sector to regional GVA is projected at about £260 million per year (2004 prices). Total direct employment in the region is estimated at about 7,400 workers in 2014, with a further 5,500 indirect plus induced jobs resulting from express sector activities in the region.

[43] The latest (2005) survey of on-site employers indicates that there is a total of close to 7,000 employees based on, or near, the airport site, of which about 39% are employed in the cargo sector (i.e. about 2,700 thousand employees).

[44] Assuming that GVA per worker directly employed in the express sector in the East Midlands is equal to the national average

Table 2 shows a breakdown of the major client sectors of the "integrator carriers". It can be seen that the express freight sector thus plays an important role in supporting high-value added sectors targeted by the RES.

Table 43: Major Client Sectors of Integrator Carriers

Sector	% sales income
Consumer goods	22
Electronics	20
Financial Services	18
Business Services	12

Source: OEF (2006)

More generally, in recognition of the overall contribution of EMA to the regional economy, a priority action of the RES is to maximise the economic opportunities and benefits of the airport.

In summary:

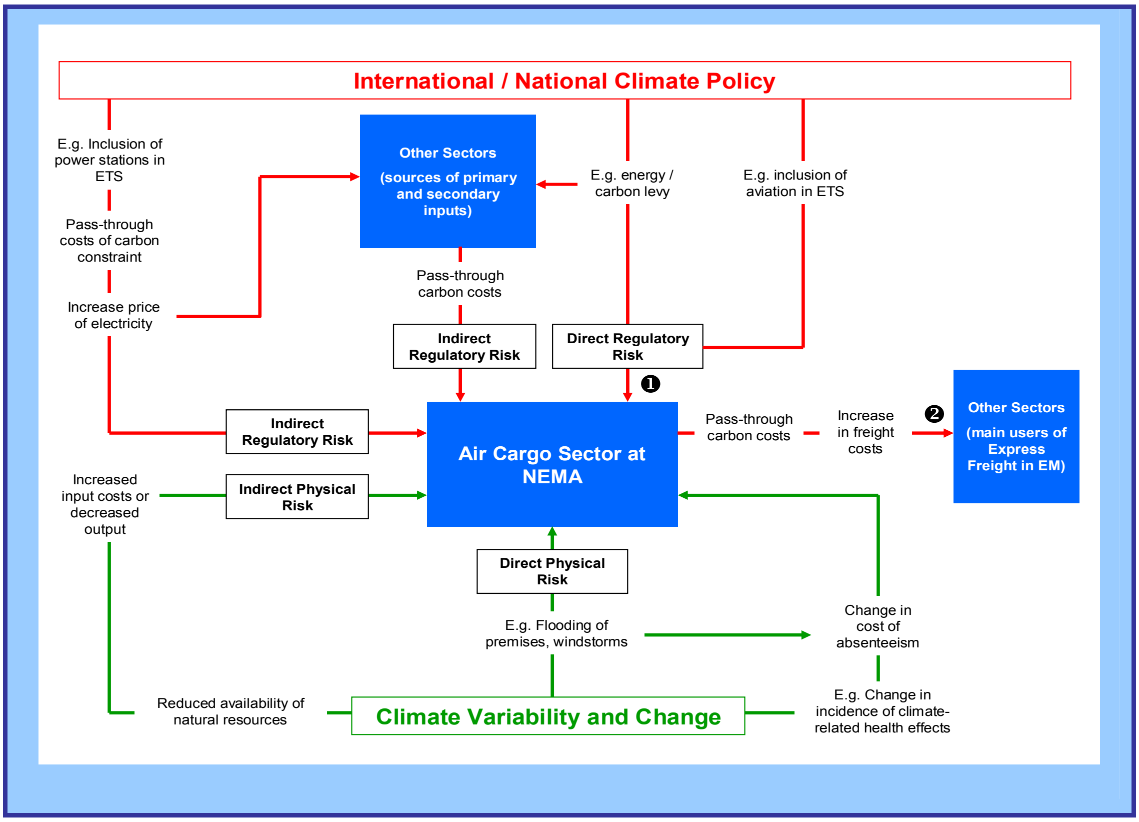
- EMA is the 13th largest passenger airport in the UK (2006);
- EMA is the 2nd largest total freight airport in the UK (next to London Heathrow), and the largest pure freight and pure mail airport in the UK (2006).
- EMA is the leading airport in the UK for express freight services (2006).
- Around 7,000 people are directly employed at EMA (2005), of which about 2,700 work in the cargo freight sector.
- The express freight sector directly contributes about £135 million to regional GVA (2004), and directly employees about 4,700 in the East Midlands.
- The express freight sector in the UK supports about 10,200 jobs in the East Midlands.
- Express freight services are important to an number of high-value added sectors

targeted by the RES.

Scope of Case Study

There are many ‘pathways’ through which climate variability and change, and international and national responses to climate change, may directly or indirectly affect EMA, and specifically the cargo freight industry using the airport. Some of the key ‘physical risk’ (green arrows) and ‘regulatory risk’ (red arrows) pathways are highlighted in Figure 1. This case study is concerned solely with regulatory risks, and only those risks arising from cargo Air Transport Movements (ATMs); we do not consider regulatory risks arising from passenger ATMs or operating the airport (e.g. lighting, heating / cooling, etc. of the terminal and other buildings on-site). With reference to Figure 1, we first quantify the regulatory risks associated with direct carbon emissions from cargo ATMs (impact pathway ❶) (e.g. if aviation is included in the EU ETS). Second, we quantify the risks to the those sectors in the East Midlands economy that make heavy use of express delivery services, if the carbon costs arising through pathway ❶ are passed on in higher prices (impact pathway ❷).

Figure 32: Potential Climate Change-related Impact and Regulatory Risks to the Cargo Freight Industry at Nottingham East Midlands Airport



Analysis of Regulatory Risks

Overview of Approach

This section gives an overview to the methodology applied to assess the regulatory risks associated with climate change mitigation and aviation at EMA. Essentially, this is based on an analysis of CO_2-eq emissions associated with cargo transport at EMA, including consideration of the indirect effects associated with aircraft emissions. Three scenarios are considered: (i) intra-EU flights only (ii) all flights departing EU airports and (iii) all flights arriving at, and all flights departing EU airports. The costs of carbon emissions are then estimated and the implications for the sector, and associated sectors, are identified using economic analysis. For details of the methodology and assumptions see the appendix.

Results

By 2020 estimated cargo ATMs at EMA at estimated at close to 41,600 per year, moving about 1.3 million tonnes. Approximately 50% of the total tonnage is on arriving flights (663,000 tonnes) and about 50% on departing flights (669,000 tonnes). In total, cargo moving through EMA travels about 22.9 million nautical miles per year by 2020. Estimated annual fuel consumption and CO_2-eq emissions by geographic coverage scenario are as follows:

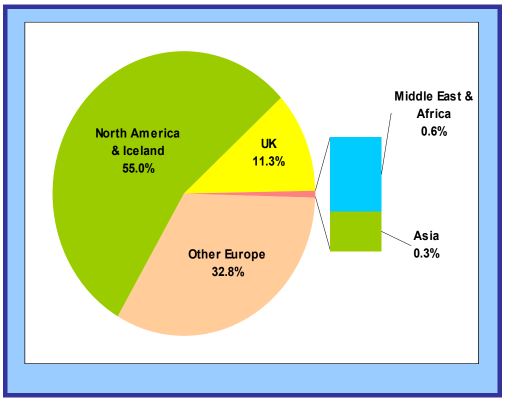
(i) intra-EU flights only = 113.8 million kg fuel and 358,600 t CO_2-eq per year by 2020;

(ii) all flights departing EU airports = 134.9 million kg fuel and 424,900 t CO_2-eq per year by 2020; and

(iii) all flights arriving at, and all flights departing EU airports = 267.7 million kg fuel and 843,400 t CO_2-eq per year by 2020.

Looking as geographic coverage scenario (iii), the majority of CO_2-eq emissions relate to ATMs to North America and Iceland (55% of total emissions) (see Figure 3). Europe, including the UK, account for nearly all of the remaining 45% of total CO_2-eq emissions.

Figure 33: Distribution of Total Annual CO_2-eq Emissions in 2020 to ATMs by Location of Airport (Geographic coverage scenario = all flights arriving at, and all flights departing EU airports; total emissions = 843,400 t CO_2-eq per year)



Source: Own calculations.

Table 17 and Table 45 show the estimated annual regulatory risk costs faced by the cargo sector at EMA (from impact pathway ❶) during, respectively, the baseline period and 2020. Under our 'best guess' regulatory risk scenario (RRS 4) total annual costs from regulated carbon emissions are:

(i) intra-EU flights only = £9.0 million (multiplier[45] = 0) to £18.0 million (multiplier = 2) per year by 2020;

(ii) all flights departing EU airports = £10.7 million (multiplier = 0) to £21.4 million (multiplier = 2) per year by 2020; and

(iii) all flights arriving at, and all flights departing EU airports = £21.2 million (multiplier = 0) to £42.4 million (multiplier = 2) per year by 2020.

Total annual regulatory costs in 2020 are only double what they are during the baseline period, despite the fact that the total tonnage of cargo going through EMA is anticipated to increase by nearly 355% over the forecast period; improvements in aircraft fuel efficiency and increases in the size of cargo planes (and thus tonnages per ATM)

[45] The multiplier takes into account the wider impacts of changes in incomes and employment than the simple sectoral level impact. A reduction in income for a given individual results in less demand for goods and services – thus reducing incomes/employment of others. In the report a range is used based on a report by York Aviation of 0 (i.e. the extreme case where no wider impact is felt) to 2 (where for every one £1 of income lost for the sector, another £1 is lost elsewhere).

between now and 2020 both act to reduce CO_2-eq emissions per tonne-mile.

Looking at the additional carbon costs per tonne of cargo moved on regulated routes[46], under our 'best guess' regulatory risk scenario (RRS 4) we find:

(i) intra-EU flights only = £9 per t regulated cargo (multiplier = 0) to £17 per t regulated cargo (multiplier = 2) by 2020;

(ii) all flights departing EU airports = £16 per t regulated cargo (multiplier = 0) to £32 per t regulated cargo (multiplier = 2) by 2020; and

(iii) all flights arriving at, and all flights departing EU airports = £16 per t regulated cargo (multiplier = 0) to £32 per t regulated cargo (multiplier = 2) by 2020.

We observe that average carbon costs are the same between geographic coverage scenarios (ii) and (iii). This is due to the fact that total annual ATMs, tonnages and CO_2-eq emissions are split roughly 50:50 between departing and arriving flights. Hence, as we move from (ii) to (iii) CO_2-eq emissions and regulatory costs roughly double, but so do total tonnages, which means that average costs remain unchanged.

[46] That is, the total annual carbon costs if, say, intra-EU flights are covered by the regulatory regime are normalised to the total tonnage of cargo on intra-EU flights, and not to the total tonnage of cargo on all ATMs.

Table 44: Total Annual Regulatory Risk Costs Faced by Cargo Sector at EMA from Impact Pathway ❶ During Baseline Period, by Regulatory Risk Scenario and Geographic Coverage Scenario (2005 £)

(i) Intra-EU flights only

	Multiplier = 0		Multiplier = 2	
	(£ mn per year)	(£ per t freight)	(£ mn per year)	(£ per t freight)
Regulatory Risk Scenario 1	0.9	4	1.7	7
Regulatory Risk Scenario 2	1.4	6	2.8	12
Regulatory Risk Scenario 3	2.5	11	4.9	21
Regulatory Risk Scenario 4	4.5	19	9.0	39
Regulatory Risk Scenario 5	7.4	32	14.8	64
Regulatory Risk Scenario 6	10.3	44	20.6	89

(ii) All flights departing EU airports

	Multiplier = 0		Multiplier = 2	
	(£ mn per year)	(£ per t freight)	(£ mn per year)	(£ per t freight)
Regulatory Risk Scenario 1	1.0	7	2.0	13
Regulatory Risk Scenario 2	1.6	11	3.1	21
Regulatory Risk Scenario 3	2.8	19	5.6	38
Regulatory Risk Scenario 4	5.1	35	10.3	70
Regulatory Risk Scenario 5	8.4	57	16.9	115
Regulatory Risk Scenario 6	11.7	80	23.5	160

(iii) All flights arriving at, and all flights departing EU airports

	Multiplier = 0		Multiplier = 2	
	(£ mn per year)	(£ per t freight)	(£ mn per year)	(£ per t freight)
Regulatory Risk Scenario 1	2.0	7	3.9	13
Regulatory Risk Scenario 2	3.1	11	6.2	21
Regulatory Risk Scenario 3	5.6	19	11.1	38
Regulatory Risk Scenario 4	10.2	35	20.4	70
Regulatory Risk Scenario 5	16.7	57	33.5	114
Regulatory Risk Scenario 6	23.3	80	46.6	159

Note: Annual regulatory risk costs are normalised to regulated tonnages only.

Source: Own calculations.

Table 45: Total Annual Regulatory Risk Costs Faced by Cargo Sector at EMA from Impact Pathway ❶ by 2020, by Regulatory Risk Scenario and Geographic Coverage Scenario (2005 £)

(i) Intra-EU flights only

	Multiplier = 0		Multiplier = 2	
	(£ mn per year)	(£ per t freight)	(£ mn per year)	(£ per t freight)
Regulatory Risk Scenario 1	1.7	2	3.5	3
Regulatory Risk Scenario 2	2.8	3	5.5	5
Regulatory Risk Scenario 3	4.9	5	9.8	9
Regulatory Risk Scenario 4	9.0	9	18.0	17
Regulatory Risk Scenario 5	14.8	14	29.6	28
Regulatory Risk Scenario 6	20.6	20	41.2	39

(ii) All flights departing EU airports

	Multiplier = 0		Multiplier = 2	
	(£ mn per year)	(£ per t freight)	(£ mn per year)	(£ per t freight)
Regulatory Risk Scenario 1	2.0	3	4.1	6
Regulatory Risk Scenario 2	3.3	5	6.5	10
Regulatory Risk Scenario 3	5.8	9	11.6	17
Regulatory Risk Scenario 4	10.7	16	21.4	32
Regulatory Risk Scenario 5	17.5	26	35.0	52
Regulatory Risk Scenario 6	24.4	36	48.8	73

(iii) All flights arriving at, and all flights departing EU airports

	Multiplier = 0		Multiplier = 2	
	(£ mn per year)	(£ per t freight)	(£ mn per year)	(£ per t freight)
Regulatory Risk Scenario 1	4.1	3	8.1	6
Regulatory Risk Scenario 2	6.5	5	13.0	10
Regulatory Risk Scenario 3	11.5	9	23.1	17
Regulatory Risk Scenario 4	21.2	16	42.4	32
Regulatory Risk Scenario 5	34.8	26	69.5	52
Regulatory Risk Scenario 6	48.4	36	96.9	73

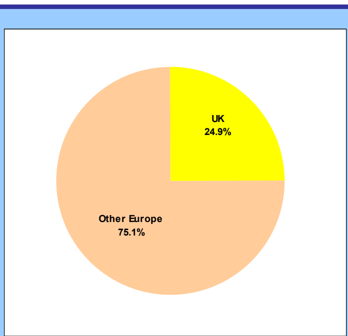
Note: Annual regulatory risk costs are normalised to regulated tonnages only.

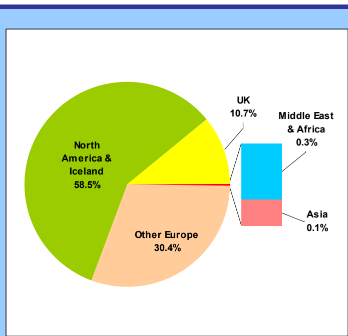
Source: Own calculations.

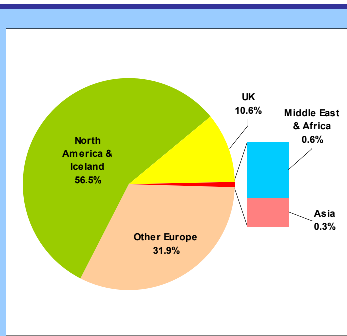
For each geographic coverage scenario, Figure 34 shows the distribution of total annual regulatory costs in 2020 under RRS 4 by the origin of the arriving flight / destination of the departing flight. The source of risk under scenario (i) is mainly flights to and from mainland Europe, with only 25% of annual carbon costs associated with flights internal to the UK. For scenario (ii) and (ii) the main source of risk are flights to and from North America and Iceland (accounting for roughly 60% of total annual carbon costs), with flights to and from airports on mainland Europe and elsewhere in the UK accounting for roughly 30% and 10% of total annual carbon costs, respectively.

Figure 34: Distribution of Total Annual Regulatory Costs by Source / Destination of ATM in 2020, by Geographic Coverage Scenario (RSS 4) (applies to both multiplier = 0 and multiplier = 2)

(i) Intra-EU flights only	(ii) All flights departing EU airports	(iii) All flights arriving at, and all flights departing EU airports







Source: Own calculations.

Depending on the assumed revenue tonne-mile, we estimate that the average price of all cargo moved through EMA ranges from (2005 prices) about £355 to £495 per tonne (see Figure 35, "All Cargo ATM"). Our estimated average prices do, as one would expect, vary significantly depending on the origin or destination of the ATM, and thus the distance a tonne of cargo must travel (as witnessed in Figure 35).

For our 'best guess' regulatory risk scenario we have expressed the average carbon cost per tonne of cargo in 2020 as a percentage of the average price of cargo. The results are shown in Figure 36 for each of the three geographic coverage scenarios, assuming no 'multiplier' to account for non-CO_2 effects. The top set of bars in each of the graphs in Figure 36 shows the average carbon cost per tonne over all regulated ATMs as a percentage of the average price per tonne on all regulated ATMs. In this case, where in effect total annual carbon costs are spread over all regulated ATMs, we observe that:

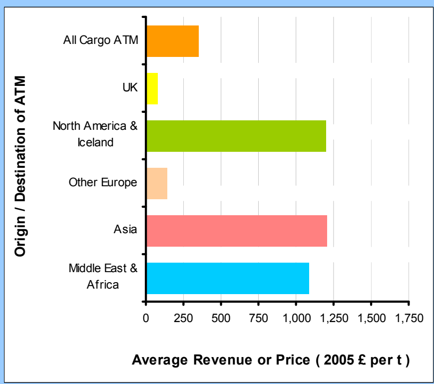
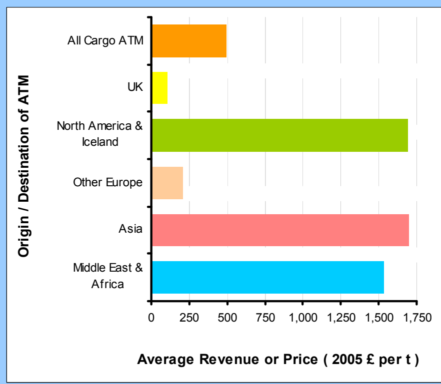
(i) intra-EU flights only = average carbon costs per tonne as a percentage of average price per tonne in 2020 ranges from about 1.5% to 4.0%;

(ii) all flights departing EU airports = average carbon costs per tonne as a percentage of average price per tonne in 2020 ranges from about 1.5% to 4.5%; and

(iii) all flights arriving at, and all flights departing EU airports = average carbon costs per tonne as a percentage of average price per tonne in 2020 ranges from about 3.0% to 9.0%.

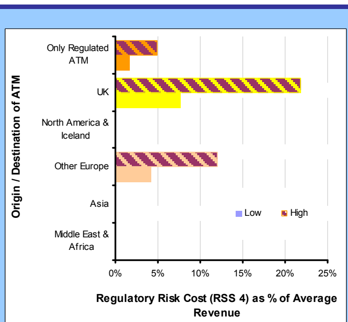
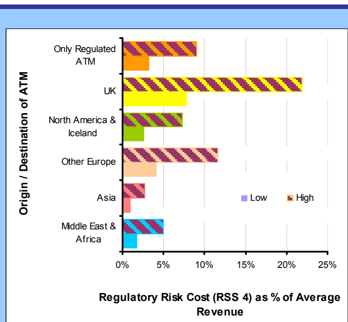
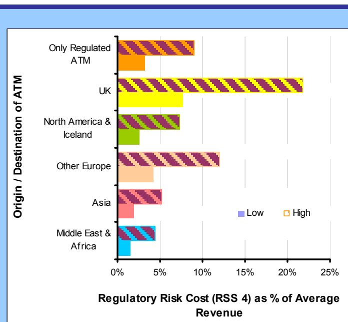
All other sets of bars in each of the graphs in Figure 36 show the average carbon cost per tonne incurred on a particular route (source / destination of ATM) as a percentage of the average price per tonne of cargo moved on that route. In these cases, we observe that the highest cost burden is experienced on cargo moved within the UK, irrespective of the geographic coverage scenario. Average carbon costs per tonne on all internal UK ATMs as a percentage of the average price of moving one tonne of cargo on these routes ranges from roughly 8.0% to 22.0%. The next highest cost burdens are experienced on cargo moved to and from airports in other European countries. Average carbon costs per tonne on all ATMs to and from mainland Europe as a percentage of the average price of moving one tonne of cargo on these routes ranges from roughly 4.0% to 12.0%.

Figure 35: Average Price of Cargo, by Source / Destination of ATM (2005 £)

(a) Low (Based on a revenue tonne-mile = 40 pence)	(b) High (Based on a revenue tonne-mile = 55 pence)
	

Source: Own calculations.

Figure 36: Total Annual Regulatory Costs as a Percentage of Average Cargo Price in 2020, by Source / Destination of ATM and by Geographic Coverage Scenario (RSS 4) (multiplier = 0)

(i) Intra-EU flights only	(ii) All flights departing EU airports	(iii) All flights arriving at, and all flights departing EU airports
		

Source: Own calculations.

Table and Table summarise the impacts on the cargo sector at EMA as a result of incurring the carbon costs under RRS 4, assuming that operators in the sector will ultimately pass through, respectively, 35% and 100% of these costs to customers. Frame (a) in both tables shows the predicted reduction in throughput (on a tonnage basis) as a result of higher cargo prices inducing reductions in demand for cargo services. In general, as expected:

- The higher the cost transfer percentage the bigger the reduction in throughput; however, it is important to remember that those costs that are not passed on will result in an equivalent reduction in gross profit. It is therefore wrong to conclude that the largest overall impact on sector profitability will occur with 100% cost pass through.
- Reductions with the lower value for revenue tonne-miles are more severe than with the higher value for revenue tonne-miles, since the percentage change in the original price is higher in the former case when the carbon costs are added.
- Reductions in throughput with the multiplier are double those without the multiplier.
- For a particular geographic coverage scenario, the largest impacts will thus occur for the ‘low cargo price-multiplier’ combination and the smallest impacts will occur for the ‘high cargo price-no multiplier’ combination.

These general findings also hold for frame (b) and (c) in both tables. Still looking at frame (a), if all flights departing and all flights arriving in Europe are covered by a regulatory regime for carbon emissions, we estimate throughput reductions in 2020 of about 0.9% to 2.6% with 35% cost pass through and 2.6% to 7.0% with 100% cost pass through, depending on the other assumptions adopted (RSS 4 only). Reductions in throughput are lower under the other two geographic coverage scenarios, but only if cargo operators spread the carbon costs over all routes, and not solely regulated routes. The latter strategy will result in relatively larger reductions in throughput (and other impacts, below) – especially in the case where only intra-EU flights are covered. This is because the average price per tonne on these routes is much lower than on routes which move cargo outside the EU, so the percentage change in price (and reduction in demand) is relatively high when the carbon costs are added. (We have assumed the same price elasticity of demand on all routes; a more accurate analysis would involve using route-specific elasticities.)

Frame (b) in both tables shows the predicted reduction in total employment in the East Midlands directly and indirectly related to, and induced by, a reduction in cargo activities at EMA in 2020. For example, if all flights departing and all flights arriving in Europe are covered by a regulatory regime for carbon emissions, we estimate total job losses in the region by 2020 of about 100 to 270 FTEs with 35% cost pass through, and 280 to 730 FTEs with 100% cost pass through, depending on the other assumptions adopted (RSS 4 only). Note that these job losses do not include losses resulting from reductions in cargo activity at airports in other regions, which would also be affected by moves to price the carbon emissions of aircraft; according to OEF (2006) a number of jobs in the East Midlands are indirectly related to, or induced by, cargo activities at other airports. Figure 37 and Figure 38 decompose the estimated job losses in the region under RRS 4 into direct, indirect and induced effects, assuming 35% and 100% cost pass through, respectively. In general, direct effects dominate, accounting for approximately 60% of total job losses, with indirect and induced effects each accounting for about 20% of total job losses.

Frame (c) in both tables shows the predicted loss of income in the East Midlands associated with the direct employment effects in frame (b). For example, if all flights departing and all flights arriving in Europe are covered by a regulatory regime for carbon emissions, we estimate total reductions in income in the region by 2020 of about £4 to £10 million per year (2005 prices) with 35% cost pass through, and £10 to £26 million per year with 100% cost pass through, depending on the other assumptions adopted (RSS 4 only).

Table 46: Summary of Impacts on Cargo Sector at EMA and Regional Economy in 2020 from Impact Pathway ❶ for a Range of Scenarios (RSS 4 only) (35% cost pass through)

(a) Percentage Change in Cargo Throughput at EMA

	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	-1.3%	-0.7%	-0.7%	-0.6%	-1.5%
Multiplier	-2.6%	-1.3%	-1.3%	-1.1%	-3.0%
High Unit Revenue:					
No Multiplier	-0.9%	-0.5%	-0.5%	-0.4%	-1.1%
Multiplier	-1.8%	-0.9%	-0.9%	-0.8%	-2.1%

(b) Total Estimated Job Losses in Region (number of FTE)

	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	- 140	- 70	- 140	- 60	- 200
Multiplier	- 270	- 140	- 280	- 120	- 400
High Unit Revenue:					
No Multiplier	- 100	- 50	- 100	- 40	- 150
Multiplier	- 190	- 100	- 200	- 80	- 290

(c) Total Income Losses in Region (2005 £ million per year)

	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	- 5	- 3	- 5	- 2	- 7
Multiplier	- 10	- 5	- 10	- 4	- 14
High Unit Revenue:					
No Multiplier	- 4	- 2	- 4	- 2	- 5
Multiplier	- 7	- 4	- 7	- 3	- 10

Source: Own calculations.

Note: figures in (b) and (c) include direct + indirect + induced effects. FTE = full-time equivalents.

Table 47: Summary of Impacts on Cargo Sector at EMA and Regional Economy in 2020 from Impact Pathway ❶ for a Range of Scenarios (RSS 4 only) (100% cost pass through)

(a) Percentage Change in Cargo Throughput at EMA

	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	-3.6%	-1.9%	-1.9%	-1.6%	-4.2%
Multiplier	-7.0%	-3.7%	-3.5%	-3.1%	-7.9%
High Unit Revenue:					
No Multiplier	-2.6%	-1.3%	-1.3%	-1.1%	-3.0%
Multiplier	-5.1%	-2.6%	-2.6%	-2.2%	-5.8%

(b) Total Estimated Job Losses in Region (number of FTE)

	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	- 380	- 200	- 390	- 170	- 560
Multiplier	- 730	- 390	- 750	- 330	- 1,050
High Unit Revenue:					
No Multiplier	- 280	- 140	- 280	- 120	- 400
Multiplier	- 530	- 280	- 540	- 240	- 770

(c) Total Income Losses in Region (2005 £ million per year)

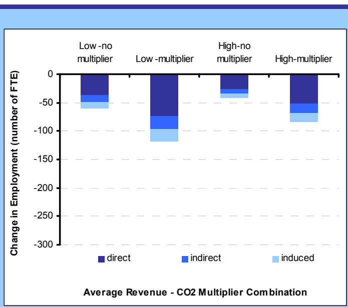
	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	- 14	- 7	- 14	- 6	- 20
Multiplier	- 26	- 14	- 27	- 12	- 38
High Unit Revenue:					
No Multiplier	- 10	- 5	- 10	- 4	- 15
Multiplier	- 19	- 10	- 19	- 8	- 28

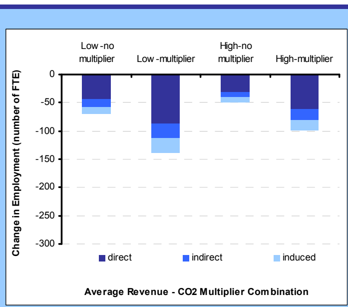
Source: Own calculations.

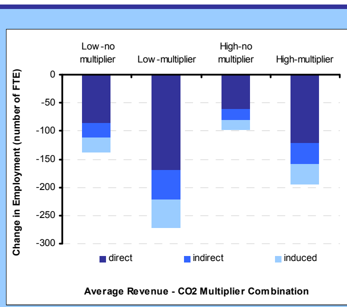
Note: figures in (b) and (c) include direct + indirect + induced effects. FTE = full-time equivalents.

Figure 37: Decomposition of Estimated Job Losses in Region, by Geographic Coverage Scenario, Average Price and Multiplier Assumption (RSS 4 only) (carbon costs are spread over all regulated ATMs) (35% cost pass through)

(i) Intra-EU flights only	(ii) All flights departing EU airports	(iii) All flights arriving at, and all flights departing EU airports



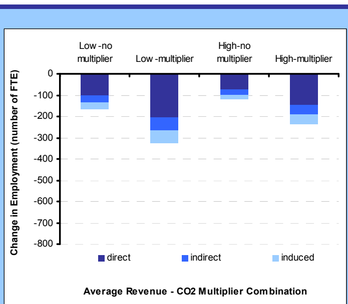


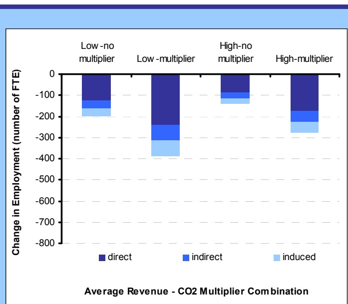


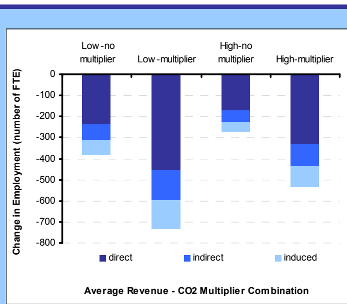
Source: Own calculations.

Figure 38: Decomposition of Estimated Job Losses in Region, by Geographic Coverage Scenario, Average Price and Multiplier Assumption (RSS 4 only) (carbon costs are spread over all regulated ATMs) (100% cost pass through)

(i) Intra-EU flights only	(ii) All flights departing EU airports	(iii) All flights arriving at, and all flights departing EU airports







Source: Own calculations.

Above, we considered the impacts on the cargo sector at EMA as a result of regulation to price the carbon emissions of aircraft (impact pathway ❶). Now let us consider the impacts on those sectors that make significant use of express delivery services only (impact pathway ❷) According to OEF (2006) the following sectors collectively account for over 70% of express sector sales at EMA: consumer goods, electronics, business services and financial services. Assuming that these customers of express delivery services make equal use of all regulated routes, we can look at the impact on their costs if express freight operators opt to pass on some (specifically, 35%) or all of the additional carbon costs. It is implicitly assumed that these same sectors will continue to account for the same percentage of total express sector revenue through 2020.

Table 48, Table 49, Table 50 and Table 51 summarise the estimated increases in operating costs of, respectively, the consumer goods, electronics, financial services and business services sectors in the East Midlands by 2020 from Impact Pathway ❷. In contrast to the magnitude of the impacts on cargo sector (discussed above), with the exception of applying the non-CO_2 multiplier, the circumstances that lead to the lowest level of impact for the cargo sector, now lead to the largest level of impact for its main customers. Basically, the smaller the percentage change in price from adding the cost of carbon emissions, the smaller the price-induced reduction in demand for express delivery services, and the larger the quantity of express freight over which customers must pay the higher price (inclusive of the carbon costs).

Looking at the worst scenario for customers of express delivery services, where all flights departing and all flights arriving in Europe are covered by a regulatory regime for carbon emissions, we estimate (2005 prices):

- Annual additional costs of between £1.5 million and £3.1 million with 35% cost pass through, and between £4.3 million and £8.4 million with 100% cost pass through, for **Consumer Goods** by 2020, depending on the other assumptions adopted (RSS 4 only).
- Annual additional costs of between £1.4 million and £2.8 million with 35% cost pass through, and between £3.9 million and £7.7 million with 100% cost pass through, for **Electronics** by 2020, depending on the other assumptions adopted (RSS 4 only).

- Annual additional costs of between £1.3 million and £2.5 million with 35% cost pass through, and between £3.5 million and £6.9 million with 100% cost pass through, for **Financial Services** by 2020, depending on the other assumptions adopted (RSS 4 only).
- Annual additional costs of between £0.8 million and £1.7 million with 35% cost pass through, and between £2.3 million and £4.6 million with 100% cost pass through, for **Business Services** by 2020, depending on the other assumptions adopted (RSS 4 only).

In order to put these additional annual costs in the context of each sector's financial performance, we have expressed them as a percentage of gross operating surplus, for the assumptions that lead to the highest impacts (i.e. high average price-multiplier combination); see Figure 39. Across all sectors, with 35% cost pass through the regulatory cost burden is negligible for Consumer Goods and Business Services, and just approaching 1% of GOS for Electronics. However, with 100% cost pass through, the regulatory cost burden for Electronics can be as high as 2.4% of GOS in the case where all flights departing and all flights arriving in Europe are covered by a regulatory regime for carbon emissions; the cost burden for Consumer Goods and Business Services is still well below 1% of GOS.

Table 48: Estimated Increases in Operating Costs of the Main Customers of Express Delivery Services in 2020 from Impact Pathway ❷ for a Range of Scenarios: CONSUMER GOODS (RSS 4 only) (2005 £ 000 per year)

(a) 35% Cost Pass-through

Consumer Goods	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	1,530	780	770	660	650
Multiplier	3,030	1,540	1,520	1,310	1,270
High Unit Revenue:					
No Multiplier	1,540	780	770	660	650
Multiplier	3,050	1,550	1,540	1,310	1,290

(b) 100% Cost Pass-through

Consumer Goods	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	4,280	2,190	2,160	1,860	1,790
Multiplier	8,280	4,310	4,170	3,660	3,410
High Unit Revenue:					
No Multiplier	4,320	2,210	2,180	1,870	1,820
Multiplier	8,440	4,360	4,250	3,690	3,510

Source: Own calculations.

Notes: allows for demand effects in response to higher priced express delivery services

Table 49: Estimated Increases in Operating Costs of the Main Customers of Express Delivery Services in 2020 from Impact Pathway ❷ for a Range of Scenarios: ELECTRONICS (RSS 4 only) (2005 £ 000 per year)

(a) 35% Cost Pass-through

Electronics	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	1,390	710	700	600	590
Multiplier	2,750	1,400	1,390	1,190	1,160
High Unit Revenue:					
No Multiplier	1,400	710	700	600	590
Multiplier	2,770	1,410	1,400	1,190	1,170

(b) 100% Cost Pass-through

Electronics	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	3,890	1,990	1,960	1,690	1,630
Multiplier	7,530	3,920	3,790	3,330	3,100
High Unit Revenue:					
No Multiplier	3,930	2,010	1,980	1,700	1,650
Multiplier	7,680	3,960	3,860	3,360	3,190

Source: Own calculations.

Notes: allows for demand effects in response to higher priced express delivery services

Table 50: Estimated Increases in Operating Costs of the Main Customers of Express Delivery Services in 2020 from Impact Pathway ❷ for a Range of Scenarios: FINANCIAL SERVICES (RSS 4 only) (2005 £ 000 per year)

(a) 35% Cost Pass-through

Financial Services	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	1,250	640	630	540	530
Multiplier	2,480	1,260	1,250	1,070	1,040
High Unit Revenue:					
No Multiplier	1,260	640	630	540	530
Multiplier	2,500	1,270	1,260	1,070	1,050

(b) 100% Cost Pass-through

Financial Services	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	3,500	1,800	1,760	1,520	1,460
Multiplier	6,780	3,530	3,410	2,990	2,790
High Unit Revenue:					
No Multiplier	3,540	1,800	1,780	1,530	1,490
Multiplier	6,910	3,560	3,480	3,020	2,870

Source: Own calculations.

Notes: allows for demand effects in response to higher priced express delivery services

Table 51: Estimated Increases in Operating Costs of the Main Customers of Express Delivery Services in 2020 from Impact Pathway ❷ for a Range of Scenarios: BUSINESS SERVICES (RSS 4 only) (2005 £ 000 per year)

(a) 35% Cost Pass-through

Business Services	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	840	420	420	360	350
Multiplier	1,650	840	830	710	690
High Unit Revenue:					
No Multiplier	840	420	420	360	360
Multiplier	1,660	850	840	710	700

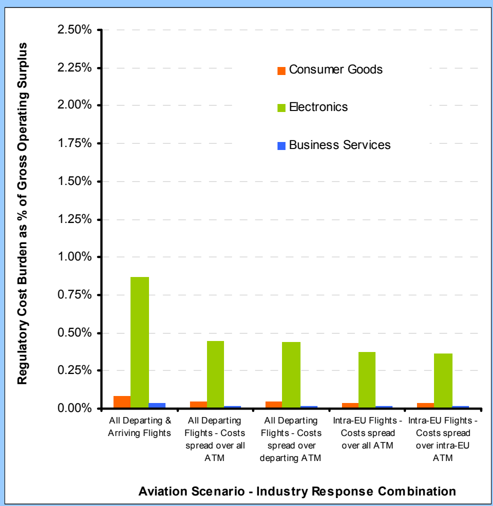
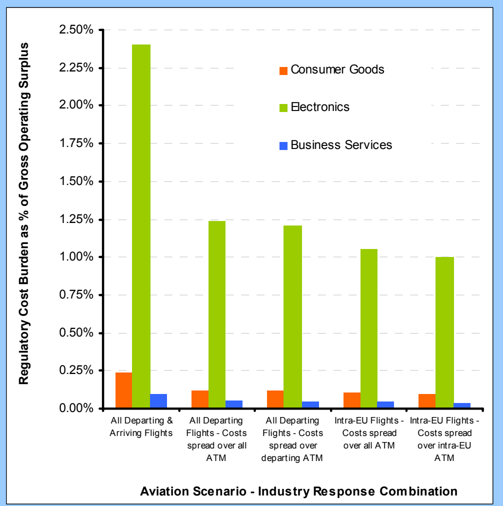
(b) 100% Cost Pass-through

Business Services	All Departing & Arriving Flights	All Departing Flights		Intra-EU Flights	
	Costs spread over all ATM	Costs spread over all ATM	Costs spread over departing ATM	Costs spread over all ATM	Costs spread over intra-EU ATM
Low Unit Revenue:					
No Multiplier	2,340	1,200	1,180	1,010	980
Multiplier	4,520	2,350	2,270	2,000	1,860
High Unit Revenue:					
No Multiplier	2,360	1,200	1,190	1,020	990
Multiplier	4,610	2,380	2,320	2,010	1,910

Source: Own calculations.

Notes: allows for demand effects in response to higher priced express delivery services

Figure 39: Regulatory Cost Burden as a Percentage of Gross Operating Surplus for the Main Customers of Express Delivery Services in 2020, by Geographic Coverage Scenario (High average price-multiplier combination)

(a) 35% Cost Pass-through	(b) 100% Cost Pass-through
	

Source: Own calculations.

Notes: It was not possible to calculate the gross operating surplus of the financial services sector in the East Midlands.

Conclusions

Summary of Economic Analysis

The climate change-related regulatory risks faced by cargo and express freight enterprises at EMA derive specifically from direct and indirect greenhouse gas emissions by the sector. However, there is an indirect impact to the regional economy as many sectors make heavy use of express delivery services.

Total annual carbon emissions from ATMs at EMA are estimated to be 1.6 million t CO_2-eq per year. Of this total, 55% derive from ATMs to North America and Iceland and 45% from ATMs to Europe (including the UK).

The total additional annual (regulatory risk) costs facing the cargo sector at EMA in 2020 under the “best guess” scenario is between £40.9 million per year (multiplier = 0) and £81.8 million per year (multiplier = 2). To allow for regulation of both the direct and indirect contribution of cargo ATMs to climate change, we calculate regulatory risk costs for two scenarios (a) estimated CO_2-eq emissions only and (b) estimated CO_2-eq emissions times a precautionary ‘multiplier’ of 2 to internalise the costs of the potential indirect effects.

This is double what they are during the baseline period, despite anticipated growth in tonnage of 355%. Improvements in fuel efficiency and increases in the size of cargo planes reduce CO_2-eq. emissions per tonne-mile.

The total additional annual (regulatory risk) costs on regulated routes in 2020 under the “best guess” scenario is between £41.0 million per year (multiplier = 0) and £82.0 million per year (multiplier = 2).

The average carbon cost per tonne of cargo for all flights arriving or departing from EU airports in 2020 under the “best guess scenario” is between 3.0 and 9.0% of the average price per tonne. The highest cost burden is expected on cargo moved within the UK. Average carbon costs per tonne on all internal UK ATMs as a percentage of the average price of moving one tonne of cargo on these routes ranges from 8.0% to 22.0%.

The impacts of an increase in additional annual costs will have direct effects on the economy of EMA. If all flights departing from and arriving in Europe are covered by a regulatory regime for carbon emissions, in 2020;

- Throughput reduction is estimated at 0.9% to 2.6% (assuming 35% cost pass through) and 2.6% to 7.0% (assuming 100% cost pass through);
- Job losses in the region of 100 to 270 FTEs are estimated (assuming 35% cost pass through) and 280 to 730 FTEs (assuming 100% cost pass through):
- Total income losses in the region are estimated at £4 million to £10 million per year (assuming 35% cost pass through) and £10 million to £26 million (assuming 100% cost pass through).

In addition to direct regulatory impacts to the cargo and express delivery sector at EMA, there will be indirect impacts on sectors that make significant use of these services. If all flights departing from and arriving in Europe are covered by a regulatory regime for carbon emissions, in 2020 we estimate:

- Additional costs of between £1.5 million and £3.1 million (assuming 35% cost pass through) and between £4,3 million and £8,4 million (assuming 100% cost pass through) for the Consumer Goods sector:
- Additional costs of between £1.4 million and £2.8 million (assuming 35% cost pass through) and between £3.9 million and £7.7 million (assuming 100% cost pass through) for the Electronics sector:
- Additional costs of between £1.3 million and £2.5 million (assuming 35% cost pass through) and between £3.5 million and £6.9 million (assuming 100% cost pass through) for the Financial Services sector: and
- Additional costs of between £0.8 million and £1.7 million (assuming 35% cost pass through) and between £2.3 million and £4.6 million (assuming 100% cost pass through) for the Business Services sector.

In terms of GOS, with 35% cost pass through the regulatory cost burden is negligible for Consumer Goods and Business Service sectors but approaches 1% for Electronics. With 100% cost pass through, the regulatory cost burden for Electronics is as high as 2.4% of GOS.

Policy Implications

Primarily, mitigation policy represents a risk to the growth of the cargo and express freight sector at EMA, due to the internalisation of the carbon externality through inclusion of aviation in the EU ETS. In July 2008, the European Parliament voted to include all flights starting from and landing in the EU in the ETS from 2012, i.e. in our phrasing “intra-EU” flights will be included in the ETS.

There is a direct risk to profitability and employment associated with this in cargo and express freight enterprises operating out of EMA and there are also indirect risks to other sectors that use these services. EMA is a nationally significant freight hub and hence this may be significant to national as well as regional policy.

The significance of these impacts will partly depend on the ability and willingness of enterprises to pass through additional regulatory costs. The direct impact to express freight operators will also depend on technological advances that increase the fuel efficiency and size of cargo planes.

There are also potential opportunities for the sector, for example in relation to aviation fuel efficiencies. Opportunities may also be realised by being an early mover – maximising gains under the EU ETS or the CCL and more generally through competitive advantage.

Significant uncertainties remain regarding policy targets and the costs of carbon and it will be prudent for emda to maintain a watching brief on these, along with emerging mitigation measures.

A number of initial recommendations can be drawn for emda and other interested parties, including the Government, to consider:

- Research into the ability and likelihood of companies passing on additional costs and the relationship with net effects on the regional economy. In particular, understanding the different elasticities and market characteristics between the express part of the market, and the rest, would be useful to get a better perspective on the scale, type and extent of the risks.
- Facilitate collaboration between enterprises operating out of EMA, the transport equipment manufacturing sector and the region's universities to ensure that the East Midlands region is a leader in the development and implementation of cleaner aviation technology. Funds to e.g. facilitate the commercialisation of research from the region's universities in this area and promote interaction between industry and the universities through Knowledge Transfer Partnerships or other initiatives may enable the East Midlands to position itself to respond to ever increasing environmental standards in aviation.
- Ensuring those employed at EMA possess transferable skills.
- Ensuring those enterprises impacted by inclusion in the EU ETS are fully briefed on the implications of the scheme for their business.
- Development of a mitigation measures toolkit to help enterprises consider how

to reduce GHG emissions and how much this may cost.

Emda's support in climate change mitigation for this sector will also help achieve other Priority Actions set out in the RES including:

- Maximise Benefits of EMA and Robin Hood Airport
- Providing Business Support on Resource Efficiency
- Reducing the Demand for Energy and Resources
- Exploiting Low Carbon Technologies.
- Developing Adult Workforce Skills

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Appendix: Methodology

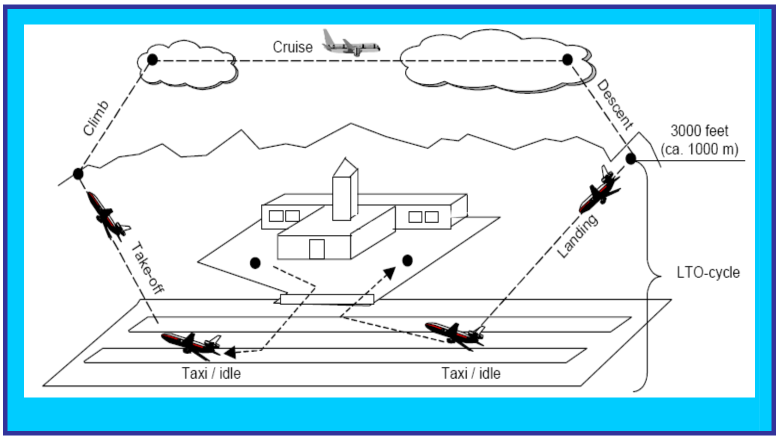
The regulatory risk analysis is based on the following steps:

19. Using data from EUROCONTROL, we identify (a) the destination airport of all cargo flights leaving EMA and (b) the origin airport of all cargo flights arriving at EMA. For each 'route' we collate data on (i) the annual cargo ATMs and (ii) the total tonnes of freight moved, over the period 2003-05. An annual average is then calculated for (i) and (ii) for each route. These average annual values function as a baseline for the analysis. For EMA as a whole, average annual cargo ATMs are estimated at just over 19 thousand, while estimated average annual tonnes of cargo moved are close to 293 thousand tonnes. The average tonnage per movement is just over 15 tonnes. For each route, average annual ATMs and tonnages are split between arrivals and departures. Over all ATMs, the split between arrivals and departures is virtually 50:50, although there is significant variation across 'routes'.
20. Total nautical air miles are next determined for an ATM on each route and for all ATMs on the route for an average year over the period 2003-05. In total, about 10.5 million nautical miles are flown, on average, per year by cargo aircraft using EMA (equivalent to about 550 per ATM). Cargo flights using EMA are estimated to give rise to nearly 265 million total tonne-miles per year, on average. Total ATMs and associated annual nautical miles are split between routes located in the following geographic regions: Asia (A), the Middle East and North Africa (M), North America and Iceland, the UK (UK), and the rest of Europe (E). Grouping total ATMs in this way is necessary since current proposals to include aviation in the EU ETS do not necessarily capture all cargo ATMs through EMA; moreover, it allows us to see the risks associated with cargo movements to different geographic areas.
21. CO_2-eq emissions are calculated, by route, for all cargo ATMs through EMA using guidelines published by the European Environment Agency (EEA) for estimating emissions from air traffic (Emission Inventory Guidebook, EEA, Copenhagen, December 2006). We employed a variation of the 'detailed'

method in the Guidebook to both of the main parts of aircraft operations (a) the landing / take-off (LTO) cycle, which includes all activities near the airport that take place below the altitude of 3,000 feet (1,000 m) (i.e. taxi-in and out, take-off, climb-out, and approach-landing) and (b) cruise, which includes all activities that take place at altitudes above 3,000 feet (1,000 m) (see Figure 10). To apply the 'detailed' method as prescribed in the Guidebook requires knowledge of the specific aircraft flying each route. In the absence of this information, we use fuel consumption data by aircraft from the Guidebook to estimate an equation describing average fuel consumption as a function of distance (nautical miles), across all aircraft currently used to carry pure freight. This function is subsequently used to calculate total fuel consumption (in kg) for an ATM on each route. CO_2-eq emissions are calculated from the fuel consumption estimates on the basis of the following emission factor: 3.15 kg CO_2-eq per kg fuel.

22. The contribution of aircraft operations to climate change are higher than the direct effect of CO_2-eq emissions alone; a number of indirect effects also play an important role. For instance, while the emission of NO_x at ground level contributes to local air pollution, emissions at altitude lead to the formation of ozone – a greenhouse gas. Furthermore, condensation trails (contrails) from aircraft may lead to the formation of cirrus clouds that can have a net climate warming effect. The direct effects are well understood; the indirect effects are less well understood. The Intergovernmental Panel on Climate Change (IPCC, 1999) estimated that the total impact of aviation on climate change is about 2 to 4 times higher than the direct effect stemming from past CO_2-eq emissions alone. However, recent research for the EC supports a value closer to 2. To allow for regulation of both the direct and indirect contribution of cargo ATMs to climate change, we calculate regulatory risk costs for two scenarios (a) estimated CO_2-eq emissions only and (b) estimated CO_2-eq emissions times a precautionary 'multiplier' of 2 to internalise the costs of the potential indirect effects.

Figure 40: Two Parts of Aircraft Operations for Emissions Calculations



Source: EEA, Emissions Inventory Guidebook, December 2006, Figure 3.1 p. B851-5.

23. The EC considered three scenarios for geographic coverage in its Impact Assessment of including aviation in the ETS – namely (i) intra-EU flights only (ii) all flights departing EU airports and (iii) all flights arriving at, and all flights departing EU airports. We calculate total annual carbon emissions (and subsequently, regulatory risk costs) for each of these three scenarios.

24. Total annual CO_2-eq emissions (kt CO_2-eq per year), by geographic coverage scenario and relevant routes, are next multiplied by the price of carbon (2005 £ per t CO_2-eq) corresponding to each of our six Regulatory Risk Scenarios (RRS). The calculations are performed with and without the 'multiplier'. Summing across all routes relevant to a geographic scenario provides a measure of the total potential regulatory costs, under each RRS, for all cargo ATMs through EMA. The calculations are performed for an average year over the period 2003-05.

25. The EMA Master Plan (Chapter 4 and Appendix 1) contains forecasts for cargo traffic through to 2030, drawn primarily from Department of Transport forecasts. We use the figure of 2.6 million tonnes as the forecast total annual cargo throughput at EMA by 2030. Assuming that, on average, tonnages per freight movement range from 37.2 to 39.4, total cargo ATMs by 2030 are

forecast to range from 66 to 70 thousand per year. Forecasts of total ATMs and total tonnages for 2020 are found by linear interpolation between our baseline values and the 2030 projections. These forecasts include all mail flights. The Master Plan expects that with alternative technologies and greater competition in the mail delivery business, mail throughput will not grow significantly higher than current levels (just over 26 thousand tonnes), and will therefore only represent a very small part of total cargo activity through to 2030. We therefore do not separate out regulatory risks to future mail services.

26. Forecast ATMs and tonnages by route are found be pro rating the totals for EMA as whole in 2020 on the basis of each route's share of the baseline totals. In other words, we assume that the current routes, and usage of those routes, remain constant over the forecast period.

27. Steps 3-6 are now repeated to determine the total potential regulatory costs, under each RRS, for all projected cargo ATMs at EMA in 2020. Historically, the fuel efficiency of aircraft has improved considerably. In calculating the fuel consumption for projected ATMs in 2020 we assume that the fuel efficiency of aircraft will improve by, on average, 1-2.5% per year over the forecast period relative to baseline levels (Peters et al 2005)[47].

28. We next analyse the effect of the additional carbon costs on the express delivery industry at EMA, in terms of impacts on (a) freight throughput, (b) employment and (c) income. Impacts are measured for our 'best guess' regulatory risk scenario (RRS 4) only. Employment and income effects include those arising directly as a result of (a), as well as indirect and induced effects. The latter two effects are calculated using relevant Type I and Type II employment and income multipliers for 2020, which are derived from York Aviation (2003)[48]. Changes in (a) are estimated assuming carbon cost pass through of 35% (York Aviation,

[47] Peters, P. et al (2005) "Fuel efficiency of commercial aircraft – an overview of historical and future trends". National Aerospace Laboratory (NLR), November 2005.

[48] York Aviation (2003) East Midlands International Airport – Economic Development Strategy, Revised Draft, EMDA and East Midlands International Airport Limited, December 2003.

2007)[49] and 100% (Delft CE,)[50], and assuming a price elasticity of demand for express delivery services of negative 0.8 (York Aviation, 2007). Recall that the lowest impact on the profitability of express freight operators is likely to occur with 100% cost pass through, while the largest impact on profitability is likely to occur with no cost pass through. A low and high average price (2005 £) per tonne of express freight is calculated assuming an average revenue tonne-mile of 40 pence and 55 pence[51]. The average price is increased by the average regulatory cost per tonne (RRS 4), with and without the 'multiplier', adjusted for the assumed level of cost pass through, and the new level of demand is determined as a function of the assumed elasticity of demand for express delivery services, the estimated change in price, and projected throughput prior to internalisation of the carbon cost.

29. York Aviation (2003) provide estimates of direct employment in or near EMA in 2015 and 2030, which are consistent with cargo throughput forecasts for the airport. To determine the direct employment in the cargo sector in or near EMA in 2020 we, first, linearly interpolate between the 2015 and 2030 forecasts of York Aviation, and second, assume 39% of this figure works in the cargo sector; the same proportion of the total workforce employed in the sector today.

30. It should be noted that – depending on the geographic coverage scenario – express freight operators could, in principle, opt to spread the regulatory risk costs over all routes or only over those routes captured by the geographic coverage scenario. For example, if carbon emissions from only intra-EU flights are priced, operators could recover the additional costs from only these fights, or spread the additional costs over all ATMs. This decision will affect the potential increase in express freight prices on a particular route and therefore the impact

[49] York Aviation (2007) Analysis of the EC Proposal to Include Aviation Activities in the Emissions Trading Scheme, Report for AEA, EBAA, ECA, ELFAA, ERA and IACA.

[50] Delft CE (2005) "Giving wings to emission trading - Inclusion of aviation under the European emission trading system (ETS): design and impacts", Report for the European Commission, DG Environment No. ENV.C.2/ETU/2004/0074, July 2005.

[51] Based on data obtained from the US ATA for FedEx and UPS.

on overall demand. We therefore consider situations in which the additional regulatory risk costs are spread over all routes or only regulated routes.

31. According to the Master Plan, about 86% of total cargo throughout in 2004 is express freight. Given that express freight's share of total throughput at EMA is anticipated to increase over time, we assume that by 2020 95% of the projected total tonnage of cargo through EMA is express freight.

32. Finally, we consider the potential impacts on the main users of express delivery services in the East Midlands (i.e. the consumer goods, electronics, business services and financial service sectors) (impact pathway ❷). This involves:

    a) Collating data on the financial performance of these sectors from EUROSTAT – e.g. number of enterprises, turnover, value added, gross operating surplus, total purchases of goods and services, and personnel costs. An annual average is calculated for the period 2001-05. As noted in CCS 1, this data is only available for the UK as a whole. We therefore normalise the financial statistics to the number of enterprises, and subsequently multiply these values for an average enterprise in the UK by the total number of enterprises in each sector in the East Midlands (the latter is again calculated as an annual average over the period 2001-05, based on data from EUROSTAT). This last step was not possible for 'financial services' since no data were available on the total number of enterprises in this sector in the East Midlands. It is implicitly assumed that an average enterprise in these sectors in the East Midlands has similar financial statistics to the national average. It is further assumed that an average enterprise in our baseline period has identical financial performance to an average enterprise in 2020.

    b) Total revenue from express freight at EMA in 2020 is estimated as a product of projected volume express freight and the average price (2005 £) per tonne of express freight (both low and high estimates). Based on each sector's share of total express freight revenue at EMA in our baseline period (see above) we determine each sector's annual express freight costs for 2020 and the tonnage of freight moved. It is implicitly assumed that each sector's share of total express freight revenue at EMA remains constant over the forecast period.

c) Next, we calculate the additional express costs likely to be faced by each sector if express freight operators pass on the additional costs of carbon (assuming 35% and 100% cost pass through), allowing for reductions in demand in response to higher express delivery services. To provide some indication of the size of the carbon cost burden, the additional freight costs are presented as a percentage of gross operating surplus (GOS). This was not possible for 'financial services' since we were unable to determine the GOS of this sector in the East Midlands.

CASE STUDY 7 – WATER RESOURCES

1. Introduction

Water is an essential resource and securing secure supplies in the future is crucial to support development in the East Midlands. Emra published a water resources strategy for the East Midlands in 2001 with a vision of "enough water for all; human uses with an improved water environment" (emra, 2001; 1). There are multiple pressures on water resources that pose a challenge to meeting this vision including climate change, development and the environment. This case study focuses on these three sources of pressure on water resources, the interaction between them and potential policy solutions.

With an average rainfall of 700mm per annum, the East Midlands region is already drier than the UK average of 900mm per annum (Environment Agency, 2007). Climate change is likely to exacerbate water stress as hotter drier summers and stormier winters reduce the amount of water available in the Region. Climate change is also likely to impact at other stages of the water cycle: waste water treatment, distribution networks and the aquatic environment.

Some impacts of climate change on water resources in the Region may well be beneficial; wetter winters, for example, may increase the opportunity for winter recharge and storage, while milder winters would reduce the frequency of pipe leakage from freeze-thaw weathering damage.

Climate change will not be the only source of pressure on water resources in the Region. Increased residential development and associated population growth will add to household demand for water services. A significant part of the Milton Keynes-South Midlands growth area (MKSM) falls within the East Midlands; this is one of the key areas identified by the government in The Sustainable Communities Plan (published in February 2003) for substantial housing development in an attempt to relieve housing pressures in the southeast. Northamptonshire has been identified to provide an additional 99,500 dwellings in the period from 2001 to 2021. The Environment Agency, in a paper provided fro the RSS8 Housing Options Appraisal, concluded that with increased housing growth there is greater potential for water resources deficits in the Water Resource Zones (WRZs) of the East Midlands (Cairns, undated). The analysis undertaken so far shows that the Severn Trent East Midlands WRZ is the most vulnerable to increased housing growth (Cairns, undated).

A third pressure on water resources in the future comes from environmental demand for water. European and national legislation (the Water Framework Directive (WFD), The Habitats Directive etc.) makes it imperative that aquatic environments are restored and enhanced to provide favourable habitats for biodiversity. The restoration and creation of wetland habitats requires large amounts of water, competing against other water uses. Further creation of wetland habitat as a means of flood defence adds to the pressure on water resources. Currently, wetland habitat creation is occurring in the Region to offset losses from coastal defence works on the Humber estuary and Lincolnshire coast, as well as inland on river floodplains.

The Regional Economic Strategy (RES) (emda, 2006) identifies priority actions for development in the Region, including ensuring provision of transport, economic, cultural, and community infrastructure, such as green infrastructure to support the creation of sustainable and integrated communities. It is therefore vital for planning in growth areas to consider water resources as part of a network of sustainable infrastructure, before development goes ahead.

This case study focuses on adaptation to the impacts of climate change on water resources and wider catchment management issues in the East Midlands. The impacts of climate change at all stages of the water cycle will be identified and appropriate adaptation strategies suggested.

2. Current situation

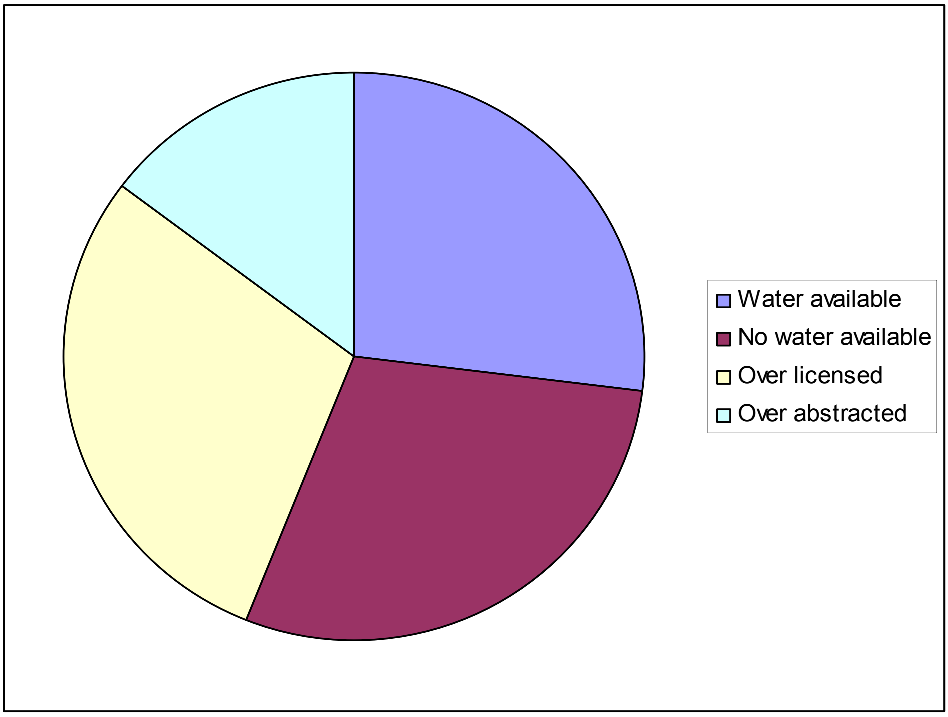
2.1 Water Supply

Over 1150 million litres of water per day (Ml/d) are abstracted for public supplies in the East Midlands. This water is supplied to domestic and industrial customers by Anglian Water and Severn Trent Water. Approximately half of all abstracted water in the region is used by households whilst industrial and commercial uses account for 30%. In addition to the 30% of public supply (345 million litres) used for non-household supply, industries abstract around 350 Ml/d for their own direct use (Emra 2001). The remaining 20% of water use is attibutable to miscellaneous uses and leakage.

Water in the Region is sourced from a combination of surface water and aquifers. Surface water sources in the Region include the rivers Derwent, Dove, Nene, Soar, Trent, Welland and Witham. Storage in the region is provided by a number of reservoirs including Carsington, Ladybower (in the Derwent Valley), Ogston, Pitsford and Rutland Water.

Surface water throughout the majority of the East Midlands is already fully committed to existing abstractions and the environment in the summer and no significant further resource is reliably available. Exceptions include the River Trent, and parts of the River Soar. However, there is scope for winter abstraction from most of the rivers. Catchment Abstraction Management Strategies (CAMS) have been prepared for a number of major rivers in the East Midlands regions. Figure 2.1 illustrates the status of the water resource management units (WRMUs) included in the CAMS completed to date for the East Midlands.

Figure 2.1 Water availability status of East Midlands CAMS WRMUs



Key

Water available - water likely to be available at all flows including low flows. Restrictions may apply.

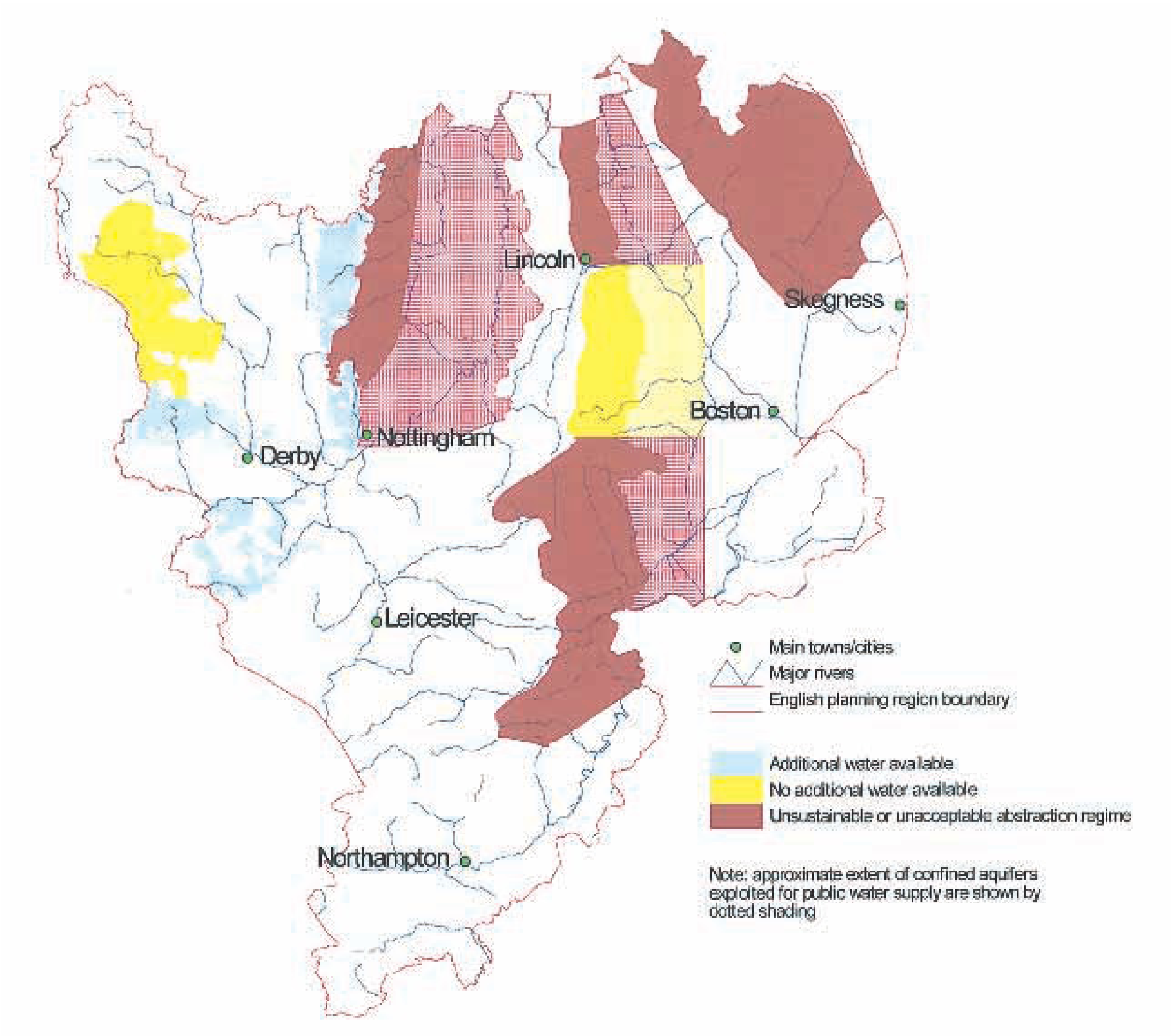
No water available - no water available for further licensing at low flows although water may be available at higher flows with appropriate restrictions.

Over-licensed - current actual abstraction is resulting in no water available at low flows. If existing licences were used to their full allocation they would have the potential to cause unacceptable environmental impact at low flows. Water may be available at high flows with appropriate restrictions.

Over-abstracted - existing abstraction is causing unacceptable environmental impact at low flows. Water may still be available at high flows with appropriate restrictions.

The Region is also served by groundwater, with approximately 40% of the Region underlain by usable aquifers (Environment Agency, 2007), notably the Sherwood Sandstones, the Lower Magnesian Limestone and Carboniferous limestone in the west of the region and the Lincolnshire Limestone, Lincolnshire Chalk and Spilsby Limestone in the east. The red shaded areas on Figure 2.2 show the Environment Agency's assessment of where groundwater abstractions currently exceed the sustainable limit.

Figure 2.2 Status of ground water resources in the East Midlands



Source Emda 2001

Defra and the Environment Agency have recently carried out a consultation into water stress. Water stress is classified into three levels, serious, moderate and low (see Table 2.1 for activity associated with each level). The East Midlands was originally classified as suffering from moderate water stress but following consultation, the Anglian Water part of the Region has been classified as suffering from serious water stress. The Severn Trent Water served area remains at moderate water stress (see Figure 2.3).

Table 2.1 Water efficiency activity required at each level of water stress

Water stress classification	Potential level of relative water efficiency activity
Serious	Highest level of activity; could include allowing compulsory metering
Moderate	Enhanced levels of activity; could include providing water saving devices
Low	Standard level of activity; could include increased communication with water users

Source Environment Agency 2007b

2.2 Water quality

The Environment Agency is responsible for monitoring water quality. During 2006, it monitored 3500km of watercourses in the East Midlands and the following results were obtained (Environment Agency 2007d):

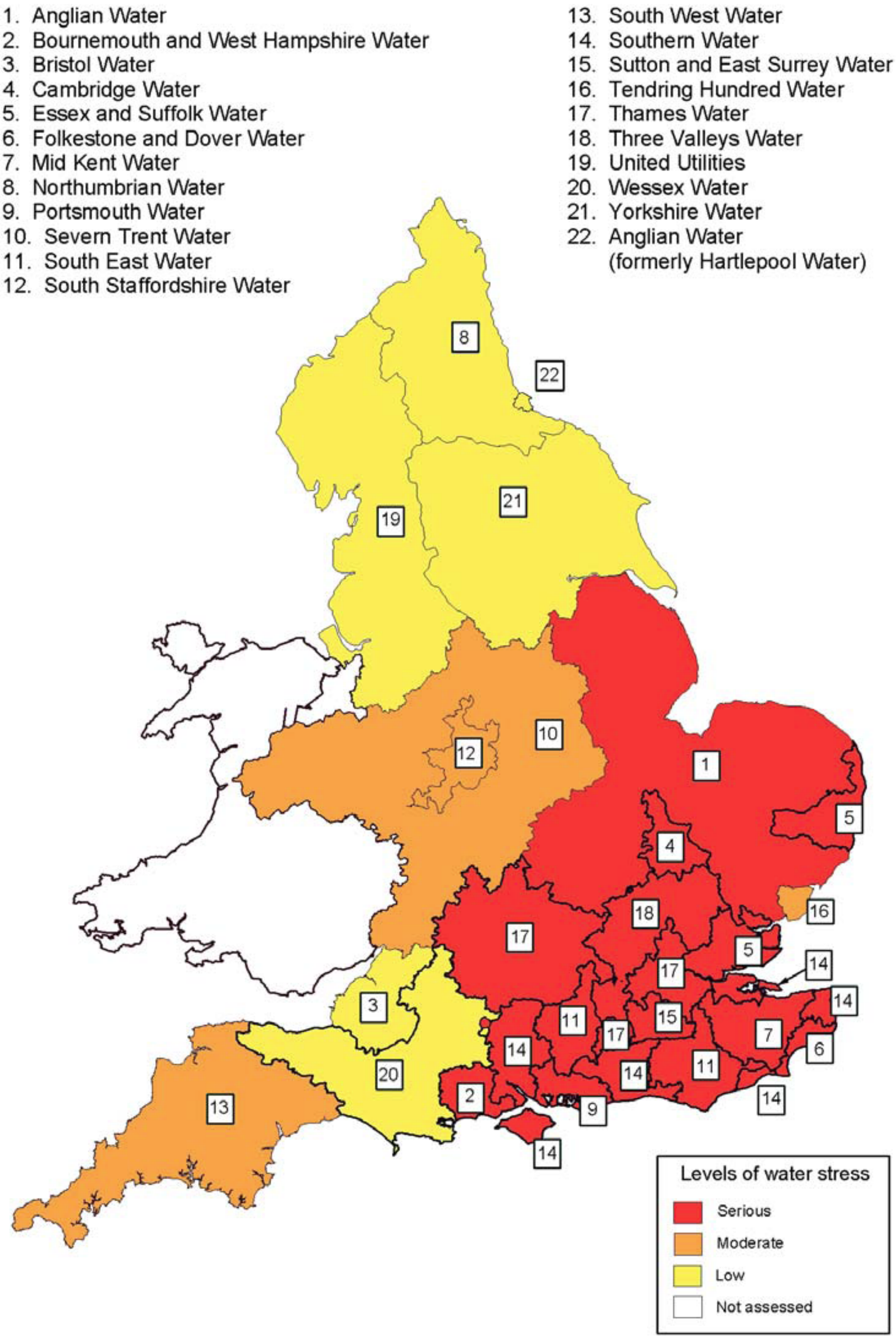
- 57% had high or very high nitrate levels;
- 60% had very high or excessively high phosphate levels;
- 94% had good or fair chemical quality;
- 97% had good or fair biological quality;
- 77% of watercourses achieved their river quality objective (RQO);
- 11% had significant failures of their RQO.

The implementation of the Water Framework Directive (WFD) will provide a more integrated framework for the sustainable management of water, linking land use with water use to deal with the pressures on our water environment. As a result, there will be a broader focus on sustainable water use and improving ecological status, dealing with diffuse pressures as well as more traditional point sources of pollution.

2.3 Aquatic environments

There are a number of sites designated sites of special scientific interest (SSSI) within the East Midlands. These sites cover a range of habitats including wetlands, canals, gravel pits and fens. The condition of SSSIs in England is assessed by Natural England. There are six reportable condition categories: favourable; unfavourable recovering; unfavourable no change; unfavourable declining; part destroyed; and destroyed. As of September 2006 68.0% of the SSSI areas in the East Midlands were classed as favourable or unfavourable recovering, compared to a UK wide figure of 73.0% (emra 2007b).

Figure 2.3 Water stress classification for England and Wales



Source Environment Agency 2007c

3. Climate change impacts on water resources

The Government's new water strategy for England, Future Water, published in February 2008, sets out the Government's long-term vision for water and the framework for water management in England. The strategy recognises the impact climate change is likely to have on water resources. Climate change is likely to have impacts on all stages of the water cycle (see Table 3.1).

Table 3.1 Impacts of climate change on the water cycle

Stage in water cycle	Climate change	Impact
Abstraction	Warmer, drier summers	Less water available for abstraction from rivers and aquifers
		Increase in drought frequency
		Increase in water demand
	Wetter winters	Increase in water available for abstraction
	Sea level rise	Salinisation of groundwater – less groundwater available
Storage	Wetter winters	Increased winter storage requirements
		Increased flood risk and risk of dam burst or overflow
	Drier summers	Greater evapotranspiration loss from reservoirs
		Change to soil conditions affecting slope stability
Treatment	Warmer summers	Increased frequency of algal blooms -

Stage in water cycle	Climate change	Impact
		operational problems at water treatment works, particularly direct filtration.
		Some treatment methods less effective
	Wetter winters	Increased risk of flooding of treatment works
Clean water distribution	Warmer, drier summers	Subsidence and cracking of pipes
Sewerage	Wetter winters	Increased runoff - increased risk of sewer flooding
Waste water treatment	Warmer summers	Some treatment methods less effective
		Odour problems
	Wetter winters	Increased risk of flooding of waste water treatment assets
	Drier summers	Increased algae risk (e.g. settlement tanks) because of lower summer flows and higher temperature
Discharge	Drier summers	Higher incidence of low flows – less dilution of discharge and potential consenting problems

3.1 Clean water services

The Region is at risk from hotter, drier summers brought on by climate change that may put pressure on water supplies. Summer temperatures are projected to rise by up to 1.5ºC by 2020, 3ºC by 2050 and 4.5ºC by 2020 (Hulme *et al*. 2002). Precipitation is projected to decrease by up to -20% by 2020, -30% by 2050 and -50% by 2080 (Hulme *et al*. 2002). Warmer, drier summers are likely to lead to an increase in the demand for water during these months as more is used for bathing, drinking, leisure and recreation and garden watering.

The Climate Change and Demand for Water (CCDeW) project forecasts the change in water demand that can be expected as a result of climate change under different climate and socio-economic scenarios. Estimates of climate change impacts on domestic demand (% change compared to a future reference socio-economic scenario) in the East Midlands are shown in Table 3.1.

Table 3.1 Climate change impacts on domestic water demand in the East Midlands

Scenario	Low 2020s	Med-High 2020s	Med-High 2050s
Alpha & Beta	1.45%	1.83%	3.04%
Gamma & Delta	1.00%	1.28%	2.18%

Source Downing *et al*. 2003

Industrial and commercial water users are also likely to increase their demand for water as a result of climate change, see Table 3.2.

Table 3.2 Climate change impacts on industrial and commercial water demand in the East Midlands

Scenario	2020s – Low	2020s – MH	2050s – MH
Alpha	Not modelled	2.6%	Not modelled
Beta	Not modelled	2.6%	5.7%
Gamma	2.4%	2.7%	Not modelled
Delta	Not modelled	2.3%	Not modelled

Source Downing *et al*. 2003

Climate change may affect supply as well as demand. Precipitation in summer months will decrease, leading to more frequent droughts. Winter rainfall is projected to increase (Hulme *et al*. 2002) but will be more likely to occur during intense storms. This type of precipitation is associated with rapid overland flow and little recharge of groundwater stores. There is also an issue over storage capacity; although winter precipitation may increase, there may not be sufficient capacity to store it. In an already water stressed region, increase in demand and reduction in available resources due to climate change is likely to increase pressure on water resources.

The two companies that supply the East Midlands will consider the impacts of climate change in their water resources management plans. The Environment Agency, in its Water Resource Planning Guideline (Environment Agency 2007e), requires water companies to screen resources zones to identify those where the impact of climate change should be investigated in more detail. The impacts of climate change on water supply from river flow, reservoir yield and groundwater flow should be analysed, ideally using a resource zone simulation model. In addition, to supply side impacts, the Environment Agency requires water companies to assess the impact of climate change on demand, using the factors presented in the CCDeW report.

The effect of climate change on the supply-demand balance should be assessed for each resource zone. If climate change makes little or no difference to activities before 2035, the company may state this and does not need to change its water resources management plan. If the impact of climate change makes little difference before 2025 but could to 2035, companies should consider the timing of the necessary investigations. If the impact of climate change is great enough to require changes to the water resources plan before 2025, the company should consider the further investigations and analysis that will be needed (Environment Agency 2007e). Both Severn Trent Water and Anglian Water are in the process of compiling their water resource management plans for 2009 and as such, it is not yet clear which resource zones in the East Midlands will be most impacted by climate change.

Climate change may also have an adverse impact on water quality as warmer temperatures increase the threat of algal blooms. Increasing salinity of water resources due to sea level rise and saline penetration will also increase treatment requirements.

Water supply and distribution may be affected by an increase in flood risk and the risk of dam burst. The embankment of the Ulley reservoir in South Yorkshire partly eroded during the floods of summer 2007. According to a report commissioned by Defra, climate change will increase the risk of failure of dams in the UK for a number of reasons (Babtie and CEH 2002):

- Summer droughts will lead to more subsidence of earth embankments;
- Stronger winds will lead to increased wave activity in reservoirs which could lead to overtopping and erosion;
- More severe rainfall events will lead to sudden loadings on embankments and spillways.

The safety of reservoir dams is a major concern to water companies as under UK legislation, the operators of reservoirs have a strict legal liability for any injury loss or damage resulting from escape of water.

Pipes are also at risk of damage due to climate change. Subsidence in areas of clay soils is likely to increase as a result of climate change. Drying out and cracking of the soil during dry periods leads to subsidence and damage to underground infrastructure including water supply pipes and sewers. Anglian Water recognises this impact of climate change in its Strategic Direction Statement (Anglian Water 2007), a key element of its consultation with customers and regulators on what it sees as the priorities for investment over the next 5-10 years and beyond. The Association of British Insurers (ABI) predicts a doubling in subsidence claims associated with climate change by the 2050s (ABI 2004). Significant parts of the East Midlands area are underlain by clay soils and as such, subsidence and the resulting damage to pipes is a concern in the Region.

Wetter winters are likely to result in an increase in the frequency and magnitude of floods. Flooding of water treatment works can have serious consequences, as demonstrated by the Summer 2007 floods around Gloucester where people were left without running water for up to two weeks after the flood event. There are a number of water treatment assets at risk of flooding in the East Midlands. Figure 3.1 illustrates Anglian Water assets at risk of flooding.

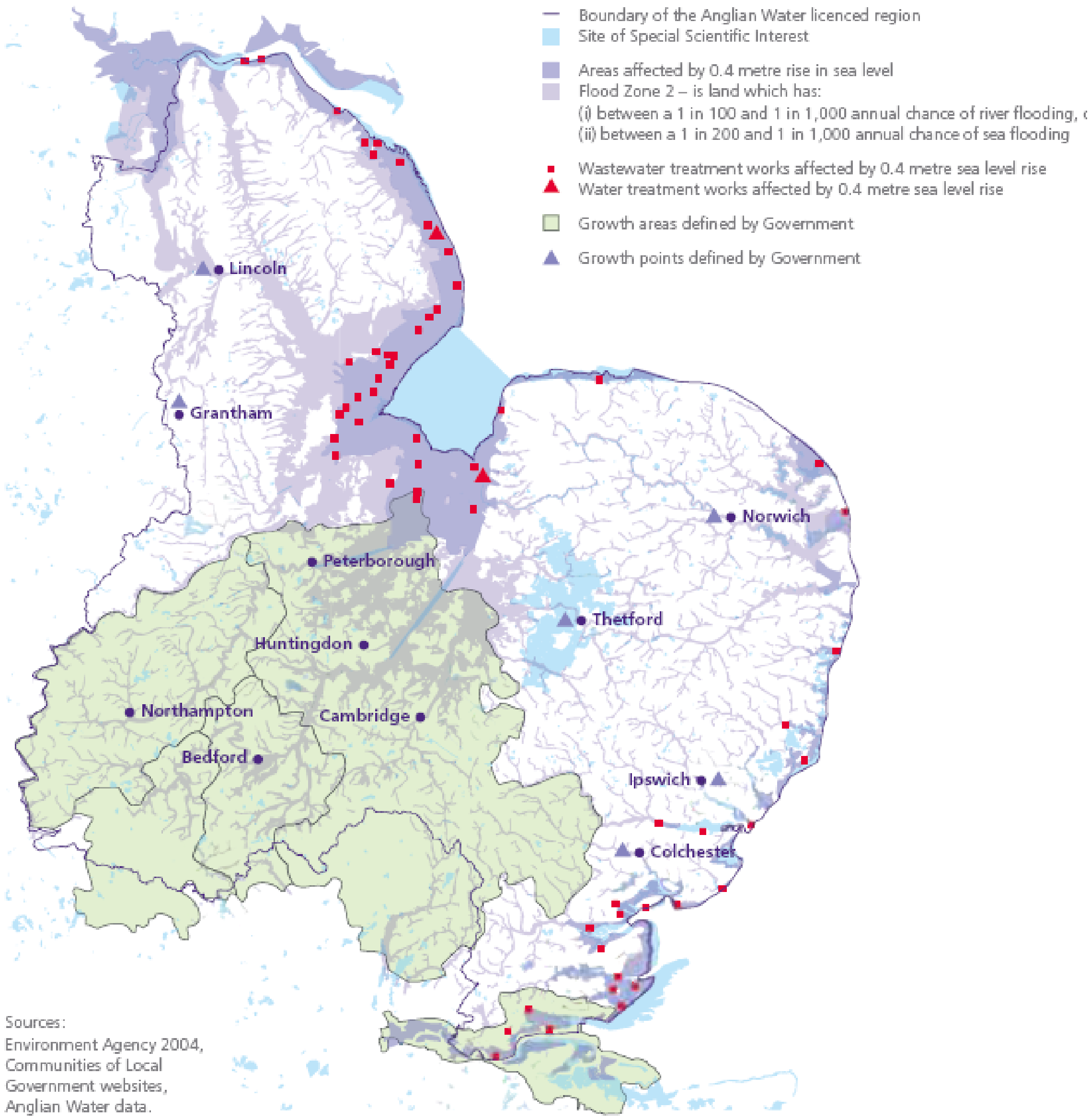
3.2 Waste water services

Waste water treatment and the sewage system are likely to be impacted by climate change. A study by the Tyndall Centre into organisational adaptation to climate change highlights four climate sensitivities in the waste water treatment sector (Berkhout et al. 2004);

- Higher temperature affecting treatment processes;
- Altered stream-flow affecting discharges;
- Higher demands for water affecting throughput; and
- Potential flooding of sewage treatment plants.

Climate change will have an impact on effluent quality standards as lower river flows result in less dilution of treated wastewater discharges. An increase in drought conditions may result in more rivers suffering from low flows and a loss of baseflow in summer. There will be a greater need for high effluent standards to be maintained. The impact of any failure in the sewage treatment process or of uncontrolled overflows into the receiving water will be more severe, and the risk to the environment thereby increased (Piper 1999). There are already a number of areas in the East Midlands which suffer from low flows including the Lincolnshire Fens and south Lincolnshire. Rivers currently suffering low flows are particularly vulnerable to climate change. There are knock-on effects on water supply as water quality and availability are closely linked. If water quality is lowered due to less dilution of effluent, less water is available for abstraction (Water UK 2007).

Figure 3.1 Anglian Water waste water treatment assets at risk of coastal flooding



Source Anglian Water 2007

A higher demand for water (see Section 3.1) will result in greater throughput of waste water. This will put pressure on the Region's waste water treatment capacity. Waste water is classified as a 'special or hazardous waste' and in 2003 it accounted for 18% of the East Midlands special waste arisings (Emra 2005).

Waste water treatment works may be at risk of flooding as a result of climate change.

Whilst the Summer 2007 floods affected water treatment works, flooding also poses a risk to sewage treatment works. Treatment works in flood zones are likely to be increasingly susceptible to flooding. Currently, sewage treatment works can be built in all flood zones except Zone 3b ‘Functional Floodplain’ as they are considered ‘less vulnerable’ developments (DCLG 2006). However, the consequences of a sewage treatment works being flooded include pollution and public health issues. Sea level rise and coastal flooding is of particular concern to Anglian Water as a number of their assets are located at the coast. Approximately 60 of Anglian Water’s waste water treatment works and in excess of 1,000 pumping stations (which would cost more than £500 million to replace) lie in the area at risk of flooding should there be a 0.4m rise in sea level by 2080 (see Figure 3.1).

Severn Trent Water has recognised the potential increase in flood risk on its assets and infrastructure in its Strategic Direction Statement (Severn Trent Water 2007). Anglian Water recognise the impact of more extreme weather events on waste water treatment, stating that more than 85 per cent of the incidents managed by their waste water incident team in 2006/7 were weather-related (Anglian Water 2007). Anglian Water anticipate this impact to increase with climate change. Anglian Water has also identified waste water treatment asset deterioration as a risk posed by climate change.

Sewer flooding can occur anywhere where sewers are inundated by large amounts of water. In summer 2006, residents of the East Midlands were warned about potential sewer flooding incidents by the Consumer Council for Water (CCW) (GNN 2006). Severn Trent Water increased its water bills by approximately 4p a day in 2006 in order to meet investment requirements, including measures to tackle sewer flooding. Table 3.3 presents current and future spending by Severn Trent Water on preventing sewer flooding. Sewer flooding is caused by two main factors: overloading after severe storms and failures/blockages within the sewerage system itself. The increase in frequency and intensity of storm events anticipated in a changing climate will increase the risk of sewer flooding.

Table 3.3 Severn Trent Water spending on sewer improvements to prevent sewer flooding

County	Action to date	Future action
Derbyshire	30 properties protected from sewer flooding	Construction underway to protect 100 more, at a cost of £8.5 million. £3 million to replace or repair damaged sewers.
Nottinghamshire	Nearly 40 properties have been protected from sewer flooding.	Improvements to tackle problem sewer overflows are being planned at Scunthorpe, Woodborough, Sutton in Ashfield and Charlton

Source Severn Trent Water 2007b

In terms of impact identification, Anglian Water and Severn Trent Water appear to be the furthest advanced of all UK water companies. In its SDS Anglian Water comprehensively identified the potential impacts of climate change on their business at all stages of their operations and Severn Trent Water have identified over 150 potential impacts in their detailed impact assessment.

3.4 Climate change impacts on water quality

Changing environmental legislation that aims to improve water quality may be impacted by climate change. The Water Framework Directive (WFD) requires all inland and coastal waters to reach "good status" by 2015. It will do this by establishing a river basin district structure within which environmental objectives will be set, including ecological targets for surface waters (Defra 2007). Its objectives are to:

- Reduce pollution, prevent deterioration and improve the health of the aquatic ecosystem (and wetlands that depend on groundwater);
- Promote the sustainable use of water;
- Help reduce the effects of floods and droughts.

The objectives of the WFD are integrated for each river basin in a River Basin Management Plan.

The risk of failing WFD targets in the East Midlands has been estimated for a number of key pressures, based on factors such as land use, water use, and pollution pressures. The main risks in the Region are from high nitrate and phosphate concentrations in surface and groundwater; 93% of East Midlands' rivers and 13% of groundwaters are at high risk of failure due to nitrates, 10% are at high risk of failure due to phosphates (Environment Agency 2007f). Being considered at risk does not mean that a water body has already failed its objectives, only that it might do so. For some water bodies, ensuring the East Midlands reaches good status may mean an increase in the environmental demand for water, an increase in treatment or a change in the way that water is used that leads to pollution.

Climate change will have impacts on water quality and will have implications for meeting objectives of the WFD. Table 3.5 describes the likely impacts of climate change on water quality. United Kingdom Water Industry Research (UKWIR) has recently published a report examining the likely effects of climate change on UK water industry compliance with the WFD, set in context of other expected changes such as demographic shifts of changes in land-use (UKWIR 2007). It concludes that in the medium to long term, the effects of climate change, and hence their impacts on water industry performance relative to other drivers, are likely to become increasingly dominant. With respect to the WFD, it is likely that the reference conditions for ecological status will need to be adjusted to reflect the effect of climate change. This is unlikely to be given consideration until after the initial phase of WFD implementation (UKWIR 2007); that is, not until after 2015.

Table 3.5 Climate change impacts on water quality

Climate change	Impact on water quality
Warmer summers	Increased frequency of algal blooms – high temperatures act as a catalyst for algal growth. Reduction in dissolved oxygen content due to algae eating bacteria can lead to fish kills.
	Low flows – less dilution of pollutants.
	Higher rates of solution – more nutrients (nitrogen and phosphorus) washed into water bodies.
Wetter winters	Higher flows – more dilution of pollutants.
	Greater run-off – nutrients and sediment washed into water bodies. Greater water turbidity.
	Higher rates of erosion – more sediment and nutrients washed into water bodies. Greater water turbidity.
Sea level rise	Saline intrusion into groundwater – switch between fresh and saline conditions.

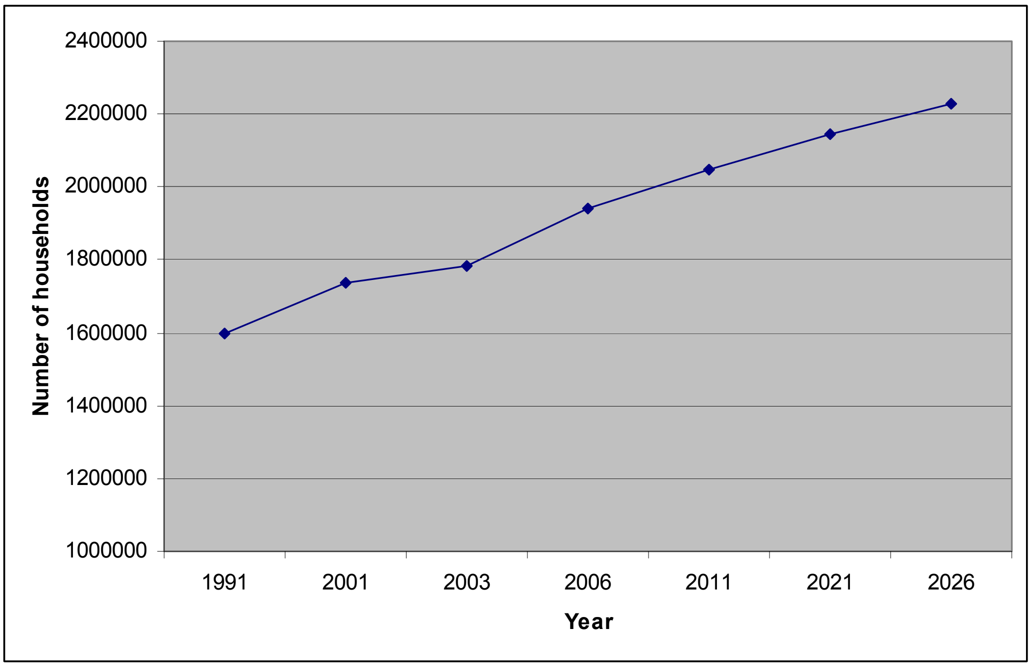
4. Other pressures on water resources in the East Midlands

Climate change will not be the only pressure on water and the environment in the future. The Government's Water Strategy, *Future Water*, recognises climate change as a major driver of change in the water industry but it also identifies several other non-climate drivers including population growth. Societal and economic trends could have a significant impact on the way we use and value water and our environment especially over the longer term.

4.1 Development in the East Midlands

Significant development is planned in the Region in the next 20 years (GOEM 2005). Figure 4.1 shows the increase in projected household numbers in the East Midlands (based on 2003 figures) if recent demographic trends continue. The Regional Spatial Strategy for the East Midlands (RSS) makes provision for this growth in households, providing for 320,000 new houses by 2020 (GOEM 2005). Within the Region there are a number of areas identified to be the focus of this housing growth, one of which is the Milton Keynes South Midlands (MKSM) sub-region. It is anticipated that 169,800 houses will be built here by 2021 (GOEM 2005). Anglian Water recognises development as one of two key challenges they face over the next 25 years (the other being climate change) (Anglian Water 2007). In its Strategic Development Statement Anglian Water anticipate that in the next 25 years they will be required to serve 224,000 new homes with water services and 207,000 with waste water services in the East Midlands.

Figure 4.1 Proposed increase in household numbers in the East Midlands



In addition to houses, there will be a growth in industrial and commercial (I+C) properties within the growth area. The high-growth option adopted by the Milton Keynes and South Midlands strategy implies a growth target of some 85,000 net new jobs in Northamptonshire between 2001-2021 (Northamptonshire County Council 2003). Successful implementation of the MKSM growth targets might require 450-500 hectares of net new employment land in Northamptonshire over the period 2003-2016, equal to roughly 35-40 hectares per year (Northamptonshire County Council 2003).

Per capita water consumption in the East Midlands was 135 litres per person per day (emra 2007) in 2005/06, down 3 litres from 2001/02, and is significantly lower than the UK average (148 litres per person per day). Whilst water use within the Region appears to be becoming more efficient, these efficiency gains may be overshadowed by the scale of future demand for the MKSM development. The increase in housing and industrial and commercial enterprises represents a significant increase in water demand in the Region.

A spatial review into the East Midlands water supply as a result of planned growth to 2030 has been carried out on behalf of the Environment Agency. It found that without delivery of the planned supply and demand measures in the 2004 water resources plans many parts of the East Midlands region will be in deficit by 2015. However, if the planned supply and demand measures are delivered about a third of the region will remain in surplus and any deficits will be greatly reduced. Deficits are still forecast to occur in the East Midlands zone (Leicestershire, Nottinghamshire and Derbyshire), Ruthamford zone and Lincolnshire Fens zone. Under the preferred housing growth option (housing provision figures based on those provisionally agreed by the Regional Assembly's Joint Board on 18 May 2006 for each Housing Market Area (HMA)) all resource zones with the exception of Lincolnshire Fens will be in surplus throughout the planning period after 2010 (Environment Agency 2006). However, under the preferred housing growth option plus 20 and 30 percent, deficits will occur in the East Midlands zone and in the Lincolnshire Fens zone from around 2015 onwards (Environment Agency 2006).

As noted in the East of England Plan, Examination in Public Report of the Panel*, "the traditional approach has been for the planning process to decide the quantity and location of development, and then for the water industry to bring forward the infrastructure… to cope with the demand".* Under this approach, water companies will supply new properties in the East Midlands with water, regardless of the increase in demand. However, in an area already deemed to be suffering water stress, this approach is not sustainable. It is therefore necessary to consider strategic and integrated provision of water services prior to development. In order to reduce pressure on the Region's resources, demand management measures need to be taken and greater gains in water efficiency realised. Plans are in place to incorporate demand management into the overall strategy for providing utilities to the new development, with a target saving of 25 percent on water consumption for new housing (GOEM, 2006).

In addition to drinking water demand, an increase in property numbers will increase the demand for waste water services. Additional sewage treatment works capacity and sewerage infrastructure will be required in future to serve the projected housing growth rates. Local Planning Authority policies will need to recognise this when considering the locations for future housing developments (Environment Agency 2006). In the South East, there are seven places where development will be limited by the capacity of STWs, including MKSM. Forty-five other works will need to be upgraded to operate to a higher standard to avoid harming the local environment. The cost of these upgrades varies from place to place but can be up to £10,000 per house (Environment Agency 2007g). If no new work is undertaken to increase sewage treatment works capacity, there will be pressure on areas of the East Midlands including Mansfield, Worksop, Newark, Derby, Leicester, Market Harborough, Melton Mowbray, Lincoln and Grantham (Environment Agency 2006) if new development goes ahead.

In addition to sewage production, increasing the area under development will increase volumes of surface runoff conveyed into the sewer system. Sewers must therefore be designed to cope with an increase in water due to development as well as climate change. Waste water and surface water drainage management need consideration when planning future development and the RSS (GOEM, 2006) states that a "co-ordinated approach to land drainage, nature conservation, landscape management and open space provision' should be taken".

A water cycle strategy provides a plan for water services infrastructure implementation in new developments. It takes a strategic approach to development, assessing the environmental and infrastructure capacity for water supply, sewage disposal, flood risk management and surface water drainage (Environment Agency, undated). A water cycle strategy provides an evidence base to support Local Development Frameworks, highlighting the scale and timing of infrastructure needed early in the planning process. Other advantages of a water cycle strategy include:

- Minimises the need for additional infrastructure at a later date;
- Proposes a strategic solution to infrastructure provision that will reduce disturbance to existing communities;
- Informs developers of required flood mitigation;
- Provide an evidence base for water companies when justifying investment plans with Ofwat;
- Ensures environmental standards are met through compliance with pollution prevention guidelines.

There is experience of undertaking water cycle strategies in the East Midlands. Box 1 describes the Corby water cycle strategy.

Box 4.1 Corby water cycle strategy

House building proposals in Corby will double the population, to 120,000, by 2031. The Environment Agency objected to the planning consultation of new developments on the grounds of environmental concern relating to wastewater quality and volumes and it was agreed a water cycle strategy was required.

Phase 1 of the Corby Water Cycle Strategy concluded by:

- Confirming the feasibility of providing water services infrastructure to meet the proposed scale of growth;
- Setting out requirements for managing flood risk, water quality and water demand;
- Identifying requirements for sustainable development and Green Infrastructure;
- Identifying the major constraints of sewage treatment and water supply;
- Identifying the overall cost of the water service infrastructure required.

The specific measures it will put in place are:

- Developer checklist advising developers what they need to do to comply with the

Source Environment Agency, undated

4.2 Environmental water demand

The third source of pressure on water resources in the Region comes from the environmental demand for water. Safeguarding the Region's environment is a key theme that cuts across a number of Regional strategies including the RES and RSS. Aquatic environments provide a number of environmental services and are an important aspect of the East Midlands green infrastructure (GI). The concept of GI has been endorsed by the MKSM Sub-Regional Strategy and provision of new GI within the MKSM growth area will be essential (Environment Agency 2005). Maintaining the quality of the environment in the East Midlands requires water, adding to the pressure on the Region's resources.

Previous water and land management regimes have resulted in environmental problems such as low flows and pollution at some of most important habitat sites. The Region also contains upland, lowland and coastal wetland habitats that have been lost or degraded through modern agricultural practices. For example, in Lincolnshire, wetlands are associated with high grade agricultural land where high value arable production is threatening the existing grazing marsh (Defra 2005). The Environment Agency is now involved in a number of projects and strategies to restore and maintain the quality of water environments including:

- Catchment Abstraction Management Plans (CAMS) - six-year plans detailing how water resources are managed. Determine whether water is available for abstraction;
- Water Level Management Plans (WLMPs) - written statement of the water level management objectives for a given area and the means by which the objectives may be achieved;
- Restoring Sustainable Abstractions (RSA) - investigations to find out where over-abstraction has occurred and works to restore sustainable supplies.

A number of CAMS have been prepared in the East Midlands region, see Section 2.1. There is only one priority site requiring a WLMP in the Region: Southfield Farm Marsh, Northamptonshire.

In addition to restoring habitat in unfavourable condition, the Environment Agency undertakes habitat creation. There are a number of drivers for habitat creation;

- Meeting Biodiversity Action Plan (BAP) habitat targets;
- Providing compensatory SAC/SPA habitat under the Habitats Directive.

Restoring or creating and maintaining new habitats often involves a significant demand for water. The amount of water required depends on the type of habitat being created; Table 4.1 illustrates the water demand of some habitat types.

In the East Midlands there are opportunities to create coastal habitats through a sustainable approach to shoreline management along The Wash and similar inland fresh water habitats for example, along the River Trent and in the Fens. Currently flood defence schemes are being progressed in Lincolnshire which require provision of compensatory habitat, including work on the Humber estuary. In addition to habitat lost as a result of the flood defence strategy, coastal squeeze will lead to further loss. As a result, 720ha of new habitat will be required to compensate for the Humber Estuary scheme (Environment Agency 2005b). Alkborough Flats in North Lincolnshire is the first coastal managed realignment site to be developed as part of the Humber Shoreline Management Plan. The project delivers a combination of habitats, including lagoons, islands, reedbeds and grazing marsh and has been successful at attracting large number of birds.

Table 4.1 Water Demand by Habitat for Creation Targets (Anglian region)

Habitat	NVC Community	Total Area (ha)	Min Demand^ (m^3/yr) *(m^3/ha/yr)*	Av Demand# (m^3/yr) *(m^3/ha/yr)*	Max Demand* (m^3/yr) *(m^3/ha/yr)*
Wet woodland	Wet woodland	56.8	69,498 *1223*	231,927 *4083*	404,780 *7126*
Coastal and floodplain grazing marsh	Species poor tussocky grassland	864.8	1,166,576 *1348*	3,138,472 *3629*	5,299,102 *6127*
Fen	Fen	214.8	353,091 *1643*	908,403 *4229*	1,587,459 *7390*
Reedbed	Reedbed	693.1	1,399,206 *2018*	2,927,619 *4281*	4,817,956 *6951*

^Minimum demand based on ponding soil in a wet climate. #Average demand based on mean demand from ponding and draining soil in average climate. *Maximum demand based on draining soil in a warm climate. Source Atkins 2006.

The impact of an increasing demand for water from the natural environment is a reduction in water available for potable abstraction. Anglian Water recognises this in their Strategic Direction Statement, as in its region 61 per cent of SSSIs are wetland habitats. Of the SSSIs in the Anglian region that are in unfavourable and declining condition, 91 per cent are wetland habitats. Measures required to protect these sites could further constrain the ability to abstract water or to discharge effluent in Anglian region.

4.3 Interaction of pressures

The multiple sources of pressure on water resources in the East Midlands are not independent of each other. The impacts of climate change, development and the environmental demand for water will interact with each other, resulting in threats and benefits for water resources. Table 4.2 illustrates the interactions between climate change impacts and other pressures.

Table 4.2 Interaction of climate change impacts and other pressures on water resources in the East Midlands

Climate variable	Impact	Impact on water services	Housing Growth	I+C Growth	Habitat restoration and creation	WFD
Reduced summer rainfall	Reduced summer rainfall leads to drought	Reduced supply and increase in water demand when temperatures are high in summer	Further increase in demand due to increased population in the region	Further increase in demand due to increased industry in the region Potential increase in water abstracted by private companies and individuals – less available for public supply	Further increase in demand to maintain wetland habitats	Further increase in demand to meet ecological and water chemistry targets
		Low flows reduce dilution	Increase in volume of waste water	Increase in volume of waste water produced likely to	Increased use of water for wetland habitats may exacerbate	Meeting WFD water chemistry standards may exacerbate

Climate variable	Impact	Impact on water services	Housing Growth	I+C Growth	Habitat restoration and creation	WFD
		making it more difficult to meet effluent standards	produced likely to exacerbate problem	exacerbate problem	low flows	problem
	Reduced soil moisture	Subsidence and cracking of pipes and other underground services	Increased number of properties at risk. Increase in insurance premiums.	Increased number of properties at risk. Increase in insurance premiums.	Reduced soil moisture threatens wetland habitats	Reduced soil moisture threatens WFD water chemistry and ecology targets
Hotter summers	Increased rate of physical	Increased soil erosion	Reduced raw water quality	Reduced raw water quality further reduces	Risk to delivering improvements in	Risk to delivering water

Climate variable	Impact	Impact on water services	Housing Growth	I+C Growth	Habitat restoration and creation	WFD
	processes such as erosion	leads to increased nutrient loading in waterbodies	further reduces water availability. Increased treatment costs may be passed to consumers.	water availability. Increased treatment costs may be passed to consumers. Nutrient loading form erosion may exacerbate nutrient loading from industrial sources.	habitat quality	quality targets
Increased winter rainfall and more frequent	Increased risk of fluvial and pluvial	Contamination of clean water supplies	Increased population and value of stock at risk due to	Increased value of stock at risk due to increased industrial presence in the	Pollution risk from flooding threatens habitat creation.	Pollution risk from flooding – risk to delivering water quality and ecology

Climate variable	**Impact**	**Impact on water services**	**Housing Growth**	**I+C Growth**	**Habitat restoration and creation**	**WFD**
storms	flooding	with flood water	population growth and housing development in the region. Increased treatment costs may be passed to consumers.	region. Increased treatment costs may be passed to consumers.		targets.
		Reduced treatment capacity	Increase in volume of waste	Increase in volume of waste water produced	Pollution risk from flooding threatens habitat	Pollution risk from flooding – risk to delivering

Climate variable	Impact	Impact on water services	Housing Growth	I+C Growth	Habitat restoration and creation	WFD
		due to flooding of treatment works	water produced from increase in housing may exacerbate this problem – need for storage.	from increase in industrial presence in the region may exacerbate this problem – need for storage.	creation.	water quality and ecology targets.
		Sewer flooding	Increased population and value of stock at risk due to population	Increased value of stock at risk due to increased industrial presence in the region.	Pollution risk from flooding threatens habitat creation.	Pollution risk from flooding – risk to delivering water quality and ecology targets

Climate variable	**Impact**	**Impact on water services**	**Housing Growth**	**I+C Growth**	**Habitat restoration and creation**	**WFD**
			growth and housing development in the region			

			Housing Growth	I+C Growth	Habitat restoration and creation	WFD
Climate variable	Impact	Impact on water services				
		Dam break	Increased population and value of stock at risk due to population growth and housing development in the region	Increased value of stock at risk due to increased industrial presence in the region		
Sea level rise	Tidal flooding	Saline intrusion and salinisation of	Reduced availability compounded by an	Reduced availability compounded by an increase in demand due to	Risk to delivering improvements in habitat quality, particularly	Risk to delivering water quality and ecological targets based on

Climate variable	**Impact**	**Impact on water services**	**Housing Growth**	**I+C Growth**	**Habitat restoration and creation**	**WFD**
		groundwater reduces raw water availability	increase in demand due to an increase in properties in the region.	an increase in industry in the region.	freshwater habitats as they become more brackish and saline.	historical habitat status

5. Climate Change Adaptation Options

The United Kingdom Climate Impacts Programme (UKCIP) defines climate change adaptation as ‘an adjustment in natural or human systems to actual or expected climatic stimuli (variability, extremes and changes) or their effects, which moderates harm or exploits beneficial opportunities ‘ (UKCIP 2007; 4). Adaptation requires effective measures directed at enhancing our capacity to adapt and at minimising, adjusting to and taking advantage of the consequences of climatic change.

Once the impacts of climate change have been identified (see Section 3), a list of adaptation options can be drawn up. UKCIP considers there are two types of adaptation response: building adaptive capacity and delivering adaptation actions (UKCIP 2007). Building adaptive capacity involves creating the information, supportive social structures and governance that is required for delivering adaptation actions which help to reduce vulnerability to climate risks or exploit opportunities. Table 5.1 suggests adaptation options for the impacts identified in Section 3.

The water industry has been following a ‘twin-track’ approach to balancing supply and demand: demand management and enhanced supply. The Government’s water strategy, Future Water, sees the twin-track approach continuing into the future although it envisages more use of ‘soft’ engineering measures in comparison with hard engineering and end-of-pipe solutions in adapting to climate change.

The first stage in adapting to climate change is identifying which assets and water bodies are most vulnerable to impacts. A significant amount of work is yet to be done to identify assets at risk of flooding and water bodies at risk of low flows and nutrient loading as a result of climate change.

Novel approaches to charging for water and regulating abstraction and discharge may be required to adapt to climate change. The Government's Water Strategy, *Future Water*, looks at new ways of charging for water including various metering options and variable tariffs which aim to take account of environmental costs.

Table 5.1 Adaptation options

Climate variable	Impact	Impact on water services	Adaptation Options	
			Building adaptive capacity	**Adaptation actions to reduce vulnerability**
Hotter drier summers	Drought	Increase demand	Education on need for water efficiency Identify current and future areas of water stress Sensitive location of new development – avoid areas already suffering water stress Water cycle study to inform location and design of new development	Drought orders Hosepipe bans Stand pipes and bottled water supplies Water meters Water efficient taps, toilets and appliances Variable tariffs Flexible consenting – based on seasonal

Climate variable	Impact	Impact on water services	Adaptation Options	
			Building adaptive capacity	**Adaptation actions to reduce vulnerability**
				or real time flow conditions Encourage rainwater harvesting and greywater recycling
		Low water levels in water bodies receiving effluent	Identify watercourses at risk Increase effluent standards	Flow support for low flows rivers Variable tariffs Flexible consenting – based on seasonal or real time flow conditions
	Subsidence	Cracked pipes, increased leakage	Identify infrastructure at risk	Replace metal pipes with flexible plastic
	Increased erosion	Nutrient loading - algal blooms	Identify water bodies at risk	Avoid using direct filtration treatment in new works

Climate variable	Impact	Impact on water services	Adaptation Options	
			Building adaptive capacity	Adaptation actions to reduce vulnerability
	rates			Retrofit existing treatment works to enable them to cope with algal blooms Contingency planning – bottled water supplies
	More rapid decomposition	Odour problems at sewage treatment works		Increase frequency of jetting
Hotter drier summers, more frequent storms	Drought Short intense periods of	Decrease supply	Identify current and future areas of water stress Sensitive location of new development – avoid areas already suffering water stress	Increase water storage - increase capacity of reservoirs, build new reservoirs, seasonal storage Variable tariffs

Climate variable	Impact	Impact on water services	Adaptation Options	
			Building adaptive capacity	Adaptation actions to reduce vulnerability
	rainfall		Water cycle study to inform location and design of new development	Flexible consenting – based on seasonal or real time flow conditions
Wetter winters, more frequent storms	Tidal and fluvial flooding	Contamination of clean water	Identify treatment works at risk of flooding Sensitive location of new treatment works - outside of flood risk zone	Defend existing works Contingency planning – bottled water supplies
		Flooding of treatment works - reduced treatment capacity	Identify treatment works at risk of flooding Sensitive location of new treatment works - outside of flood risk zone	Defend existing works Insurance Contingency planning
		Dam break	Identify assets at risk	Contingency planning

Climate variable	Impact	Impact on water services	Adaptation Options	
			Building adaptive capacity	**Adaptation actions to reduce vulnerability**
			Sensitive location of new development – avoid areas at risk	Insurance
		Salinisation	Identify areas at risk	Reduce dependence on groundwater supply in affected areas Build de-salinisation plants in areas most affected
	Increased run off	Sewer flooding	Identify infrastructure at risk Sensitive location of new development – avoid areas at risk	Sustainable Urban Drainage Systems (SUDS) – ponds, swales, green spaces Reduce area of impermeable surface – increase green space, use permeable paving Design sewers with headroom for

Climate variable	Impact	Impact on water services	Adaptation Options	
			Building adaptive capacity	**Adaptation actions to reduce vulnerability**
				increases in water due to climate change Contingency planning Insurance Separate combined sewers and storm drains

5.1 Who needs to act?

Pressure on water resources comes from a number of sources and similarly, adaptation will need to be delivered by a range of actors. Whilst many adaptation responses will be delivered by water companies, partnership working between water companies, stakeholders and regulators will be required. The first UKCIP 'good adaptation' principle suggests that good adaptation requires collaborative working with stakeholders. UKCIP (2007) regard identifying and engaging relevant stakeholders as key to successful adaptation due to the knowledge and skills they bring to the process. The more comprehensive that knowledge and skills base is, the more likely adaptation is to be successful. Whilst there may be one organisation who is the primary owner of the action, it is important to identify wider partners who will be involved in the delivery of that action. Table 5.2 highlights the potential partners required to successfully deliver the specified adaptation actions.

Table 5.2 Actors in climate change adaptation.

Adaptation action	Lead organisation	Other stakeholders
Education on need for water efficiency and demand management	Water companies	Local Authorities – education function
Identify current and future areas of water stress	Environment Agency	Water companies Planning authorities
Sensitive location of new development – avoid areas already suffering water stress	Planning authorities – EMRA, GOEM, Local Authorities	Water companies, Environment Agency
Water cycle study to inform location and design of new development	Planning authorities – EMRA, GOEM, Local Authorities	Water companies, Environment Agency

Adaptation action	Lead organisation	Other stakeholders
Rainwater harvesting and greywater recycling	Planning authorities	Developers, Water companies, Building Control Authority
Identify water courses at risk of low flows	Environment Agency	
Increase effluent standards	Environment Agency	
Identify infrastructure at risk of subsidence	Water companies	
Identify infrastructure at risk of flooding	Water companies	Environment Agency
Identify water bodies at risk of nutrient loading	Environment Agency	Water Companies, Farmers representatives – NFU
Drought orders	Water companies	Environment Agency
Stand pipes and bottled water supplies	Water companies	Local Authorities – Emergency Planning, Drinking Water Inspectorate
Water meters	Water companies	Planning authorities, Developers, Ofwat
Water efficient taps, toilets and appliances	Planning authorities	Developers, Water companies, Building

Adaptation action	Lead organisation	Other stakeholders
		Control Authority
Variable tariffs	Water companies	Ofwat
Flexible consenting – based on seasonal or real time flow conditions	Environment Agency	
Flow support for low flows rivers	Environment Agency	Water companies
Replace metal pipes with flexible plastic	Water companies	Local Authorities, Planning authorities, Ofwat
Retrofit existing treatment works to enable them to cope with algal blooms	Water companies	Environment Agency, Ofwat
Increase water storage - increase capacity of reservoirs, build new reservoirs, seasonal storage	Water companies	Planning authorities, Environment Agency, Ofwat
Defend existing works	Water companies	Planning authorities, Environment Agency, Ofwat
Insurance	Water companies	Insurance providers
Build de-salinisation plants in areas most affected	Water companies	Planning authorities
Sustainable Urban Drainage Systems (SUDS) – ponds, swales,	Planning authorities	Environment Agency, Sewage

Adaptation action	Lead organisation	Other stakeholders
green spaces		undertaker, Local authority, Building Control Authority
Design sewers with headroom for increases in water due to climate change	Water companies	Ofwat, Planning authorities, Developers, Highways Authorities
Reduce area of impermeable surface	Planning authorities	Developers, Highways Authorities
Separate combined sewers/storm drains	Water companies	Ofwat, Planning authorities, Developers, Highways Authorities

Water companies

There is a significant role for the water companies to play in ensuring that water resources are used in a sustainable manner; it is in their interests to invest in adaptation measures if they wish to continue supplying customers with water. However, the water industry is probably the most advanced economic sector in terms of identifying how climate change will affect it and the measures required to adapt to it.

Both the water companies serving the East Midlands have already taken steps to adapt to climate change and have plans for further action in future. Table 5.3 sets out the current and planned adaptation undertaken by Anglian Water and Severn Trent Water. The information in Table 5.3 has been collected from a review of the companies' SDSs, CSR reports and through telephone interview with representatives from the companies. As all companies are required to take climate change into consideration when calculating headroom for their Water Resource Plans, this has not been included as an adaptive action in the table below. Similarly, all water companies have a responsibility to produce Drought Contingency Plans so this is not included in the table.

Table 5.3 Current adaptation to impacts of climate change on water and waste water services in the East Midlands

	Adaptation	
	Current	**Planned**
Anglian Water	Climate Change Action Plan developed (2005) - identifies impacts and adaptation. Cross business working group set up to deliver plan.	Key priorities for the next 25 years include securing and conserving water in the face of climate change
	Provided evidence to Stern Review and Defra's national adaptation policy framework.	Climate change recognised as one of two key challenges for Anglian Water – described as the biggest risk to the business
	Appointed a climate change officer to cover adaptation and mitigation	Greywater use and water recycling
	List of impacts identified in SDS	Evaluate new reservoirs, transfers etc.
	Identified critical infrastructure at risk from flooding	Potential research collaborations - Tyndall centre coastal simulator to determine risk to coastal assets.
	Member of East of England Climate Change Partnership (EECCP) and new East of England Water Partnership – focus on water resources in face of growth and climate change.	Trialling UKCIP08 scenarios.
	Regional collaboration with water companies to deliver water efficiency	

	Adaptation	
	Current	**Planned**
Severn Trent Water	Assessed the outcomes arising from UKCIP02 scenarios on water resources and demand. Worked with UKCIP on climate change impact study in West Midlands (2004). Chairs the sustainability West Midlands climate change adaptation partnership. Provided technical advice and guidance to the Caribbean states on the development of their own climate change adaptation programme. Working with the Institutional Investors Group on Climate Change (IIGCC) to develop a methodology for investors to assess the vulnerability of business to climate change Decision-making on adaptation is integrated within the business planning process. Impact assessment has identified over 150 potential impacts (or climate 'hazards') including general impacts such as working conditions for employees, facilities management and transport.	Recognise need to adapt to greater climate variability e.g. developing more sustainable drainage systems to deal with increased rainfall Potential impact of flooding on assets being evaluated to establish need for schemes to increase resilience Plans to increase metering, promote water efficiency, reduce leakage and increase water resources

Planning authorities

In addition to the water industry, the spatial planning process can play a significant role in adapting to the pressures which climate change places on water resources. Through the planning process there is an opportunity to increase water efficiency, change behaviour and attitudes towards water, increase water storage and reduce the risk of flooding. In its spatial planning role, emda has a significant part to play in adapting the water resources of the East Midlands to climate change. For example, the planning authorities can inluence:

- The use of water cycle strategies to inform the location and design of new development and identify the impacts the development will have on water resources and measures for adapting to them;
- The location of new development – avoiding areas at serious risk of water stress;
- Research into locations at risk of water stress in the future;
- The design of new properties to include water efficiency measures such as low flush toilets, low flow showers and taps and efficient white goods;
- Inclusion of water storage devices such as water butts in the design of new buildings;
- Retrofitting of water storage devices to existing buildings through the planning application system (mandate retrofitting of water saving and storage devices when granting planning permission for extensions, conservatories etc);
- Inclusion of SUDS techniques in plans for new development;
- Use of permeable paving in new developments and when upgrading existing surfaces;
- The area of impermeable surfaces allowed in urban areas through the planning application process e.g. refusing permission for applications to concrete over front gardens unless the material to be used is permeable.

In the case of SUDS there has been uncertainty over responsibilities for installing and maintaining systems. Surface water drainage is also considered in the Government's *Future Water* Strategy and Defra have recently consulted on improving surface water drainage, including proposals to clarify responsibilities for ownership and adoption of SUDS.

Emda

In addition to its spatial planning function, emda can influence adaptation in the water sector through the RES. Table 5.4 assesses the RES priority actions in terms of how they can contribute to water efficiency and adaptation of water services.

Table 5.4 How RES Priority Actions can Contribute to Adaptation in the Water Sector

Aim	Priority	Priority Action	Contribution to adaptation
Employment, Learning and Skills	Developing the skill levels of the current and future workforce	Engage Schools and Colleges with Businesses	Encourage skills in sustainable design and construction – e.g. designing SUDS
		Developing Adult Workforce Skills	
	Stimulating business demand for skills	Stimulating Skills Demand	Encourage water efficiency and climate change adaptation in the business sector – stimulate demand for products and services
	Supporting innovation and diversification in manufacturing	Supporting Innovation and Diversification in Manufacturing	Adaptation to climate change impacts is a way of diversifying manufacturing – market for new products
	Building the visitor economy	Increasing Visitor Spend	Encourage water efficiency in the tourism sector – additional seasonal population could put extra pressure on water resources
	Supporting SMEs to harness business opportunities such as public procurement	Maximising the Benefits of Public Procurement	Ensure products and processes are water efficient
		Maximising the Benefits of the London 2012 Olympic and Paralympic Games	Ensure new developments are water efficient

Aim	Priority	Priority Action	Contribution to adaptation
Innovation	Increasing investment in research and development	Increasing Research & Development	R&D into new products and services
	Helping existing businesses deploy technologies and processes	Developing and Applying New Technologies	Encourage uptake of new technologies that can assist with water efficiency e.g. precision irrigation using GIS
	Resource efficiency through effective use of technology and management practices	Providing Business Support on Resource Efficiency	Include water in resource efficiency (not just energy)
		Development of Land and Property	Restrict development to areas where sustainable water resources exist on a regional and local basis
	Growing the regions key sectors	Growing the Region's Key Sectors	Many of the Region's key sectors depend on water resources (food and drink, construction etc) – ensure growth is sustainable in terms of water resources
Energy and Resources	Responding to the challenge of climate change	Adaptation to Climate Change	Water efficiency is key to adaptation
		Reducing the Demand for Energy and Resources	Include water in resource efficiency – encourage efficiency
	Exploitation of new and growing low carbon markets	Utilising Renewable Energy Technologies	Water companies can contribute to renewable energy generation – sludge, anaerobic digestion
	Ensuring infrastructure for low carbon economy	Energy and Waste Capacity	Efficient use of water is also necessary in a low carbon

Aim	Priority	Priority Action	Contribution to adaptation
			economy – link between water use and energy use
Environmental Protection	Protecting and enhancing our environmental infrastructure to ensure sustainable economic growth	Environmental Infrastructure	Water is a key part of environmental infrastructure – use SUDS, storage etc to deliver this priority but also adapt to climate change
		Sustainable Construction	Encourage water efficiency in sustainable construction
	Protecting and enhancing green infrastructure through environmental stewardship	Improve Damaged Environments	Improving water quality will have multiple benefits for water resources
		Protect and Enhance Green Infrastructure	Water is a key part of environmental infrastructure – use SUDS, storage etc to deliver this priority but also adapt to climate change
Land and Development	Development land	Secure the Supply of Quality Employment Land	Employment development should reflect likely demand for water and sustainability of supplies
		Infrastructure for Employment Related Schemes	Employment development should reflect likely infrastructure constraints e.g. water cycle strategy
	Housing	Supporting Infrastructure for Housing Growth	Development should reflect likely infrastructure constraints e.g. water cycle strategy
	Reviving local infrastructure	Built and Green	Water is a key part of

Aim	Priority	Priority Action	Contribution to adaptation
	and environments	Environments	environmental infrastructure – use SUDS, storage etc to deliver this priority but also adapt to climate change
	Stimulating new markets and enterprise opportunities	New Markets and Enterprise Opportunities	Encourage water efficiency and climate change adaptation in the business sector – stimulate demand for products and services

5.2 Costs and benefits of adaptation

Figure 5.1 illustrates the relative cost and complexity of adaptation measures. There are a number of low cost, low complexity actions which could be implemented now with little or no regret. These include:

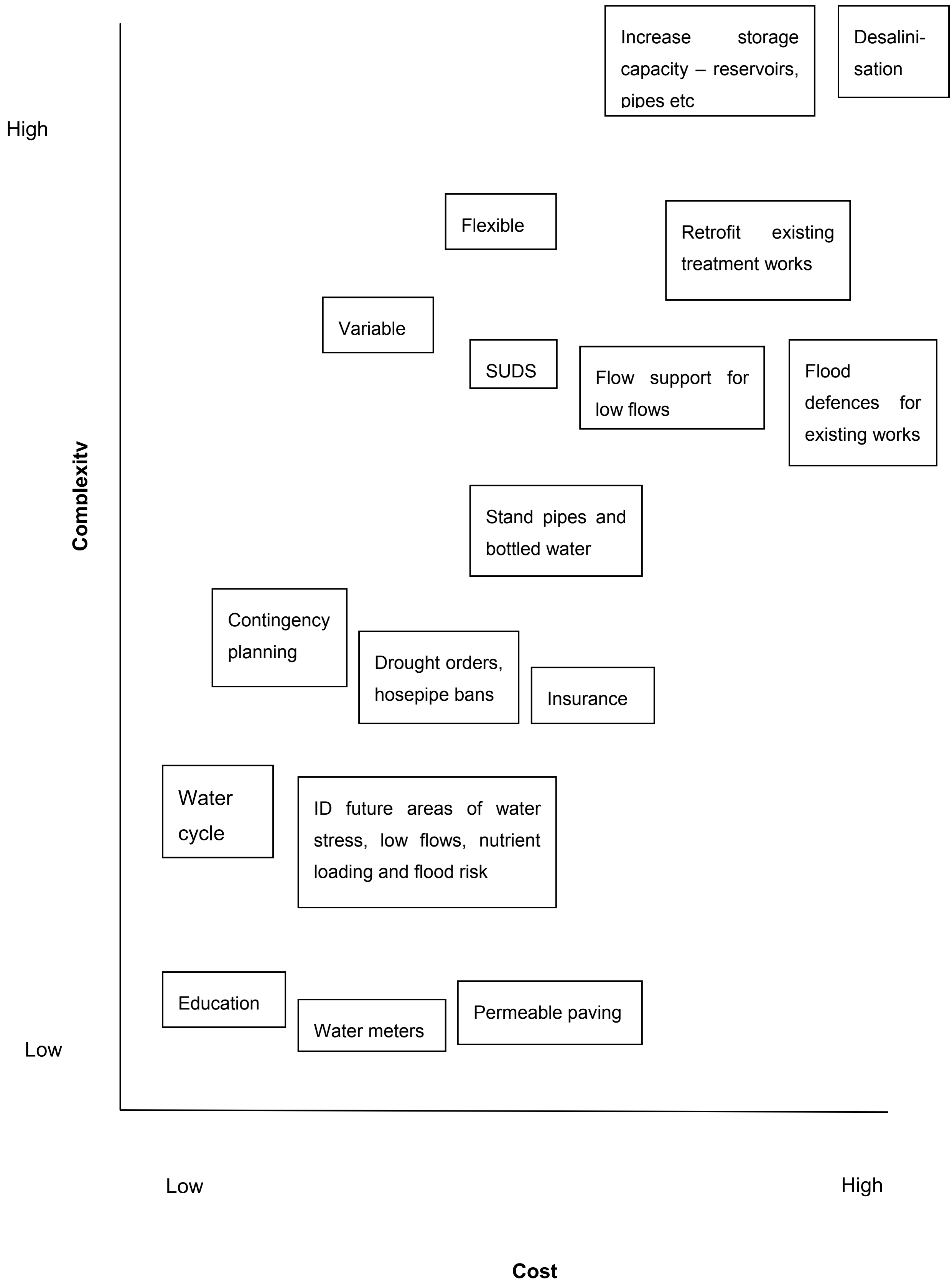
- Education on water efficiency and demand management
- Water cycle studies
- Installing water meters
- Identifying areas of future water stress, low flows nutrient loading and flood risk

There is little detailed information of specific costs of adaptation actions but the Environment Agency has commissioned a report looking into the costs of adaptation in the water industry. An economic assessment of adaptation to water quality impacts, storm water management and sea level rise has been undertaken.

Meeting higher water quality regulations due to the impacts of climate change may require a step change in costs as retrofitting existing treatment facilities may not be feasible; instead, new more expensive technology may be required. If the starting point for economic analysis is taken as current water quality status, then the assumed flow reductions due to climate change would generate an incremental cost in present value terms of between £120m to £370m (ICF 2007). However, if the starting point is based on improved water quality due to implementation of the WFD, then the present value cost estimate is between £60m to £150m. The starting point also affects the unit cost; the more stringent the starting point, the higher the unit cost of further pollution removal associated with climate change adaptation (ICF 2007). The unit costs of BOD removal (£ per kg per year) are about 40% higher under the post-WFD scenario compared to the pre-WFD scenario (ICF 2007).

Holistic catchment management, although complex, is a cost-effective adaptation to increasing storm water flows in comparison to building additional storage. Using Ofwat June Return data and an Ofwat storage cost estimate of £650K per 3000 m^3 of storage at a CSO site, a unit storage cost of £217 per m^3 was estimated (ICF 2007). Modelling in the report estimates that the costs of increasing storage capacity to maintain current CSO standards for 30 – 40 years would be £15 billion at present value (ICF 2007). However, only £1 billion of this is accounted for by sewerage undertakers in the Midlands (Anglian Water, Severn Trent Water and Welsh Water).

Figure 5.1 Relative cost and complexity of adaptation options for water and waste waster services



The risk and the cost of either protecting, abandoning or relocating assets will be site specific and be subject to a range of factors such as asset value, proximity to sea, value of alternate assets, site specific flood defence options and costs and the nature and value of surrounding assets that may share flood defence costs. The spatial heterogeneity of sea-level rise risks makes a case for site specific climate change risk assessments for individual assets (ICF 2007).

The report assumes that the adaptation measures considered are undertaken now. If investments were to be deferred to some future time period, the scale of the present values would be lower. Figure 5.1 illustrates the relative cost and complexity of adaptation options for water and waste waster services.

6. Recommendations and Conclusions

Climate change represents a risk to water resources in the East Midlands due to increases in demand, decreases in supply and an increase in flood risk for assets and infrastructure. Many of the impacts are exacerbated by other pressures on water resources, mainly development and environmental demand.

The adaptation options identified in Table 5.2 have different lead organisations. The key to successful adaptation is partnership working. Emda will need to work with all the organisations identified in the second column of Table 5.2 in order to deliver effective adaptation. There are a number of initial policy recommendations for emda to consider:

- Work with schools and other training organisations to deliver education on the multiple benefits of water efficiency;
- Research to identify areas at risk of severe water stress in future;
- Spatial policy that is sensitive to pressure on water resources – locate development away from areas of severe water stress;
- Planning policy that encourages the use of SUDS;
- Encourage adaptation of existing buildings through planning policy – retrofit water meters, water efficient appliances etc;
- Use Water Cycle Studies when planning new development;
- Ensure contingency plans are in place to deal with flooding incidents and supply outages.

Emda's vision is that by 2020, the East Midlands will be *a flourishing region, "*with growing and innovative businesses, skilled people in good quality jobs, participating in healthy, inclusive communities and living in thriving and attractive places" (emda 2005). Emda aims to meet this through sustainable economic growth and economic wellbeing. Planning for water resources is a key criterion for sustainable development and emda should ensure that the multiple challenges facing water resources in the Region are managed.

Emda will have an opportunity to comment on water resource issues in the Region through the water resource planning framework. Water companies will be consulting on their WRMPs in 2008; this provides and important opportunity for emda to engage and to integrate planning strategies. Similarly, River Basin Plans (RBPs) will be published at the end of 2008. Both are reviewed on 5-6 year rolling timetable and provide an opportunity to review the changing effects of climate change and economic impacts on the water environment.

There is particular scope for emda to influence adaptation in the water resources sector through its new spatial planning role. However, there are also economic benefits associated with adaptation and emda's support for this sector will also help achieve other Priority Actions set out in the RES including:

- Engage Schools and Colleges with Businesses;
- Providing Business Support on Resource Efficiency;
- Adaptation to Climate Change;
- Reducing the Demand for Energy and Resources;
- Environmental Infrastructure;
- Protect and Enhance Green Infrastructure.

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CASE STUDY 8: WATER MANAGEMENT - INCREASED RISK FROM RIVERINE OR URBAN DRAINAGE FLOODING

Introduction

Climate change in the UK is projected to result in an increased risk of riverine or urban drainage flooding during the winter months. Given that there is a potential conflict between this risk and the population projections, and associated house-building planned for the Milton Keynes-South Midlands (MKSM) growth area, it is informative to explore the size of the potential flood risk associated with the growth area developments. This case study provides some illustrative results to demonstrate the possible size of such a risk.

Scope of Case Study

In this case study we undertake a physical risk assessment of the climate change associated flood risk to that portion of the MKSM growth area located in the East Midlands under climate change and growth scenarios. We focus our attention on the flood risk to the additional domestic properties projected under the regional spatial strategy to be constructed in this area by 2020. We monetise the identified flood risks to the study area, including direct and indirect effects to residential property, human health, etc., where the risk can be quantified

Estimating the Economic Impact of the Risks

In broad terms, our methodology comprises two stages. Before the impacts of weather-related events, like flooding, can be valued they must first be identified and measured. Only once they have been quantified is it possible to determine their relative economic importance by expressing them in monetary terms. The identification and measurement (i.e. quantification) of impacts is therefore a prerequisite to their valuation. The two-stage nature of the method is illustrated in

Box 2. This two-stage process underpins the approach adopted in this case study to cost the impacts of the flooding in that portion of the MKSM growth area located in the East Midlands region. That is, first we quantify potential impacts (Impact Assessment), and second, we value those impacts (Economic Valuation). The method is derived from the UKCIP Costing Methodology reports (Metroeconomica, 2004) and is consistent with Defra flood appraisal guidance.

This information can then used to construct a loss-probability function for the area for the present day (in £2007) (the **Base Case**). This function shows the relationship between annual flood probability (APF) for one or more of a range of flood events (e.g. 1-10 year return period, 1-50 year return period, 1-100 year return period, etc) and the damages associated with each event. The loss-probability function defines the expected annual damages from the flooding projected on the basis of the planned growth scenario (i.e. estimated increases in the population and households in the flood plain of the river) in the area. We then re-calculate the Base Case loss-probability function on the basis of rainfall projections for the region under (a) selected climate scenario(s), in this case the Defra guidance on including climate change into FCDPAG3, which assumes a 20% increase in peak flow, as an indicative sensitivity range for larger catchments covering the future period 2025-2115. The area between this (**Climate Case**) loss-probability function and the Base Case loss-probability function represents the increment in expected annual damages from climate change.

Box 2: The General Approach to Valuation Used

The cost (or benefit) of a weather-related event on a specific vulnerable receptor (or group of receptors), under selected climate and socio-economic scenarios (£ per event in year *t*)

is equal to

The predicted 'physical' impact on the vulnerable receptor(s), under selected climate and socio-economic scenarios (the number of physical units affected by the event in year *t*)

times

The appropriate economic unit value or 'price' (£ per affected unit in year *t*)

Impact Assessment – Base Case

The first task is to identify the weather-related impacts that are likely to occur and distinguish who is likely to be affected by the impacts.

Figure 41 presents a matrix of broad (first-order and key second-order) impacts from a river flooding event, those sectors most likely to be affected by these broad impacts, potential economic consequences and the main stakeholder groups. Of course, flooding of the MKSM growth area will not necessarily give rise to all these impacts.

The impacts covered in this case study are listed below:

- Direct physical damage to residential property (repairs plus clean-up).
- Direct impact on human health (mortality, injuries and anxiety).
- Additional electricity needed for equipment to dry properties.
- Emergency services.
- Second-order economic impacts on surrounding area. Evacuation of households (cost of temporary accommodation).

Due to either a lack of physical data or access to appropriate models, it was not possible to quantify the following impacts, which are also likely to occur as a result of flooding in the MKSM Growth area - (a) short-term disruption to road and rail transport, (b) direct physical damage to utility and flood defence infrastructure, (c) short-term disruption to utility services, (d) direct physical damage to buildings with historical and cultural heritage value, (e) forgone output (value added) from short-term disruption to non-residential properties and (f) direct physical damage to non-residential property (repairs plus clean-up) (excluding buildings with historical and cultural heritage value).

However, these impacts are still very real, potentially significant and thus relevant to the appraisal of alternative adaptation strategies, regardless of the fact that they cannot be valued. Prior to formulating adaptation policies and measures it would be advisable to quantify these impacts – in particular, short-term disruption to road transport.

Figure 41: Impact Matrix for flooding from Increased Winter Precipitation – Potentially Relevant Economic Impacts

First-order Impact	Sector Affected	Potential Economic Impacts	Relevant Stakeholders
River Flooding → Direct Physical Damage	Habitat	Mortality in ‘valued’ species (foregone use and non-use value)	General public, tourists, national interest groups, government departments
		Destruction of ‘valued’ ecosystems (foregone use and non-use value)	
	Forestry	Destruction of trees (loss of timber products and producer surplus)	Timber producers, consumers, national interest groups, government departments, general public
		Destruction of trees (loss of recreation and amenity)	
	Agriculture land	Loss of crops (lost producer surplus)	Local farmers, consumers of farm products, government departments
		Loss of livestock (lost producer surplus)	
	Transport infrastructure	Loss of infrastructure/equipment (replacement necessary)	Transport operators, contractors, local public (users and employees in this sector), business and wholesale distributors
		Damage to infrastructure/equipment (repairs necessary)	
	Buildings (residential, commercial, industrial, agriculture, government)	Loss of private and public property (replacement necessary)	Households, property owners, insurers, contractors, business
		Damage to private and public property (repairs necessary)	
	Historical and cultural heritage	Loss of cultural objects (foregone amenity and non-use value)	Local public, tourists, national interest groups, government departments, insurers, business
		Damage to cultural objects (repairs necessary)	
	Human health	Increased risk of mortality (fatal injuries)	Local public, employers, insurers, public health services, government, regulators
		Increased risk of morbidity (non-fatal injuries and anxiety)	
	Utilities	Damage to transmission network	Power generators and suppliers, electricity customers - both households and business (prices), regulator, insurers, other utilities, government departments
		Damage to power generation infrastructure	
		Damage to water treatment facilities and pumping stations	Water authority, customers - both households and business (prices), regulator, insurers, government departments
		Damage to distribution and sewer system	
	Flood protection infrastructure	Decreased strength (damage), increased maintenance and repair requirements	Local authorities, government departments, contractors, general public, property owners, insurers
		Destruction (replacement required)	

First-order Impact	Sector Affected	Potential Economic Impacts	Relevant Stakeholders
Flooding → Short-term Disruption	Road transport	Increase in travel cost (individual, work time)	Local population, users and operators of public transport (buses), businesses, highways authorities
		Increase in travel cost (individual, non-work time)	
		Disruption to inputs / sales (business losses)	
		Change in demand for unaffected, alternative transport routes or modes	
		Increase in highway agency's costs	
Flooding → Evacuation	Households / government	Increase in costs of 'emergency service' and related activities	Local public, emergency services, government departments
		Temporary accommodation costs	
		Disutility costs to individual (e.g. from stress and anxiety)	

Second-order Impact	Sector Affected	Potential Economic Impacts	Relevant Stakeholders
Damage to Utilities → Outages / Disconnections	Electricity	Disutility (individual)	Power generators and suppliers, electricity customers - both households and business (lost services), regulator
		Lost output / increased costs (business customers)	
		Additional costs / foregone producer surplus (supplier)	
	Water	Disutility (individual)	Water authority, customers - both households and business (lost services), regulator
		Lost output / increased costs (business customers)	
		Additional costs / foregone producer surplus (supplier)	
Damage to property → Short-term disruption	Commerce and industry	Lost business during repairs / replacement (lost producer surplus)	Local manufacturing and service sector, insurers

The Stock-at-risk of Flooding

The detailed method used in deriving the results is provided in a separate technical note [see Appendix 1]. As explained below, damages to property are a function of flood depth, while impacts on human health are a function of flood depth and velocity, as well as the flood's return period. It is assumed that the depth and velocity data is constant across the width of the flood plain and along the relevant section of river.

Using a NEXTmap Digital Elevation Model (DEM) and the latest flood levels for the main rivers that flow through the key MKSM settlements modeled by the Environment Agency, we identified the number of residential properties located within the growth area and in the 1-100 year flood area, distinguishing between existing households and planned households. As mentioned above, the damage functions for residential property relate flood depth (m) to damages (£·m^{-2}). It was therefore necessary to convert the total number of residential properties at risk to flooding to the total residential household area at risk to flooding. To do this we assumed that the average size of the ground floor of a residential property is 81.6 m^2. We assume all households will reside on the ground floor and be at risk to flooding. The total residential household area (m^2) at risk to flooding is thus given by:

[(Number of households within the flood plain * 81.6m^2 per household)

The current and future population living in the flood plain is calculated by multiplying the total current and future number of households by the average size of households in the UK. The next task is to calculate the monetary damage associated with the predicted depth of flooding at each property.

Economic Valuation

Below we explain how the direct damages of flood waters to residential building fabric and inventory items have been estimated. The costs are summarized in Table 1.

Core Analysis: Direct - Residential

In assessing the direct flood damage to residential property we utilise depth-duration-damage curves published by the UK Flood Hazard Research Centre (FHRC) in their "Multi-coloured Manual". We simplify the damage calculation for residential properties by grouping all residential properties into the same code and calculating damages using a single duration-depth-damage curve. This is an average depth damage curve for all properties that does not distinguish between property ages, types or size. The flooding is assumed to be of 0.1 metres in all properties. We also assume that 50% of the properties are flooded for more than 12 hours, and 50% for less than 12 hours. We use a value of £14,182 and £19,871, per property for properties assumed to have been flooded for less than, or more than, 12 hours, respectively. This is a simplification typical of a broad scale approach.

In addition to building fabric and household inventory items, clean-up costs are also an important variable in determining the potential damages to residential properties. Average clean-up costs have been derived by the FHRC, based on actual observed damage costs (FHRC, Multi-coloured Manual 2003). We employ the conservative estimate associated with flooding below a depth of 0.1m of £6,470 per property (2007 prices).

Indirect: Residential Property

While the costs of cleaning residential property following a flood include the rental and labour costs of dehumidifiers (as part of the depth-duration-damage curves) they do not include the additional electricity costs incurred by households. On average, a dehumidifier utilises 3kw of electricity per hour of use, which at 2007 prices costs £0.058 per kWh. The electricity cost for one dehumidifier for a 24-hour period is thus £1.39. For flood depths below 0.1m four dehumidifier units are typically required for 28 days. The total additional electricity cost in this case would be £156 per household.

Emergency Costs

Floods also disrupt communications and impose extra costs on those involved in responding to the flood event and in the recovery process. Depending upon the severity of the flood event, several emergency services may be involved in both emergency works and clean-up operations, during and after the flood event. Extra (emergency service) staff time and materials may be required, and additional administrative costs may be involved.

Based on detailed research of a series of flood events in the UK during the autumn of 2000, the FHRC Multi-coloured Manual found that the total cost of all emergency services and communication disruptions, as a percentage of total direct economic property losses, was 10.7%. In the absence of specific information for MKSM we have used this ‘multiplier’ (applied to total direct property losses) to approximate the additional emergency and communication costs associated with the flood event.

Second-Order Effects

Floods not only impact upon the property and infrastructure directly affected, but that the impact can spread further into neighbouring economic units, in turn causing general disruption to the regional or sub-regional economy. Such impacts are typically termed second-order or secondary effects, and are notoriously difficult to measure. Nonetheless, the FHRC Manual reports the findings of a detailed case study of flooding in the Thames Valley, UK in which secondary effects were calculated. They found that secondary effects in the locality of the flood (i.e. within 15-20 kilometres of the flood plain) were 0.2 per cent of total direct property losses.

We have used this ‘multiplier’ to approximate the second-order effects of the flood event in MKSM. There is, of course, considerable uncertainty in using this ‘multiplier’: for a start, the structure and linkages between elements of the regional economy in MKSM will differ from the Thames Valley. The resulting estimates of the second-order effects are, nonetheless, very small relative to the total costs of each flood event. The uncertainty surrounding the ‘multiplier’ is therefore unlikely to have a significant bearing on the results.

Table 1 Economic value of stock at risk

Type of cost	Economic valuation
Direct – residential (damange)	£17,027 per household (average)
Direct – residential (clean up)	£6,470 per household
Indirect – residential	£156 per household
Emergency costs	10.7% of total direct property losses
Second-order effects	0.2% of total direct property losses

Sensitivity Analysis: Health Effects

The health (or 'intangible') effects of flooding are now recognised as being potentially significant. The effects on human health as a consequence of flooding range from risks to life, hypothermia and injuries during, or immediately after, the flood, to more long term physical and psychological health effects during the weeks or months following a flood (e.g. anxiety during heavy rainfall, increased stress levels, mild, moderate, and severe depression, flashbacks to flood, etc.) However, these health effects have not been formalized for inclusion in the Defra FCDPAG guidance on flood management project appraisal. Thus, in this case study we include these effects as an additional sensitivity.

Direct: Injuries and Fatalities

Our approach to estimating the cost of injuries and deaths that arise from flood events are outlined below. We consider:

- Death (usually drowning) as a direct and immediate consequence of deep and / or fast flowing floodwaters.
- Physical injuries as a direct and immediate consequence of deep and / or fast flowing floodwaters.

The risks of death and physical injury as a result of an individual flood event are known to be determined by three broad sets of characteristics; these are:

- Flood characteristics (e.g. depth, velocity, etc.).
- Location characteristics (e.g. inside / outside, nature of housing, etc.).
- Population characteristics (e.g. age, health, etc.).

Previous work (DEFRA, 2003)[52] has attempted to develop an algorithm that combines these characteristics to provide quantitative estimates of the number of injuries and premature deaths as a consequence of a given flood event. We use this algorithm.

From DEFRA (2003) the number of deaths and injuries is calculated according to:

$$N(I) = N \times X \times Y$$

Where:

N (I) = number of injuries and deaths.

[52] DEFRA (2003) Flood Risks to People Phase 1. R & D Technical Report FD2317. DEFRA & Environment Agency, Flood and Coastal Defence R&D Programme.

N = population within floodplain.

X = proportion of population exposed to a risk of injury or death.

Y = proportion of those at risk who will suffer injuries or death.

In order to determine the number of people at risk, the number of people in each hazard zone should be identified, where the hazard zone is defined by the depth and velocity of flood water. The degree of hazard, or **hazard rating**, is calculated as being determined by the function: $(v + 1.5) \times d$, where v = velocity ($m{\cdot}s^{-1}$) and d = flood depth (m). The hazard rating varies across the flood plain, as flood depth and velocity change.

The number of people exposed is taken to be a function of: flood warning; speed of onset; nature of area (e.g. type of housing); and the timing of the flood. A simple scoring system that characterises variation in these elements – outlined in Table 2 - is used to define the vulnerability of the area in terms of an area vulnerability score. The sum of the factors provides an indication of the vulnerability of the area. We have characterised the MKSM growth area as a 'low risk area' for each parameter, yielding a total vulnerability score = 3.

The proportion of the population exposed to a risk of injuries or death (X) is estimated by multiplying the **area vulnerability score** by the hazard rating.

Table 2: Characteristics of Area Vulnerability

Parameter	**1 = Low Risk Area**	**2 = Medium Risk Area**	**3 = High Risk Area**
Flood warning [a]	Effective tried and tested flood warning and emergency plans	Flood warning system present but limited	No flood warning system
Speed of onset	Onset of flooding is very gradual (many hours)	Onset of flooding is gradual (an hour or so)	Rapid flooding
Nature of area [b]	Multi-storey apartments	Typical residential area (2-storey homes); (low rise) commercial and industrial properties	Bungalows, mobile homes, busy roads, parks, single storey schools, campsites, etc

Notes:

(a) In this context, flood warning includes emergency planning, awareness and preparedness of the affected population, and preparing and issuing flood warnings.

(b) High and low 'nature of area' scores are intended to reflect judgements as to whether there are particular features of the area in question which will make people in the area significantly more or less at risk than those in a 'medium risk area'.

The proportion of those at risk who will suffer injuries or death (Y) is derived from a function comprised of characteristics of the people exposed to the risk, and specifically, the percentage of the very old and ill in the exposed population relative to the national average; for each characteristic three scores are possible: 10 = low risk people; 25 = medium risk people; and 50 = high risk people. We have assumed that the proportion of elderly and the infirm / disabled / long-term sick in the MKSM growth area is below the national average; the corresponding people vulnerability score (Y) is equal to 20 (i.e. 20%).

The number of injuries is then given by the population of the hazard zone multiplied by the fractions X and Y. The number of deaths is subsequently derived from the number of injuries, by multiplying this number by a factor equalling two times the hazard factor.

The estimates are based on an assumption of 20% of the population residing at ground level within the flood plain. This assumption represents our ‘best guess’, since people living on the first, second or upper floors of buildings are very unlikely to be injured or die as a result of flooding unless they happen to be outside when the flood arrives.

We have expressed the injuries and deaths derived from application of the above algorithm in monetary terms, as well as physical terms. In order to convert the results from physical to monetary units we multiply the numbers of estimated injuries and deaths by unit values of: a) an injury, and b) a premature death. These unit values have been derived from the environmental and transport safety value literature. The cost of a premature death is based on the value of statistical life (VOSL). We have used the VOSL recommended by the Department for Transport of £1.41 million (2007 prices). The values of slight and serious injuries are £13,970 and £181,170, respectively. We assume that 80% of injuries are slight.

Indirect: Anxiety

To householders, the impacts of flooding, such as increased stress and loss of memorabilia, can be as important as the direct material damages to their homes and their contents. To account for these intangible values we use the results of a recent survey[53].

The results of the UK national survey confirmed that flooding caused physical effects in the short-term and psychological effects in the short and longer-terms. Psychological effects included memory of the stress from flooding and damage, and the stress of recovering after an event, including that arising from settling claims with insurers and dealing with builders and repairers.

The results of the survey are presented in Table 3. For a 1 in 100 year event, the annual value per household is £290.

Table 3: The Foregone Benefits (Psychological Damages) from Flood Events (2005 prices)

Return Period (1-X years)	**Annual Flood Probability**	**Benefit of Moving to Next RP** (€ / hh / yr)	**Health Damages at RP** (€ / hh / yr)
1	1.000	-	-
10	0.100	7	7
20	0.050	10	18
30	0.033	18	35
50	0.020	70	105
75	0.013	117	222
100	0.010	69	290
125	0.008	22	312
150	0.007	4	316

Note: Figures in the last column may not exactly correspond to the accumulated value of the figures in the third column due to rounding.

[53] DEFRA (2004) Appraisal of Human Related Intangible Impacts of Flooding, Supplementary Note to Operating Authorities, July 2004.

Base Case Cost Summary

Our estimates of the total (Base Case) damages from the case study flood event are shown in Table 4. It shows the relative contribution of each impact category to total damages. Damages to residential property is by far the largest source of cost from the core analysis, though the health impacts are valued higher within the sensitivity analysis. The next most significant impact category is emergency services. The other impact categories contribute relatively little to total damages.

Table 4: Summary of Estimated Total Damages in 1 in 100 year Flood Event for MKSM (Base Case) (2007 prices)

	Low	High
Direct	73,273,000	93,458,000
Indirect	553,000	553,000
Emergency services	7,840,000	10,000,000
Secondary effects	147,000	187,000
Total (without health)	81,813,000	104,198,000
Health	246,020,000	246,020,000
Total (with health)	327,833,000	350,218,000

Impact Assessment – Climate Case Scenario

Interpretation of Flood Risk

Fluvial flood outlines with an allowance for climate change have been mapped onto an outline of the location of new development in the MKSM area and compared to existing maps of current flood risk. The resulting map illustrates that there will be increase in area potentially at risk of flooding as a result of climate change (see Figure 2). Under current flood risk conditions, 274ha of the proposed growth area is at risk of fluvial flooding. Under the climate change scenario, 291ha will be at risk of flooding. This is an increase of 6%.

Costing Method

The detailed method used to quantify the costs of flooding to the MKSM sub-region is identical to that described in the Base Case above. The only difference is that the domestic properties vulnerable to flooding increase in number in a climate change scenario where a 1 in 100 year event is considered.

Climate Case Cost Summary

The gross costs of a 1 in 100 year flood event under a climate change scenario, with allowance for the additional growth in housing planned for the MKSM growth area, are presented in Table 5. The impact categories have the same relative monetary weight as in the Base Case scenario, with direct property damage again dominating the core analysis, though health being three times larger in the sensitivity analysis.

Figure 2: Growth area at risk of flooding

Table 5. Summary of Estimated Total Damages in 1 in 100 year Flood Event for MKSM (Climate Case) (2007 prices)

	Low	High
Direct	81,582,000	104,055,000
Indirect	616,000	616,000
Emergency services	8,729,000	11,134,000
Secondary effects	163,000	208,000
Total (without health)	91,090,000	116,013,000
Health	273,917,000	273,917,000
Total (with health)	365,007,000	389,930,000

Comparing the results in the two tables, the impact costs including climate change are approximately 12% higher than those excluding climate change impacts. The net climate change impact costs are presented in Table 6.

Table 6. Estimated Net Damages attributable to climate change of a 1 in 100 year Flood Event for MKSM (2007 prices)

	Low	High
Direct	8,309,000	10,597,000
Indirect	63,000	63,000
Emergency services	889,000	1,134,000
Secondary effects	16,000	21,000
Total (without health)	9,277,000	11,815,000
Health	27,897,000	27,897,000
Total (with health)	37,174,000	39,712,000

Note that these flood impact cost results are presented for a specific flood event – a 1 in 100 year event with, and without, climate change. Expressed as annualized values, the net climate change impact costs for a 1-in-100 year event range from £335,450 to £427,200, without health impacts included, and from £1.34m to £1.44m when health impacts are included.

Conclusions

On the basis of the analysis undertaken, climate change is projected to increase the costs of a 1 in 100 year flood event by about 12% for the MKSM growth region. Note in this regard that the analysis considers only the flood impacts to the additionally planned domestic properties in the growth area. Annual additional costs, without considering potential health impacts, are calculated to be around £400,000 and these annual costs are increased by £1 million if health impacts are included.

Since we only consider one flooding event severity – the 1 in 100 year event - the annualized results represent only a fraction of the total costs associated with climate change flooding. In reality, there will be climate change impact costs associated with a full range of flood event frequencies – we typically consider a range from a 1 in 3 year event to a 1 in 250 year event. Also, we do not consider the impacts on non-domestic property associated with the growth area; factoring these into the calculations would further increase the scale of the costs. As a consequence, we cannot make firm recommendations for flood management policy. However, what is important to emphasize is that the additional costs are not likely to be insignificant.

Policy Implications

Flooding exacerbated by climate change represents a risk to the MKSM development. The most efficient way of avoiding this risk is to ensure that development is appropriate to the risk – for example by leaving floodplains as active floodplains or by incorporating them as parkland.

If development does proceed, the additional costs of the increased flood risk are likely to be borne by individual home owners and their insurers but developers could also be impacted if development areas become blighted by potential flood risk. Furthermore, as demonstrated there will be wider economic costs in terms of emergency services and healthcare. Flood management policy, therefore, has to be responsive to climate change risks in this growth area if it is not to leave the additional development vulnerable to climate change induced flooding.

The actual costs of increased flood risk will depend on the extent to which flood risk is mitigated by hard defences and resilience and resistance measures included in new developments. Traditionally, the adaptation response to flood risk has been to build hard defences. However, hard defences are not the only option. An alternative response to the increase in flood risk in MKSM is to ensure new buildings are resistant and resilient to the effects of flooding. A number of measures can be included in the design of new buildings: resistance measures help prevent water getting in to buildings and resilience measures ensure minimal damage occurs if water does get in. Ideally buildings should be fitted with both. Examples of flood resistance measures include:

- Increasing the floor level above the projected flood level by raising the main occupied area of buildings

- Installing pump and sump systems which drain water from below floor level faster than it rises
- Using groundfloor spaces for non-residential uses e.g. car parking;
- Using permeable paving materials for pavements, driveways, footpaths and car parking areas to prevent high levels of run-off during flash floods;
- Using SUDS to collect and store surface water.

Flood resilient measures include:

- Replacing timber floors with concrete, and carpet with tiles
- Replacing perishable materials such as MDF or chipboard kitchens with plastic or steel alternatives
- Replacing gypsum plaster with more water resistant materials such as lime plaster or cement render
- Raising items which can be damaged by flooding (e.g. boilers, wall sockets, meters) above the projected flood level
- Installing one-way valves on drainage pipes - decrease risk of sewage backing up into a building during a flood.

The costs associated with retrofitting these measures to existing houses are given in Case Study 11 – Boston. In the case of MKSM, where a large number of houses are being built at once, there is an opportunity to exploit economies of scale in providing flood resilience and resistance measures. Therefore, the cost of providing these measures in new developments should be significantly lower than retrofitting them to existing properties.

Planning policy should ensure new developments that are likely to be affected by flood risk in future include these measures in their design. In addition to reducing flood risk to new developments, this policy is likely to result in the creation of a new market in flood resilience and resistance technologies and construction techniques in the MKSM area.

Emda's support in climate change adaptation in this area will also help achieve other Priority Actions set out in the RES including:

- Helping existing businesses deploy technologies and processes

- Translating scientific excellence into business success
- Sustainable Construction
- Supporting Infrastructure for Housing Growth
- Stimulating new markets and enterprise opportunities.

Emda has a particular role to play in ensuring that growth to support the regional economy is achieved without increasing vulnerability to climate change. This may be achieved through more appropriate placement of housing and related infrastructure, striking a balance between economic imperatives and a range of environmental criteria including flood risk, or through smarter design of development, both at the development and individual household scale.

APPENDIX 1: FLUVIAL FLOODING AND DEVELOPMENT TECHNICAL NOTE

Introduction

This Technical note supports the output of the fluvial analysis carried out for the EMDA Climate Change project. The aim of the analysis was to determine the extent of climate change on fluvial flood risk in key growth areas within East Midlands. The tasks carried out are described in brief below:

- Create a new set of fluvial flood outlines with a 1% AEP for current and future climate change scenarios for the growth areas in Northampton, Wellingborough, Kettering and Corby.
- The flood outlines area created using a simple GIS projection method which utilises the NEXTmap DEM and the latest modelled flood levels for the main rivers that flow through the key settlements identified above.
- The flood outlines were then used to identify the increase in floodplain area for each growth area due to increases linked to climate change

Data Sources

The following data sources were used in the analysis:

- **NEXTmap DTM** – The Digital Elevation Model (DEM) depicts the topography of the land as a grid of elevation values. NEXTMAP Digital Terrain Model (DTM) was used for this purpose. This provides complete topographic coverage of the study area at a 5m grid resolution. The DTM version of NEXTmap is a filtered version of the DEM. This is where both the flood defences and buildings have been removed from the dataset to provide a bare earth model.
- **Modelled Flood Levels** – The latest modelled levels for the main rivers passing through the growth areas were provided by the Environment Agency. The rivers used in the analysis were the Upper

Nene, Middle Nene, Ise and Willow Brook. Climate change scenario for the year 2080 was represented by a 20% increase in peak river flow volume in each stretch of river as recommended in Defra's Flood and Coastal Defence Appraisal Guidance (ref.1)

- **Growth Areas** –Data depicting the latest growth area extents for Northampton, Wellingborough, Kettering and Corby, provided by the ABI.

Methodology

Modeling Approach

A simple GIS projection method was used to create the extreme flood outlines in the analysis. Compared to other flood mapping solutions such as 2D hydrodynamic modelling, GIS projection provides a simple but effective solution.

This involves comparing the difference between the DEM and a water level surface derived from the modelled flood levels for the required flood scenario. The Water Level Surface is created by creating a series of cross sections perpendicular to the direction of the river channel at each model node and extrapolating the node value along the cross section. The surface is then derived by linear interpolating between each cross section.

To create the flood outline, the DEM was subtracted from the Water Level Surface. Any positive values (i.e. were the ground elevation is lower than the water level) within the resultant grid was considered inundated and represent the depth of flooding at that location. Any negative values (i.e. areas where the ground elevation is above the Water Level Surface) are considered out of the floodplain and was therefore removed.

The resulting depth raster grids were converted to a vector based polygon shapefile using ArcGIS Spatial Analyst. During the conversion process, polygon edges were generalised or smoothed to reduce the jagged step effect, created when converting from a raster grid to a polygon vector format. This dramatically reduces the file size and speed it takes to view the outlines as the number of vertices, or nodes, required to represent each polygon outline is significantly lower.

Polygons are then cleaned to remove any independent water islands (areas lower than the flood water level but not connected to the river) and holes in the flood outlines (usually caused by noise or other discrepancies caused by the filtering process to the DEM)

QA

A series of QA checks were carried out against the two outlines to ensure that the extents are realistic and fit for purpose. The flood extents were compared against the EA Flood Zones for the locations where they intersected the growth areas. Minor manual alterations were made where there were discrepancies such as gaps or over estimations of flood area. Such areas are likely to be a result of errors in either modelled flow data or the DEM. This is described in further detail below.

The flood outlines are presented as GIS polygons in ESRI Shapefile format. These outlines have been created using a simple and general approach and only fit for purpose for broad scale analysis of flood risk.

Growth Area Analysis

To determine the increase in flood risk on the key growth areas, the flood extent outlines were intersected with the growth area extents. For each growth polygon, the area of inundation for each scenario was calculated and exported to excel for further analysis.

Caveats and known issues

Data Sources

NEXTmap DTM - Error or uncertainty for NEXTmap DEM in the study area is unknown. However, across the UK, NEXTmap is documented to have a global error of +/- 0.5-1m. This varies depending to the complexity of the terrain and is generally more accurate in lower lying or low urban areas.

Modeled Flood Levels - Modeled river level data was only provided for the main rivers. When compared to the EA flood zones, there are other small rivers, drains and tributaries that may provide a fluvial flood risk. These have been identified in a separate polygon Shapefile in locations where these areas (identified in the EA flood zone) intersect the growth areas.

Modeling Approach

The GIS projection method is a simple approach to deriving the flood outlines. The accuracy of the water level surface is largely dependant on the number of and suitability of the modelling output. If there are too few nodes, this can produce poor flood outlines as the water level does not reflect the localised water level variations in those areas.

Output

As discussed in the data sources section above, there are areas identified as at risk in the EA flood map that are not identified in the created outlines. These are mainly from small drains and rivers which are likely to provide a smaller risk than from the main rivers. These areas are identified in the "no data available" dataset.

References

Flood and Coastal Defence Appraisal Guidance FCDPAG3 Economic Appraisal – Supplementary note to operating authorities – Climate Change Impacts; October 2006, Defra.

CASE STUDY 9: WASTE

1. Introduction and case study scope

The East Midlands produces approximately 25 million tonnes of waste annually (emra 2006) and this is forecast to increase. The Regional Waste Strategy forecasts an increase in total controlled wastes of 1.8 million tonnes by 2020 (emra 2006). A significant generator of waste in the region in future will be the Milton Keynes South Midlands (MKSM) development.

Globally, waste is an important contributor to climate change. Methane (CH_4) produced at solid waste disposal sites contributes approximately 3-4 percent to annual global anthropogenic greenhouse gas emissions (Monni *et al*. 2007).

As well as policies which directly affect the waste sector (e.g. Landfill Directive, Waste Electronic and Electrical Equipment (WEEE) regulations, Packaging Waste Regulations etc) climate change mitigation policy is increasingly having an indirect impact on waste management. Climate change represents both threats and opportunities to the waste sector in the East Midlands, depending on the ability and willingness of households, businesses and actors involved in waste management to change behaviour, adopt new practices and technologies.

One of the synergies between waste policy and climate change mitigation policy is energy production. The potential to generate energy from waste, reducing the need for fossil fuel burning, is great and climate change mitigation may increasingly influence decision making on new waste management facilities. Other waste policies such as recycling may reduce greenhouse gas emissions from the manufacture of new goods although the process itself can be energy intensive. Another area where waste management can contribute to carbon dioxide (CO_2) reductions is transport. Currently, the majority of waste is transported by road but rail and waterways offer a lower carbon alternative.

It should be noted that climate change will also pose a physical threat to waste collection, storage, transportation, treatment and disposal and therefore some degree of adaptation will be required. However, the focus of this case study is climate change mitigation.

This case study will provide a summary of waste and climate change mitigation policies at an international, national and regional scale and will assess the contributions these will make to waste and emissions reductions. A review of potential waste reduction and treatment techniques and technologies has been undertaken, indicating where possible their costs and the potential for the minimisation of waste and emissions.

The structure of the case study is as follows:

- Section 2: Current waste arisings and contribution to greenhouse gas emissions in the East Midlands;
- Section 3: Future waste arisings and contribution to greenhouse gas emissions in the East Midlands;
- Section 4: Review of current waste policy and how this will contribute to a reduction in waste and emissions;
- Section 5: Review of climate change mitigation policy and how this will further contribute to a reduction in waste and emissions;
- Section 6: Review of techniques/technologies available for waste/emissions reduction including comment on cost effectiveness at reducing waste and emissions;
- Section 7: Conclusions and gaps in regional waste policy.

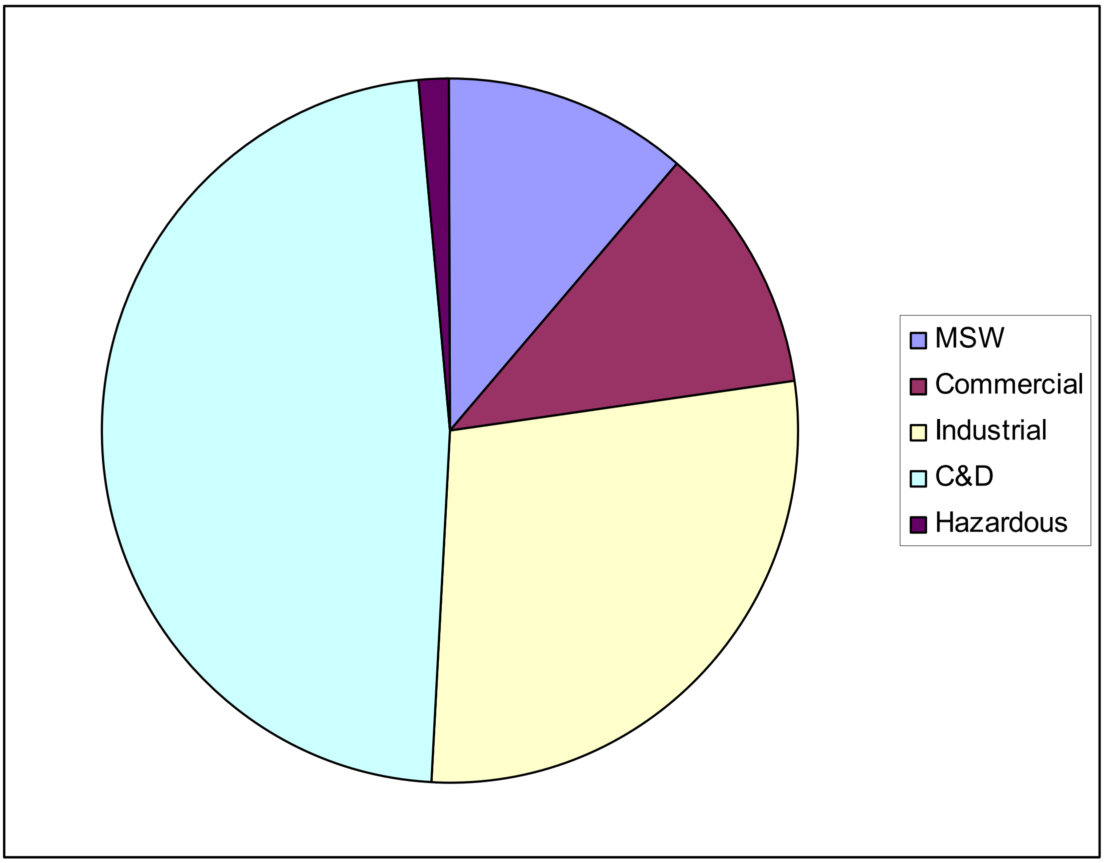
2. Current waste arisings and contribution to greenhouse gas emissions

2.1 Current waste arisings

The East Midlands produces approximately 25 million tonnes of waste annually (emra 2006). In 2003, 20.3 million tonnes of controlled waste (excluding agricultural waste) was produced (emra 2006). Figure 2.1 shows the breakdown by waste type.

Of the 25 million tonnes, 12.7 million tonnes were treated, disposed of or transferred through licensed waste management sites in the Region. The additional tonnages will also have been treated at sites exempt from the waste management licensing or pollution prevention and control regime.

Figure 2.1 Controlled waste arisings in the East Midlands by type (2003)



Source emra 2006

MSW - Municipal Solid Waste

C&D - Construction and Demolition

2.2 Contribution to greenhouse gas emissions

Globally, the waste sector is an important contributor to climate change. Decomposition of waste produces methane, a greenhouse gas twenty-one times more potent than carbon dioxide. Methane produced at solid waste disposal sites contributes approximately 3-4% to annual global anthropogenic greenhouse gas emissions (Monni *et al*. 2007).

In the East Midlands, the waste sector is responsible for 748kt of greenhouse emissions equivalent to carbon dioxide (CO_2e)[54] annually, 2% of the regional total (emra 2007).

[54] Equivalent CO_2 (CO_2e) is the concentration of CO_2 that would cause the same level of radiative forcing as a given type and concentration of greenhouse gas.

3. Future waste arisings

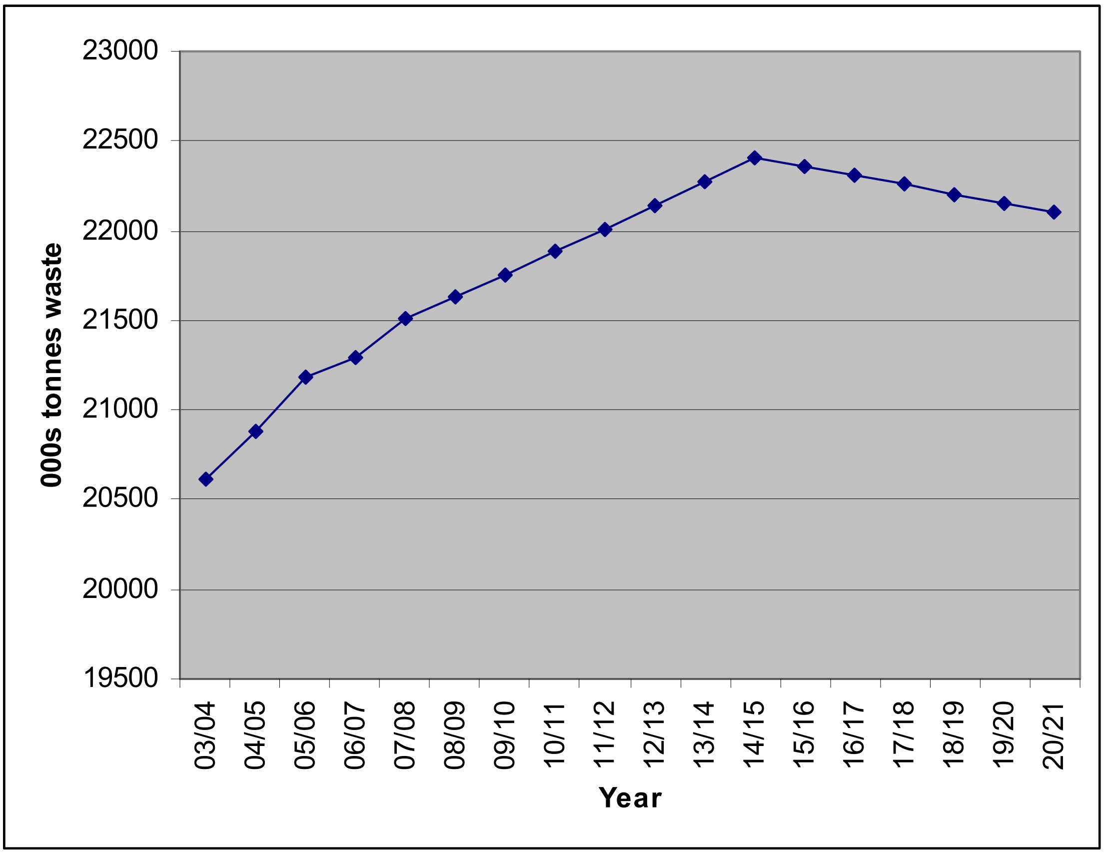
3.1 Future waste arisings

The Regional Waste Strategy forecasts an increase in total controlled wastes to 22.1 million tonnes by 2020 (emra 2006). Figure 3.1 shows the projected trajectory of waste arisings in the East Midlands over the period 2003 to 2020. It can be seen that waste arisings are forecast to peak in 2015 at 22.4 million tonnes, reducing slightly by 2020.

Figure 3.2 shows the breakdown of waste arisings in 2020 by type. There is little difference in the proportion of waste coming from the MSW, Commercial and Hazardous streams but there is a predicted increase in the amount of C+D waste by 2020.

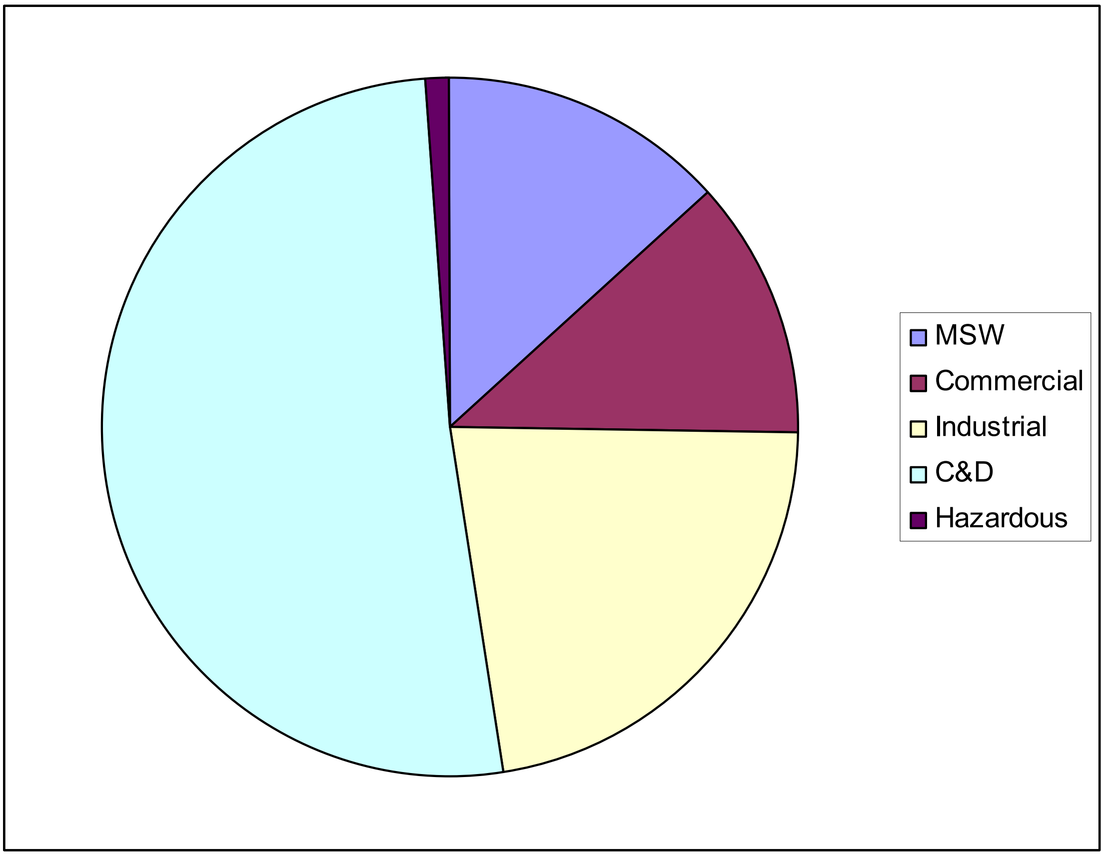
Some of this growth in C+D waste can be explained by the high level of projected housing growth in the region over the next twenty years. A significant generator of waste in the region in future will be the Milton Keynes South Midlands (MKSM) development. Northamptonshire (the part of MKSM within the East Midlands) has been identified to provide an additional 99,500 dwellings in the period from 2001 to 2021. The resulting incremental increase in waste arisings has been calculated (see Table 3.1).

Figure 3.1 Projected controlled waste arisings in the East Midlands 2003 to 2020



Source emra 2006

Figure 3.2 Forecast controlled waste arisings in the East Midlands by type (2020)



Source emra 2006

Table 3.1: Projected increase in waste as a result of MKSM development

Waste Stream	Additional waste arisings (tonnes) in 2015 compared with 1999
Municipal solid waste	31,200
Commercial and Industrial	125,400
Construction and Demolition	163,700
Total	**320,300**

Source: Regional Waste Strategy (emra 2006)

3.2 Contribution to GHG emissions

Assuming no efficiency improvements, extrapolating from the current contribution of waste to greenhouse gas emission in the East Midlands, an increase in waste arisings from 25 million tonnes in 2003 to 28 million tonnes in 2020 could result in an increase in greenhouse gas emissions from 748kt per year to 838kt per year. This represents a 12% increase. However, improvements in energy efficiency and new waste treatment technologies mean this increase is likely to be lower.

4. Current waste policy

Legislation aimed at reducing waste arisings exists at international, national and regional scale. In this section, the main polices aimed at reducing waste arisings are identified and their contribution to climate change mitigation assessed.

4.1 International

There are several pieces of EU legislation covering the waste sector. The Framework European Legislation on waste (2006) aims to limit the generation of household waste and to optimise the organisation of waste treatment and disposal. Under this legislation, Member States must prohibit the abandonment, dumping or uncontrolled disposal of waste, and must promote waste prevention, recycling and processing for re-use. In addition, Member States must appoint a competent authority to issue and monitor permits to establishments treating, storing or tipping waste on behalf of third parties. In the UK this is the Environment Agency.

The Strategy on the Prevention and Recycling of Waste (2005) sets out guidelines and describes measures aimed at reducing the pressure on the environment caused by waste production and management. The objectives of the Strategy, namely limiting waste, and promoting the re-use, recycling and recovery of waste are integrated into an approach based on environmental impact and on the life-cycle of resources. Member States are required to develop programmes to prevent waste production. These programmes include specific prevention targets to be implemented at the most appropriate level and which must be made public. In addition, recycling targets could be set at appropriate levels. The Strategy places particular emphasis on biodegradable waste, two-thirds of which must be disposed of using methods other than landfill.

The Integrated Pollution Prevention and Control (IPPC) Directive (1996) defines the obligations with which highly polluting industrial and agricultural activities must comply. One of the aims of the Directive is to reduce the quantity of waste arising from industrial and agricultural installations. In order to receive a permit an industrial or agricultural installation must comply with certain basic obligations including preventing, recycling or disposing of waste in the least polluting way possible.

There are also a number of pieces of legislation which cover individual waste streams including hazardous waste, packaging, electronic equipment and radioactive substances. In addition, waste form a number of industrial processes is controlled by European legislation including waste from mining, shipping and the use of sewage sludge in agriculture.

The Packaging and Packaging Waste Directive (1994) aims to reduce the formation of packaging waste and encourages the use of packing reuse systems. Member States must introduce systems to meet the following targets:

- By no later than 31 December 2008, at least 60% by weight of packaging waste to be recovered or incinerated at waste incineration plants with energy recovery;
- By no later than 31 December 2008, between 55 and 80% by weight of packaging waste to be recycled;
- By no later than 31 December 2008 the following recycling targets for materials contained in packaging waste must be attained: 60% by weight for glass, paper and board; 50% by weight for metals; 22.5% by weight for plastics and 15% by weight for wood.

The Waste Electrical and Electronic Equipment (WEEE) Directive (2003) takes measures to reduce the amount of electrical equipment waste and improve the environmental performance of operators involved in its management.

4.2 National

The National Waste Strategy, published by Defra in 2007 sets out Defra's vision for sustainable waste management. The key objectives of the Strategy are to:

- Decouple waste growth from economic growth and put more emphasis on waste prevention and re-use;

- Meet and exceed the Landfill Directive diversion targets for biodegradable municipal waste in 2010, 2013 and 2020;
- Increase diversion from landfill of non-municipal waste and secure better integration of treatment for municipal and non-municipal waste;
- Secure the investment in infrastructure needed to divert waste from landfill and for the management of hazardous waste; and
- Get the most environmental benefit from that investment, through increased recycling of resources and recovery of energy from residual waste using a mix of technologies.

One of the key objectives of the National Waste Strategy is to reduce the amount of waste going to landfill. The landfill tax escalator and the introduction of the Landfill Allowance Trading Scheme (LATS) have created sharp incentives to divert waste from landfill. The landfill tax escalator was announced in 2002 and in Budget 2007 the Chancellor announced that the tax would increase more quickly and to a higher level than previously planned. Increases of £8 per tonne per year for active waste (those that give off emissions) were announced from 2008-09 to at least 2010-11. The current standard rate of landfill tax is £24/tonne. This will have doubled to £48/t in 2010/11 (Defra 2007). The landfill tax escalator has bee successful at reducing the amount of waste reaching landfill. Overall quantities of waste recorded at landfill sites registered for the tax fell from around 96 million tonnes in 1997-98 to around 72 million tonnes in 2005-06, a reduction of around 25%.

Another key objective of the Strategy is to focus on waste prevention. This is recognised through a new target to reduce the amount of household waste not re-used, recycled or composted from over 22.2 million tonnes in 2000 by 29% to 15.8 million tonnes in 2010 with an aspiration to reduce it to 12.2 million tonnes in 2020 – a reduction of 45%. This is equivalent to a fall of 50% per person (from 450 kg per person in 2000 to 225 kg in 2020).

A further key objective of the Waste Strategy is to use waste as an energy source. Defra aims to achieve this through a package of measures of incentives and regulation.

The National Waste Strategy also places expectations on local and regional government with respect to waste. Through the Strategy the Government will encourage Regional Development Agencies to coordinate business waste and resource management in partnership with local authorities and third sector organisations (Defra 2007).

Table 4.1 sets out how Defra intend to deliver the objectives and targets of the Strategy.

Planning Policy Statement 10: Planning for Sustainable Waste Management recognises the role that the planning system has to play in delivering sustainable waste management. The spatial planning system contributes to waste management at the strategic level through the development of strategies (such as the East Midlands Regional Waste Strategy), and through the development control process by providing opportunities for the development of new waste management facilities of the right type and in the right place. PPS10 sets out the key objectives and the decision-making principles to be employed by waste planners.

Table 4.1 Policies from the National Waste Strategy

Type of action	Examples
Incentives	• Increasing the landfill tax escalator • Consulting on removing the ban on local authorities introducing financial incentives for household waste reduction and recycling • Introducing enhanced capital allowances for investment involving the use of secondary recovered fuel (SRF) for combined heat and power facilities
Regulation	• Waste protocols that clarify when waste ceases to be waste • Consultation on whether the introduction of further restrictions on the landfilling of biodegradable wastes or recyclable materials would make an effective contribution to meeting the objectives set out by the strategy • Action on flytipping and on illegal dumping abroad
Target action on materials, products and sectors	• Establish an agreement with the paper industry with targets to reduce paper waste and increase paper recycling • Support for anaerobic digestion through the new technologies programme, Renewable Obligations system, Private Finance Initiative (PFI) and a digestate standard • Proposals for higher packaging recycling requirements beyond the 2008 European targets to increase recycling • Develop eco-design requirements which will consider waste impacts as part of the wider life cycle assessment of energy using products • Producer responsibility arrangements (both statutory and voluntary) place responsibility on businesses for the environmental impact of products they place on the market • Setting optimal packaging standards for a product class • Make, subject to consultation, Site Waste Management Plans a mandatory requirement for construction projects over a certain value
Investment in infrastruct ure	• Ensuring that Regional Spatial Strategies and local development plans conform to national planning guidance on waste • Improving procurement by local authorities through strengthened central and regional coordination by the Waste Infrastructure Delivery Programme (WIDP) • Using PFI, and, where appropriate, Enhanced Capital Allowances, and/or Renewable Obligation Certificates (ROCs) to encourage a variety of energy recovery technologies • Developing the energy market for wood waste
Local and regional governanc e	• Encouraging local authorities to take on a wider role (in partnerships) to help local businesses reduce and recycle their waste • Encouraging the Regional Development Agencies to coordinate business waste and resource management in partnership with local authorities and third sector organisations
Culture change	• Extend the campaigns for recycling to awareness and action on reducing waste • Incentivising excellence in sustainable waste management through a zero waste places initiative • Reduce single use shopping bags through a retailer commitment to a programme of action to reduce the environmental impact of carrier bags by 25% by the end of 2008 • Providing more recycling bins in public places • Placing greater emphasis on promoting the reduction of waste and increase of recycling in schools • Government has set itself demanding targets for reducing and recycling its own waste

Source Defra 2007

4.3 Regional

There are a number of regional documents which consider waste, see Box 4.1. However, the Regional Waste Strategy, published by emra in 2006, is the main document concerned with waste policy in the East Midlands.

Box 4.1 Extracts from regional strategies

Regional Waste Strategy Policy RWS 1.8

Waste development plan documents and municipal waste management strategies should encourage the development of advanced recovery technologies as part of an integrated approach to waste management. Proposed thermal facilities should, wherever practicable, aim to incorporate combined generation and distribution of heat and power (EMRA 2006).

Regional Energy Strategy Policy ENG 10 (and accompanying text)

To ensure that an increasing amount of the electricity used is generated from renewable sources. There are opportunities to utilise waste gases from landfill sites, and organic waste through anaerobic digestion and other processes (EMRA 2006b).

Regional Environmental Strategy Policy ENV 16 (and accompanying text)

To promote and support sustainable waste management practices and minimise the impact of waste on the environment. Waste can be used for energy production through incineration, anaerobic or aerobic digestion. Waste heat can be used in district heating schemes. Methane production from landfill or sewage can be used to create energy (EMRA 2002).

Regional Freight Strategy Action Plan

Ensure that the emerging Regional Waste Strategy is consistent with this Strategy and supports actions to address potential opportunities for carriage of waste by more sustainable modes, in particular through promotion of rail and water transfer terminals (EMRA 2005).

The Regional Waste Strategy translates many of the priorities in EU and national policy into action at a regional scale. It provides a framework for delivery of the waste management principles and targets set out in the Regional Spatial Strategy (GOEM 2005). The Waste Strategy identifies ten priority actions for the Region, based on the priorities identified in the Spatial Strategy:

1. Planning future waste management infrastructure;
2. Education, behaviour change and promotion of best practice;
3. Improving the efficiency of resource use and reducing commercial and industrial waste;
4. Prevention and improving management of hazardous wastes;
5. Prevention and improved management of municipal solid wastes;
6. Procurement and market development;
7. Reduction and management of construction and demolition waste;
8. Managing the impacts of regional and sub-regional growth;
9. Addressing agricultural and rural waste management; and
10. Reducing fly tipping.

A series of policies, targets and an Action Plan for each priority action has also been developed and indicators identified in order to measure progress.

One of the key priorities of the Regional Waste Strategy is to reduce the amount of waste produced by the East Midlands. The Regional Waste Strategy sets a minimum target for MSW recycling in the Region of 50% by 2015 (Emra 2006). This is in line with the Regional Spatial Strategy and national recycling targets. However, there is an aspiration in the Region to exceed these targets.

There is great variation in recycling rates throughout the East Midlands. Three out of the top ten English local authorities for recycling in 2006 were from the East Midlands; North Kesteven, Rushcliffe and Melton Mowbray recycled 51.5%, 49.9% and 47.1% of waste respectively. For comparison, the national average was 26.7% and the Government's target was 25% (GNN 2006). However, some of the lowest performing local authorities were also from the East Midlands; High Peak and Bolsover managed to recycle just 12.3 and 13.7% respectively (GNN 2006). The difference in recycling rates indicates there is still scope for improvement in the East Midlands. One of the objectives of the Regional Waste Strategy is to bring all parts of the Region up to the levels of current best practice.

The Regional Waste Strategy sets out the responsibilities of local authorities in terms of waste. One of the central policies of the Strategy is that Waste Local Plans should include policies and proposals to promote sustainable waste management by the development of additional waste management capacity, taking into consideration:

- the Best Practicable Environmental Option (BPEO) for each waste stream;
- socio-economic implications;
- the principle of regional self-sufficiency;
- the proximity principle; and
- the waste hierarchy.

Anecdotal evidence presented in the Regional Waste Strategy suggests that the majority of waste transported within or to/from the region is by road (emra 2006). Road transport is one of the biggest contributors to CO_2 emissions and in order to reduce the impact of vehicle emissions associated with waste transport, waste should be disposed of as near as possible to the point of production. This is recognised in the Northants waste study, which recommends locating new non-municipal waste management facilities close to existing transport links.

Where it is not possible to locate waste disposal facilities close to the waste source, alternative modes of transport should be used to transport waste. As an alternative to road transport, the Regional Waste Strategy recognises the potential for waste transport by other modes including rail and waterways and direct links with the Regional Freight Strategy are made. Further work to clarify how waste is currently transported, the impacts of this mode of travel versus alternatives, and to identify the potential opportunities for and associated advantages of modal change is being taken forward through the implementation of the Regional Freight Strategy.

4.4 Contribution to waste reduction

The National Waste Strategy sets the following targets for waste prevention, reduction and recycling (Defra 2007):

- 29% reduction in amount of household waste not re-used, recycled or composted by 2010 (based on 2000 levels) with an aspiration to reach a 45% reduction by 2020;

- Recycling and composting of household waste;
    - 40% by 2010;
    - 45% by 2015;
    - 50% by 2020;
- Recovery of municipal waste;
    - 53% by 2010;
    - 67% by 2015;
    - 75% by 2020.

The policies in the Regional Waste Strategy are designed to meet the following targets (emra 2006):

- MSW arisings will not exceed the predicted 2.96 million tonnes per annum as at 2021;
- The tonnage of commercial and industrial waste arisings will not exceed 7.5 million tonnes per annum as at 2021;
- Hazardous waste arisings should not exceed 0.287 million tonnes per annum by 2021;
- C&D arisings will not exceed 11.3 million tonnes per annum as at 2021;
- A minimum target for the recycling and composting of MSW of:
    - 30% by 2010;
    - 50% by 2015;
- 10% of the materials value of public sector construction projects to be derived from recycled content by 2010.

However, assuming these targets are achieved and successful waste minimisation measures are employed, total waste arisings in the East Midlands are expected to increase from an estimated 25.6 million tonnes in 2004 to at least 27.8 million tonnes by 2020. Failure to deliver the Strategy could result in total waste arisings increasing to as much as 39.4 million tonnes per annum (emra 2006).

4.5 Contribution to emissions reduction

The overall impact of the National Waste Strategy is expected to be an annual net reduction in global greenhouse gas emissions from waste management of at least 9.3 million tonnes of carbon dioxide equivalent per year compared to 2006 (Defra 2007; emra 2007). The additional greenhouse gas emissions reductions result from an increase in diversion of waste from landfill of around 25 million tonnes of waste per annum. In addition, waste prevention measures in the Strategy will further reduce greenhouse gas emissions. Policies that encourage generation of energy from waste will also contribute to climate change mitigation as waste will be diverted from landfill and there will be a reduction in the amount of fossil fuels burnt to produce energy.

Figures for the impact of the Regional Waste Strategy on greenhouse gas emissions are not available.

5. Climate change mitigation policy

In Section 4, policies specifically aimed at reducing waste were identified and their contribution to emissions reduction assessed. In addition to waste policy, climate change mitigation policy can provide an additional driver for minimising the amount of waste generated and processed.

5.1 International

Kyoto Protocol

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was the first international agreement on climate change. It was adopted at the Third Session of the Conference of the Parties (COP) to the UNFCCC in 1997 in Kyoto, Japan. Countries included in Annex B of the Protocol (most OECD countries, including the UK, and countries with economies in transition) agreed to reduce their collective anthropogenic greenhouse gas emissions by at least 5% below 1990 by 2008 to 2012. The Kyoto Protocol entered into force on the 16th February 2005.

The Kyoto Protocol makes provision for climate change mitigation in a number of ways;

- International emissions trading between Annex I countries (Parties include the industrialized countries that were members of the OECD in 1992, plus countries with economies in transition).
- Clean Development Mechanism: Annex I countries implement projects in non-Annex I countries that reduce emissions and use the resulting certified emission reductions (CERs) to help meet their own targets.
- Joint Implementation: Annex I countries implement projects that reduces emissions or increases removals by sinks in the territory of another Annex I country and count the resulting emission reduction units (ERUs) against its own target.

The European Commission negotiates on climate change as a single unit. The EU15 agreed 8% reduction in GHG emissions relative to 1990 levels by 2012 has been shared between the member states in a Burden Sharing Agreement. Analysis from the European Environment Agency shows that the EU15 is 2.3 percentage points away from a hypothetical linear path between 1990 and the 2008 to 2012 target. What it also shows is that some countries are doing better than others: Spain still has a long way to go to reach its target, whereas the UK and Sweden appear on track to meet their commitment.

The UK submitted its climate change progress report to the European Commission, and to UNFCCC in March 2006. The report shows that UK greenhouse gas emissions were 14.6 percent below base year levels in 2004; under its Kyoto Protocol target of 12.5%. However, this does not imply that there is room for complacency in the UK; GHG emissions have been rising annually for the last three years (Prof. David Read, Vice-president of the Royal Society, quoted in Connor 2006).

EU Climate Change Programme

The first phase of the European Climate Change Programme (ECCP) was launched in 2000 with a goal to identify and develop all the necessary elements of an EU strategy to implement the Kyoto Protocol. In the first report (ECCP, 2001), forty-two measures to reduce GHG emissions were proposed covering emissions trading, energy efficiency, renewable energy, transport and industrial processes.

One of the most important and innovative initiatives to come out of the ECCP is the EU Emissions Trading Scheme (EU ETS), which at present covers carbon dioxide emissions from some 11,500 large emitters in the power generation and manufacturing sectors. It began on 1st January 2005 and has been described as “the cornerstone of policies designed to achieve the targets of the Kyoto agreement” (Haar and Haar, 2005; 1). The aim of the EU ETS is to reduce emissions cost-effectively by facilitating the trading of allowances between installations, such that allowances flow to their highest valued use.

Activities of combustion installations with a rated thermal input exceeding 20 megawatts are covered by the EU ETS with the exception of hazardous or municipal waste incinerators. However, where the primary purpose of a municipal waste installation is to produce energy from a waste-derived fuel, as in the case of municipal waste EfW plants, it is covered by the scheme. This presents both a threat and opportunity to the development of EfW plants. Coverage by the ETS could represent a threat in terms of increased costs associated with buying permits and administration of the scheme but for installations emitting less than their permit allocation there is opportunity to make money by selling excess permits.

5.2 National

UK Climate Change Programme

EU climate change legislation is transposed into UK policy through the UK Climate Change Programme (CCP). The first UK CCP was launched in 2000 (DETR, 2000) and was updated in 2006 (Defra, 2006).

Under the EU Burden Sharing Agreement the UK has a target of a 12.5% reduction in GHG emissions relative to 1990 levels by 2008 to 2012. In addition to this, the UK has adopted a more challenging target of a 20% reduction by 2020 (DETR, 2000) and aspires to a 60% reduction by 2050 (DTI, 2003). A number of policy and legislative instruments to address these targets are brought together in the UK CCP. These include:

- Climate Change Levy (CCL) – a levy on business use of energy set at a different rate for each type of fuel used. Discounts of up to 80% are available to energy intensive industries that enter into energy efficiency or emission reduction targets (known as Climate Change Agreements).
- Renewables Obligation (RO) – a market mechanism to increase installation of renewable energy such that 10% of grid-generated energy is provided by renewable energy by 2010.
- UK Emissions Trading Scheme (UK ETS) – a domestic ETS that pre-dated the wider EU scheme. Now finished.
- Voluntary Agreements (VA) package in the transport sector.
- Reform of company car taxation and graduated Vehicle Excise Duty (VED).
- Renewable Transport Fuel Obligation (RTFO) – requirement that transport fuel suppliers ensure that 5% of their road fuel sales are from a renewable source by 2010-11. The target may be increased after 2010 based on the EU Renewable Energy Directive which sets a target of 10% of transport fuel to be derived from renewable sources by 2020.
- Energy Efficiency Commitment (EEC) – electricity and gas suppliers are required to achieve targets for the promotion of improvements in domestic energy efficiency.

UK Sustainable Development Strategy

The UK Strategy for Sustainable Development (Defra, 2005) aims to enable people to satisfy their basic needs and enjoy a better quality of life without compromising the quality of life of future generations. There are four agreed priorities of which one is climate change. In addition to the measures already described under other policies, the Strategy includes measures to:

- Engage in discussion at an international level on further engagement of all Parties to the UNFCCC on post 2012 action to reduce GHG emissions;
- Press for the inclusion of intra-EU air services in the EU ETS from 2008 or as soon as possible thereafter;
- Launch the Climate Change Communication Initiative with funding of £12 million over the period 2005 – 2008

Draft Climate Change Bill

The draft Climate Change Bill intends to provide a legal framework for a move towards a low carbon economy. The Bill will put into statute the UK's targets to reduce carbon dioxide emissions through domestic and international action by 60% (relative to 1990 levels) by 2050. In the medium term it proposes a target of a 26-32% reduction by 2020. The Bill focuses on carbon dioxide. Whilst it is recognised that other GHGs play an important part in global warming, the Government argues that carbon dioxide is the most significant in terms of volumes emitted.

In addition to the two carbon dioxide reduction targets, the Bill proposes a system of carbon budgeting based on five year periods. The carbon budget will set a limit on emissions within a five year period. The Bill would place a legal duty on the Government to ensure that the UK meets its targets and stays within the limits of its carbon budgets.

The draft Climate Change Bill proposes creating an independent Committee on Climate Change. The Committee will advise on the level of carbon budgets, the costs and benefits of achieving such budgets, the balance between domestic and overseas action, the use of banking and borrowing and any other advice on climate change deemed necessary by the Government. The Committee will also be responsible for reporting the UK's progress towards its targets and budgets. Reporting will be annual and will go before Parliament. Every five years, the Government should make a statement to Parliament to state whether the budget was met. The Committee will then assess the validity of the statement.

A key element of the Bill is the creation of new powers to introduce new policies to help stay within carbon budgets and meet targets. There is a presumption towards the use of trading schemes in the Bill and the Government is proposing to take enabling powers to make it easier to implement new schemes as well as consolidate and extend existing schemes more easily. These powers will avoid the need for more primary or secondary legislation to introduce trading schemes.

5.3 Regional

Whilst there is no Regional climate change mitigation strategy, there are polices concerned with greenhouse gas emissions reduction included in a number of other regional polices. The East Midlands Regional Environmental Strategy, prepared by EMRA (EMRA, 2002), is a response to the four sustainable development objectives set out in the Integrated Regional Strategy (IRS). The IRS is the Sustainable Development Strategy for the region, developed by EMRA to ensure that policies and strategies in the region are compatible and more sustainable. Policies for the East Midlands Environment are split into five components: People and Heritage; Air; Land and Land Use; Water; and Natural Heritage. Climate change is a theme that cuts across all the policy areas and there are many policies that directly or indirectly relate to mitigation, see Box 5.1. The Strategy also recognises that climate change may bring opportunities to the region.

The East Midlands Regional Energy Strategy is based on the seventeen policies set out in the Regional Energy Policy (EMRA, 2004) and has been developed within the framework of the IRS. The Framework for Action identifies seven priorities and groups them under three work strands: Energy for Communities; Energy for Enterprise; and Communicating the Energy Challenge. Each of the seven priorities addresses one or more of the seventeen policies set out in the Regional Energy Policy (EMRA, 2004). Responsibility for each work strand is assigned to a regional stakeholder.

The Regional Spatial Strategy (RSS) provides a broad development strategy for the East Midlands up to 2021. There are 10 Regional Core Objectives of which one is focused on climate change mitigation through “the prudent use of resources, in particular through patterns of development and transport that make efficient and effective use of existing infrastructure, optimise waste minimisation, reduce overall energy use and maximise the role of renewable energy generation“ (GOEM 2005). The policies are split into regional and sector specific categories. There are many policies contained within the RSS that affect mitigation, see Box 5.1.

The Regional Transport Strategy is incorporated into the Regional Spatial Strategy for the East Midlands (GOEM, 2005). Similarly to transport policy at the national level, there are some policies which have a negative effect on GHG emissions but overall there is a stronger presumption towards modal shift and sustainable development. Policies have been drawn up that affect the whole region but there are also some geographically specific policies relating to each of the sub-areas identified in the RSS.

Box 5.1 Extracts from regional strategies concerned with climate change mitigation and waste

Regional Environmental Strategy

- ENV 6 - minimise greenhouse gas emissions when adapting to the challenges and taking up the opportunities which climate change will bring
- ENV 8 - support the implementation of energy efficiency and renewable energy schemes to at least the level of the targets set out in the Regional Planning Guidance
- ENV 16 - promote and support sustainable waste management practices and minimise the impact of waste on the environment

Regional Energy Strategy

- ENG 1 - ensure that greenhouse gas emissions are significantly reduced to protect the Region from future impacts of climate change
- ENG 4 - encourage people and communities to reduce the impact that their use of energy has on their local and global environment, particularly in relation to climate change
- ENG 6 - promote and support the improvement in energy efficiency as a means of improving the condition of homes and health
- ENG 10 - ensure that an increasing amount of the electricity used is generated from renewable sources
- ENG 11 - promote and support a growing market in renewable energy electricity generation
- ENG 13 - encourage the uptake of domestic and small scale community owned or run renewable energy schemes
- ENG 16 - support the energy generation and supply industries within the East Midlands and promote a shift to a low carbon economy

6. Techniques/technologies for reducing waste

6.1 Waste hierarchy

The waste hierarchy identifies waste disposal options and ranks them in terms of preferred approach. Drawing on the precautionary principle, the waste hierarchy prioritises the prevention and reduction of waste, then its reuse and recycling and lastly the optimisation of its final disposal. The waste hierarchy was first introduced into European waste policy in the European Union's Waste Framework Directive of 1975 and now forms the cornerstone of international and national waste policy.

The preferred approach to dealing with waste in the waste hierarchy is to reduce the amount generated. The government has implemented a number of initiatives aimed at reducing waste in the industrial and commercial sector, for example the Business Resource Efficiency and Waste (BREW) programme and from individual consumers through the Waste and Resources Action Plan (WRAP).

However, waste reduction is not going to reduce waste arisings to zero. Therefore the second tier of the waste hierarchy encourages the re-use of goods. The re-use of products or materials that would otherwise become waste can provide a range of social, economic and environmental benefits. This is an area where the voluntary and community waste sector is currently leading the way through initiatives such as Freecycle and charity shops. In the East of England and Yorkshire and Humber regions, there is a waste exchange service

The third tier in the waste hierarchy is recycling and composting. Whilst reducing the amount of waste going to landfill, recycling materials can help reduce carbon emissions by avoiding the need to extract and refine raw materials. For example, recycling 1kg of aluminum cans avoid the emissions of up to 11kg of carbon as 75% less energy is needed to make items from recycled steel than it does from new steel (ZSL, 2007). The rate of recycling in the UK has been increasing in recent years. The amount of household waste recycled between 1983/84 and 2005/06 increased from 3kg per person per year (or less than 1%) to 135kg per person per year (or 26%) (Defra 2007). The region with the highest household recycling/composting rate in England in 2006/07 was the East with 38.3 per cent. This is followed by the South West with 37.2 per cent and the East Midlands with 35.6 per cent (Defra 2007).

There are now a number of alternative technologies available which use waste to generate energy and secondary products. Energy from Waste (EfW) refers to a process whereby energy is derived from the burning of waste. The combustion process produces high-pressure steam that can be converted to electrical power by the use of a turbine and generator. EfW plants can also be used to supply heat in Combined Heat and Power (CHP) plants. This reduces the demand for electricity generated by fossil fuels, thus reducing greenhouse gas emissions. There are a number of EfW technologies that can be used to generate electricity, including;

- Anaerobic digestion: organic waste decomposes in a sealed vessel, methane is collected and used as a high energy fuel. CO_2 is still produced as a result of burning methane but it is a less potent greenhouse gas.
- Pyrolysis: medium temperature (300ºC to 800ºC) thermal process which breaks down organic based materials under the action of heat in the absence of oxygen. A pyrolysis oil or combustible gas is produced which can be used as a fuel for generating electricity.
- Gasification: higher temperature (800-1200ºC) thermal process in the presence of oxygen. Outputs include a combustible gas containing carbon monoxide and hydrogen which can be used as an electricity generating fuel.
- Mechanical and Biological Treatment (MBT): mechanical sorting of mixed waste stream before biological treatment of the organic fraction. Combustible materials (e.g. paper and some plastics) are separated and used as a fuel whilst other recyclable materials are also removed for re-use.

Energy recovery allows value to be recovered from waste that would otherwise have been disposed of via landfill or incineration. Recovering value from waste includes recycling, composting, incineration with energy recovery and Refuse Derived Fuel manufacture. The West Midlands has the highest municipal recovery rate of 58.4 per cent. The East Midlands has a recovery rate of 41.2% (Defra 2007).

An example of an energy recovery facility in the East Midlands is a MBT plant owned by Biffa plc in Leicester. The city has a population of 330,000, generating just under 160,000 tonnes of waste each year of which 60,000 tonnes is directly recycled from kerbside or civic amenity sites. The waste passes through a mill which reduces and homogenises the material. The homogenised waste then passes through trommels, magnets, eddy currents and screens to create 20,000 tonnes of rejects to landfill and 40,000 tonnes of organic rich solids. The organic solids pass to an integrated anaerobic digester that generates 8,000 tonnes of methane which is then burnt in gas engines to produce 1.5 megawatts of electricity. Heat is re-circulated, while residues are used as a soil conditioner in reforestation and coal mine renewal projects.

Traditionally waste in the UK has been disposed of via landfill or incineration. This is unsustainable in the long term for a number of reasons including pressure on land and negative environmental impacts. It is thus regarded as the last resort for waste disposal in the waste hierarchy. Under the European Landfill Directive, England has a binding obligation to reduce the amount of biodegradable municipal waste diverted to landfill to 75 per cent of that produced in 1995 by 2010; by 2013 this is reduced to 50 per cent and by 2020 to 35 per cent. Currently the majority of waste is sent to landfill (63% in 2003) and it has been estimated that the Region has 10 years worth of landfill capacity remaining (emra 2006). However, the amount of waste going to landfill in the region is dropping; in 2004/05 6.4 million tonnes of waste was deposited at landfill sites in the East Midlands compared with 9.3 million tonnes in 2000/1, a fall of around 30%.

6.2 Costs/benefits

There are economic costs and benefits associated with the different options for waste treatment. Reduction of waste and re-use of products generate significant environmental benefits in terms of landfill and greenhouse gas emission reductions at low or no cost, making it a particularly cost effective option for dealing with waste. Re-using products has the additional benefit that demand for new raw-materials and processing is reduced.

The main economic costs of recycling and composting schemes are associated with the collection, sorting and processing of recyclable materials. WRAP has analysed the costs of different types of kerbside recycling and found that kerbside sort schemes (where different types of materials such as glass and plastic bottles are put into separate compartments of a collection vehicle) are more cost effective for Local Authorities than single stream co-mingled (where everything goes into one vehicle and is then sorted at a materials recovery facility (MRF)) (WRAP 2008) (see Table 6.1).

Economic benefit can be derived from recycling due to the revenue gained from the sale of the collected materials (this is included in the net recycling cost figure in Table 6.1). The difference between the collection only and net costs of recycling is due to the inclusion of the revenue gained from the sale of recyclables and the costs of sorting (for co-mingled streams). Indicative values for recyclable materials used in the WRAP report are as follows (WRAP 2008);

- Clear glass £29/tonne
- Brown glass £25/tonne
- Green glass £19/tonne
- Mixed glass £16/tonne
- Plastic bottles (mixed polymers) £110/tonne
- Mixed cans £142/tonne
- News and Magazines £68/tonne
- Textiles £110/tonne

It can be seen from Table 6.1 that kerbside collection is the most cost effective as sorting costs are low. In this case, the revenue gained from the sale of collected material and low sorting costs reduces the net recycling costs significantly. In the case of co-mingled waste, the sorting costs are much higher and increase the net recycling costs.

Table 6.1 Costs of recycling

Collection method	Collection costs[1] (£/tonne)	Net recycling costs[2] (£/tonne)
Kerbside sort (urban)	107.97	52.24
Single stream co-mingled	83.99	110.95
Double stream co-mingled	77.79	70.79

1 cost of collecting recyclables prior to any Material Recovery Facility (MRF) gate fees or bulking costs being added or income from the sale of recyclables deducted

2 cost of collecting recyclables plus bulking costs and MRF gate fees less any income from the sale of recyclables

The majority of energy recovery facilities have similar sources of revenues and costs, see Table 6.2 below. The relative importance of these sources of revenues and costs will depend on the technology used and the size of the plant although the costs are usually evenly split between capital and operating items (Ilex 2005). For energy recovery facilities, the revenue is dominated by the gate fee even if the plant is eligible for Renewable Obligation Certificates (ROCs). However, energy sales and ROCs become more proportionally more significant as the plant size increases.

Table 6.2 Revenue and costs sources for EfW plants

Revenue	Costs	
	Capital	Operational
Gate fee levied on each tonne of MSW (including avoided costs such as Landfill Tax) Value of recyclable products recovered Value of energy recovered ROCs Levy Exemption Certificates	Planning Plant Land	Labour Consumables (e.g. energy) Maintenance Cost of disposing of residuals (e.g. bottom ash)

The environmental benefits of energy recovery derive from the reduction in greenhouse gas emissions associated with landfill but also the emissions avoided from burning fossil fuels to generate energy. The relative net CO_2 emissions for different waste management options do not always favour EfW. The climate change mitigation benefits of EfW depend largely on the source of electricity being replaced. Currently, the most polluting (in terms of GHG emissions) electricity source is coal, followed by natural gas (Parliamentary Office of Science and Technology 2006). Replacing these electricity sources with EfW may have a positive impact on GHG emissions. EfW schemes have additional benefits, including assisting in meeting the Government's commitment to diversify energy sources.

There are a number of environmental costs associated with energy recovery. Contaminated water is a by-product of the flue gas cleaning process. This has to be treated by an onsite treatment plant before the water is permitted to be discharged to the foul sewer. There is also a number of air pollution issues associated with incineration: smells and odours, acid gases, heavy metals, particulates and organic compounds.

Public acceptability is a major constraint to the delivery of EfW. There is often considerable concern over air quality and public health issues and many schemes have met resistance with the public in many places yet to be convinced of the safety of incinerators.

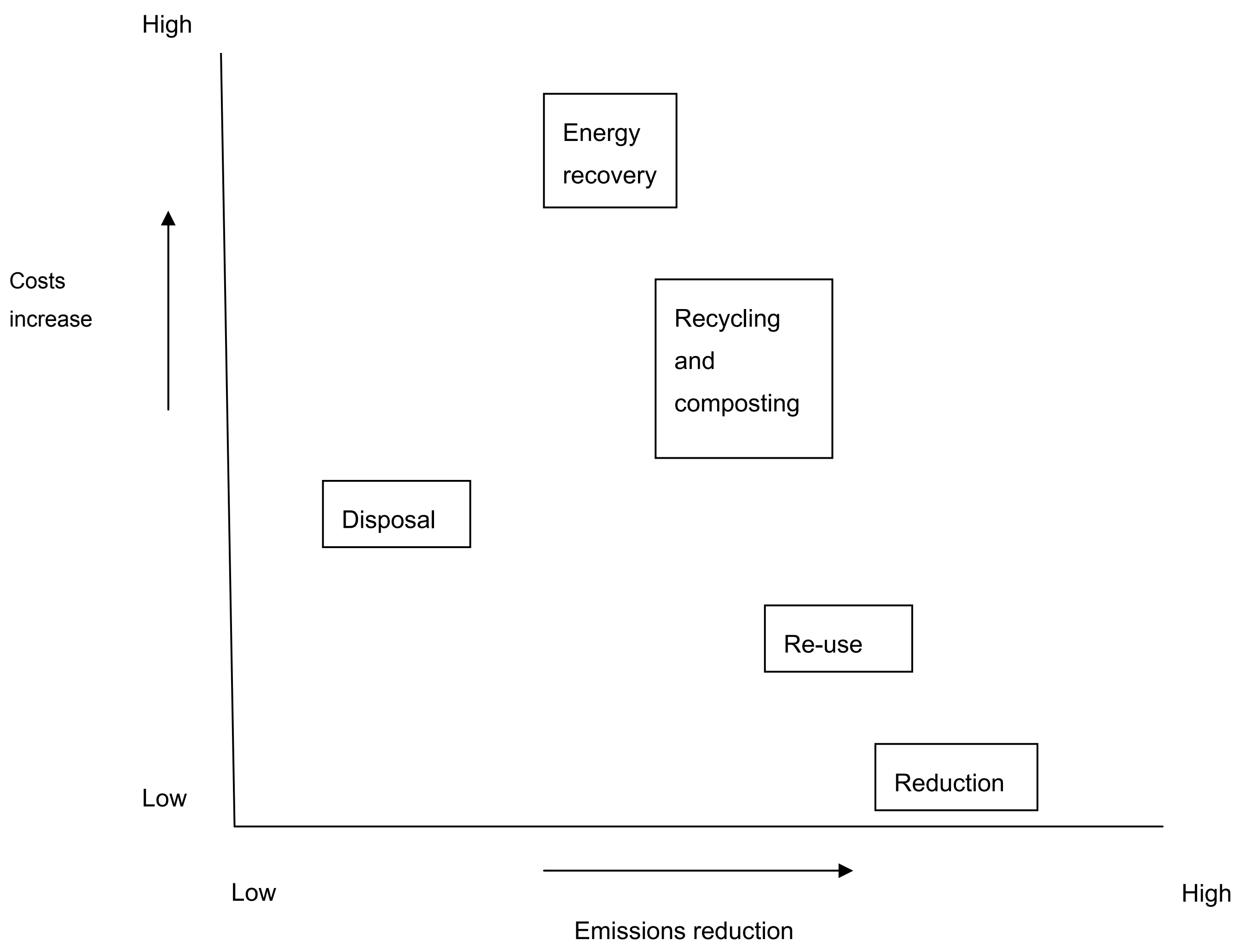
There may be technical limitations that affect the choice to switch to EfW technologies. The efficiency of producing electricity is limited by the use of a steam cycle in the same way as all other fuels. To fully exploit the energy potential of waste requires the selection of the right mix of technologies at an appropriate scale to allow full use of the heat produced (Environment Agency 2007). Generating and supplying heat alongside electricity improves the efficiency of a facility. Recovering heat from electricity generating plant allows for increased carbon savings through displacement of energy otherwise used for heat or steam production as well as the carbon avoided form conventional power generation. It has been estimated that EfW with CHP will produce additional carbon savings of between 120 and 380 kg CO_2 per Mega Watt hour (MWh) of heat produced (Ilex 2005) when compared to electricity only EfW plants.

Traditionally, landfill or incineration was the cheapest option for waste disposal. However, with landfill space running out and as the landfill tax rises, this option becomes uneconomical. Traditional disposal techniques are also associated with high environmental costs including greenhouse gas emissions, water and air pollution.

6.4 Cost effectiveness in terms of emissions reduction

There are different costs and levels of emissions reductions associated with the various techniques of dealing with waste (see Figure 6.1). The most cost efficient way of reducing emissions is to reduce the amount of waste generated and by re-using products. These techniques are no or low cost and are likely to deliver significant emissions savings.

Figure 6.1 Cost-effectiveness of waste management methods with respect to GHG emissions



Techniques involving more complex technology such as recycling and energy recovery will have higher costs associated with them but can deliver significant emissions reductions. The initial costs involved in setting up MRFs or EfW plants are likely to be large. Over the lifetime of the plant, these set-up costs are likely to be offset by landfill costs avoided, the sale of energy and secondary materials and the value of emissions reductions achieved (measured using the social cost of carbon).

7. Conclusion and recommendations

7.1 Conclusion

Waste is a significant source of greenhouse gas emissions and its effective management has the potential to contribute towards climate change mitigation. Current waste policies are driven by a need to comply with regulations including the Landfill Directive, the WEEE Regulations, Packaging Regulations and Hazardous Waste Regulations. Climate change mitigation is not currently a primary driver of waste policy but may be seen as a secondary benefit of complying with regulations. Climate change mitigation policy represents an opportunity for waste reduction in the East Midlands and provides an additional driver for meeting the region's waste targets.

The most significant waste and emissions reductions are likely to be realised if climate mitigation and waste polices are more closely coupled. Climate change mitigation could equally be seen as a driver of waste policy although this is not acknowledged in the Regional Waste Strategy. By failing to recognise the importance of climate change mitigation in waste management, emda is missing a significant opportunity to reduce the Region's greenhouse gas emissions. It is recommended that the Regional Waste Strategy takes a similar approach to climate change mitigation and waste as the National Waste Strategy i.e. explicitly recognising the link between waste and greenhouse gas emissions and the potential reductions that can be realised from the sector.

There is scope to increase the amount of re-use of products, preventing them from becoming waste. Currently this sector is dominated by voluntary and community schemes such as charity shops or websites. There is scope for emda in partnership with local authorities to investigate the feasibility of more formal re-use schemes such as the materials exchange service in the East of England and Yorkshire and the Humber.

The Regional Waste Strategy contains policies and targets to increase the amount of recycling in the region. As recycling rates in the region are already relatively high, it may be prudent to focus resources on encouraging recycling of non-usual recyclables including batteries, aerosols, textiles and kitchen waste. The feasibility of kerbside textile and kitchen waste collections (as practised elsewhere in the UK) could be investigated. Regional research into the economics of recycling following the WRAP model could be useful to determine the most costs effective way of collecting and sorting recyclables in the East Midlands.

The Regional Waste Strategy fails to recognise the importance of energy recovery schemes in meeting waste management and climate change mitigation objectives. Reference is made to the development of ‘advanced recovery technologies’ and the importance of CHP over traditional electricity only plants is recognised but there are no policies which directly encourage the development of EfW in the Region. Explicit reference to the role that EfW can play in reducing greenhouse gas emissions needs to be included in the Strategy and a package of incentives similar to that presented in the National Strategy needs to be identified at a regional scale.

There are a number of fuel sources that the Regional Waste Strategy could consider including sewage sludge, poultry litter, wood waste and non-food crops. There is little recognition of the potential to reduce waste streams other than MSW through energy recovery schemes in the East Midlands. By considering the above as fuel and using them to generate electricity rather than sending them to landfill, the overall waste arisings (and methane emissions) of the Region could be significantly reduced. As well as climate change mitigation benefits, there are significant economic benefits associated with reclassifying ‘waste’ as ‘fuel’.

There is scope for the Regional Waste Strategy to be linked to other regional strategies in order to realise the potential benefits of waste and emissions reduction; other strategies with a role to play are the Regional Energy Strategy, Regional Environmental Strategy, the Regional Economic Strategy (RES) and the Regional Spatial Strategy. Currently, the treatment of waste in terms of climate change mitigation in these Strategies is fragmented. There appears to be a general consensus that renewable energy is to be encouraged although the Strategies differ in their definition of what constitutes a renewable source. The Regional Spatial Strategy explicitly states that it does not include waste in a list of renewable energy sources yet the Regional Energy Strategy recognises the potential to generate energy in the accompanying text to a policy encouraging renewable energy generation (see Box 5.1). There needs to be a consistent approach to waste management, climate change mitigation and promotion of renewable energy across the Regional Strategies.

Opportunities may also be realised by being an early mover – developing new technologies and expertise in the field of waste disposal may give the region a competitive advantage.

7.2 Recommendations

A number of recommendations for the East Midlands have been made in this case study. These are summarised here:

- Ensure the Regional Waste Strategy explicitly recognises the link between waste and GHG emissions and the potential reductions that can be realised from the sector.
- Reconsider the definition of waste - reclassify waste as fuel.
- Ensure consistency between regional strategies in their treatment of waste and climate change mitigation.
- Investigate the feasibility of more formal re-use schemes such as the materials exchange service.
- Encouraging recycling of non-usual recyclables including batteries, aerosols, textiles and kitchen waste.
- Assess the feasibility of kerbside textile and kitchen waste collections (as practised elsewhere in the UK).
- Undertake research into the economics of recycling following the WRAP model to determine the most costs effective way of collecting and sorting recyclables in the East Midlands.
- Develop a package of incentives for EfW similar to that presented in the National Waste Strategy.
- Carry out analysis to determine the additional waste management capacity required as a result of MKSM using cost benefit analysis to assess the feasibility of energy generation plants to dispose of the municipal waste.
- Extend the Northamptonshire waste study to include energy generation technologies as a means of waste disposal in response to climate change mitigation policies.

Emda's support in climate change mitigation for this sector will help achieve other

Priority Actions set out in the RES including:

- Utilising Renewable Energy Technologies
- Exploiting Low Carbon Technologies
- Energy and Waste Capacity
- Environmental Infrastructure

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Case Study 10 – Tourism

1.0 Introduction and Scope

Tourism is an important industry to the East Midlands, contributing £5.6 billion to the economy in 2006 (EMT, undated). The East Midlands has many areas of interest that make the Region a popular tourist destination, including the Peak District National Park, Sherwood Forest, Lincolnshire coast, Rutland Water, Chatsworth House, several large and vibrant cities and a wide variety of sporting arena. The leisure and tourism industry in the East Midlands is a key employer, providing the equivalent of 95,000 full-time jobs (EMT, undated). The economic importance of the tourism industry in the East Midlands is highlighted in the Regional Economic Strategy, which identifies creative industries, arts, heritage and sport as large and growing sectors in the Region's economy (emda, 2006).

Tourism is closely associated with the weather and climate of a potential destination; thousands of people travel from the UK each year in search of sun and warmer climes. Traditionally, the Mediterranean region has been and continues to be a popular destination, with guaranteed hot weather in the summer holiday season and warm conditions in the shoulder seasons of spring and autumn. However, the onset of climate change will bring rising temperatures and increased likelihood of extreme conditions. This has the potential to deter visitors from the current hot spots in southern Europe, to resorts with cooler summer temperatures further north. Therefore, climate change could result in UK resorts becoming more popular for both domestic and international tourists.

After an overview of tourism in the East Midlands (Section 2), there are two main parts: the first (Section 3) provides a general review of relevant literature, identifies potential climate change impacts in the East Midlands, summarises possible adaptation options and highlights gaps in research and knowledge. The second part (Section 4) focuses on the example of Skegness, a seaside town on the Lincolnshire coast and a popular holiday destination. An analysis of the current and future impacts of climate on the resort is presented, along with possible options for adaptation.

Data on tourism in the East Midlands are available from the UK Tourism Survey (UKTS). However, figures for the Region are only available from the mid-1990s, which therefore hinders the use of regression modelling to identify the significant climatic indicators for tourist behaviour. As a result, this case study is predominantly qualitative and analyses the data available and appropriate literature regarding climate impacts to the Region and similar studies on tourism and climate.

2.0 Tourism in the East Midlands

2.1 Overview

Each year, the East Midlands welcomes around 140 million tourists come to the Region for day trips or overnight stay (see Table 1). However, the East Midlands still only lies 8th out of the nine regions in England in terms of domestic and overseas tourism spend, and 6th out of nine for day visitor spend (EMT, 2005).

Table 1 – Impact of tourism on the East Midlands economy, from the STEAM model (EMT, undated)

Sector	2003	2004	2005	2006
Economic impact of tourism	£5.206bn	£5.216bn	£5.351bn	£5.600bn
Total tourist numbers	139.81m	139.53m	143.51m	142.87m
Number of staying visitor trips, both overseas and domestic	14.81m	15.1m	15.38m	15.87m
Number of staying visitor nights, both overseas and domestic	41.38m	41.59m	42.74m	46.10m
Spend by staying visitors, both overseas and domestic	£1.960bn	£1.985bn	£2.024bn	£2.224bn
Number of day visitor trips	125m	124.4m	128.13m	127.0m
Spend by day visitors	£3.246bn	£3.230bn	£3.327bn	£3.376bn
Employment supported by tourism expenditure – full time equivalents*	94,563	93,635	95,124	95,338

* Full time equivalents (FTEs) – this includes people involved in seasonal and part time work, adjusted as the equivalent as full time work.

Trips by domestic tourists to the Region in 2007 were predominantly from the Yorkshire and Humberside region (15 percent), the East of England (12 percent) and the East Midlands itself (25 percent) (UKTS, 2007b). Fewest tourists travelled from Northern Ireland (less than 1 percent), Scotland (2 percent) and the Northeast (4 percent) (UKTS, 2007b). International tourism brought £365 million to the East Midlands in 2005, at 2.6 percent of the market in the UK; this is one of the lowest of any region in the UK, excluding Wales (£311m), Northern Ireland (£131m) and the northeast (£206m) (ONS, 2006).

The most popular time of year in 2007 for visitors to the East Midlands was during the summer period of July to September, with around a third of all overnight stays in the Region (see Table 2). This was then followed by April to June, October to December and January to March. Traditionally popular periods of tourism are based around the school holidays of summer, Christmas and Easter, which is reflected in these figures. These figures also reflect a tourist industry that isn't confined to a single holiday season. One interesting point is that the greatest visitor spend actually occurs in the April to June quarter and not the main summer holiday period.

Table 2 – Trips to East Midlands by quarter for 2007 (UKTS, 2007b)

	Trips		Nights		Spend	
	million	**%**	**million**	**%**	**£million**	**%**
Jan-Feb-Mar	1.29	17.5	2.96	14.7	163	15.5
Apr-May-Jun	1.98	27.0	5.23	25.9	335	31.8
Jul-Aug-Sep	2.1	28.5	6.84	33.9	301	28.5
Oct-Nov-Dec	1.99	27.0	5.13	25.5	256	24.3

Improvements in transport links and large increases in private car ownership in past decades have made the day trip a more available option. The majority of domestic tourists travel to the East Midlands by car and those travelling by car account for 81 percent of the annual spend by tourists in 2007, compared to just 12 percent by those coming by train and 4 percent by those arriving on scheduled bus or coach tour (UKTS, 2007b). Reliable infrastructure is necessary to allow tourists to visit the Region without difficulty. This includes both the roads to accommodate peak volumes of cars and buses and a reliable and affordable train service to provide a viable and attractive alternative to the car. The reliance on the car for travel to the Region also suggests there will be strong sensitivity to socio-economic factors such as fuel prices.

2.2 Sports, Arts and Culture

Sport is another key attraction in the Region; the East Midlands is home to football stadia such as the Walker Stadium (Leicester City), Pride Park (Derby County) and The City Ground (Nottingham Forest). In the last 5 years, £50 million of investment has been seen in the National Ice Centre, National Water Sports Centre, National Squash Racquets Centre, Rutland Water Sailing Club and Loughborough University (emda, 2006). The East Midlands is also popular for fishing, with over 150,000 fishing licences being bought every year, around thirteen percent of the national total (emda, 2006).

The Region is home to many motorsports in the UK, with Silverstone and Donington Park racing circuits, synonymous with the British Formula 1 Grand Prix and British Motorcycling Grand Prix respectively. Silverstone attracts over 1 million visitors each year, with 120,000 for the Grand Prix weekend (emda, 2006). However, Donington Park has recently been awarded a ten year contract to host the British Grand Prix from 2010. This forms part of a 5-year masterplan for the circuit, which will see around £100 million of investment (BBC, 2008).

Arts and Heritage in the Region are also important for the tourism economy. Nottingham's museums, art galleries and castle, for example, see over 620,000 visitors a year. Other notable attractions include Lincoln's cathedral and castle, Chatsworth House and many market towns including Stamford, Newark and Sleaford. The Tourism Strategy (emda, 2003) highlights Arts in the Region for investment, including plans for a cultural centre in Northampton and a new performing arts space in Leicester. This will add to the Broadway Media and Arts centre in Nottingham and the Visual Arts and Media centre in Derby.

2.3 Targets

In April 2004, East Midlands Tourism (EMT) was established. Funded by emda, EMT was charged with the task of increasing the volume, and improving the competitiveness of tourism in the Region between 2005 and 2008. In February 2005, the EMT published its Corporate Plan for 2005-08; the plan details the EMT vision for tourism in the Region in 2010, including:

- Increasing staying visitor spending by 30% (~£500m).
- Creating 15,000 jobs.
- Increasing inbound tourism spend by £79m and domestic tourism by £153m.

The Corporate Plan has three key desired outcomes, for which it has secured £14 million of funding from emda:

- An increase in visitor spending underpinning new jobs, new businesses and supporting the development of a professional and skilled workforce.
- A considerable increase in the profile of the region, together with its constituent destinations.
- A higher quality experience for both visitors and residents.

3.0 Tourism Implications from a Changing Climate

3.1 Tourism and Climate

Tourism and climate are closely linked; summer travel in Western Europe is driven by seasonal contrast as holidaymakers go in search of guaranteed hot weather and good beaches. This annual movement of people from northern to southern Europe each summer is the largest tourism flow in the world, accounting for one sixth of global tourism in 2000 (EC JRC & IPTS, 2007). According to a study in 2006 by Bigano *et al.*, international tourism is driven by the positive impact of sunny but mild climate and the attraction of coasts, while at the same time tourists are deterred by distance, extreme hot or cold weather, political instability and poverty. Southern Europe is therefore a popular choice for summer tourism, with preferable climate as the dominant driver. In a survey of British tourists in Spain in 2000, those stating that climate was the main reason for their choice of destination was 83 percent for January, February and March; 85 percent for April, May and June; 75 percent for July, August and September, and 71 percent for October, November and December (Belén Gómez Martin, 2005). Southern Europe experiences a maximum daytime temperature of just over 30ºC (Maddison, 2001) and a daily mean temperature of around 21ºC (Lise & Tol, 2002). The Mediterranean Region is an example of a destination with desirable climatic attributes and as a result receives around 100 million tourists per year, who spend an estimated £100 billion annually (EC JRC & IPTS, 2007).

While summer sun is one of the main attractions of southern Europe, heat wave conditions can dissuade visitors. With the onset of climate change, Europe can expect to experience an increase in extreme weather, including periods of very high temperatures, spells of drought and heavy rainfall events. Heat waves, such as those seen in Europe in the summer of 2003 will affect a destination's desirability as a tourist destination. Mediterranean regions may become too hot at the height of summer, with the preferred warm and sunny summer weather instead found in northern Europe (Hanson *et al.*, 2006). Climate change may result in Mediterranean countries becoming more popular in spring and autumn when conditions are cooler. This may have added benefit to the Mediterranean of spreading demand more evenly and preventing extra pressure on water and energy associated with the influx of tourists in summer (Amelung & Viner, 2006).

3.2 Tourism Climatic Index

Recent analyses of tourism and climate have made use of Tourism Climatic Index (TCI) analysis (e.g. Amelung & Viner, 2006). The TCI was originally developed by Mieczkowski (1985) as a process of quantitative evaluation of the impact of climate on tourism. This method analyses the following five climatic indices:

i. Daytime comfort (maximum daily temperature, minimum daily relative humidity);
ii. Daily comfort (mean daily temperature, mean daily relative humidity);
iii. Precipitation (total precipitation);
iv. Sunshine (total hours of sunshine); and

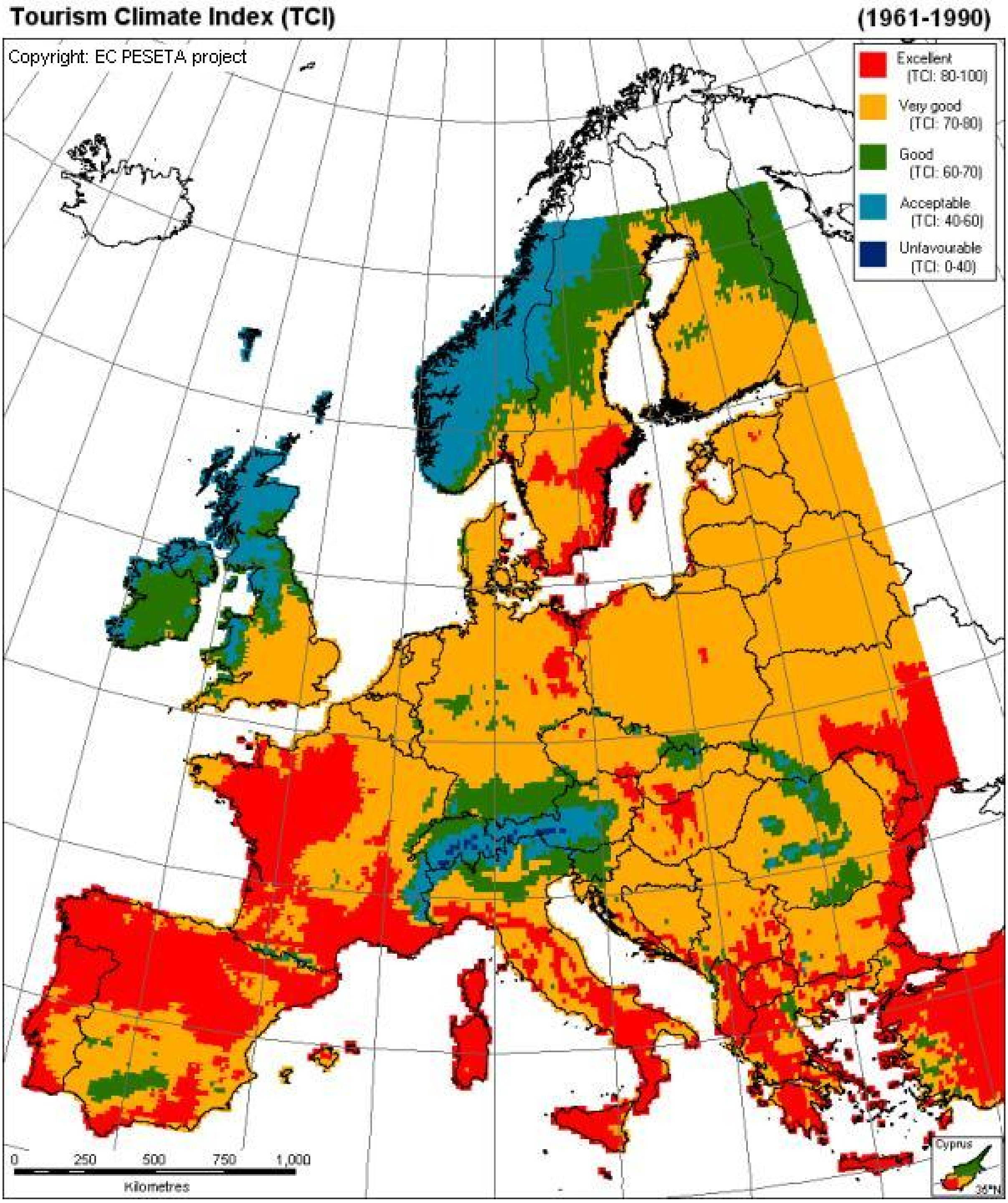
v. Wind (wind speed).

These indices are then combined into a TCI value for each month of the year. A scale of -30 to 100 indicates a destination's suitability for tourism from Ideal (90-100), and Excellent (80-89) to Extremely Unfavourable (10-19) and Impossible (-30 to 9). It is suggested that a score of 70 or higher is considered attractive to the typical tourist. Highest priority in the TCI is placed on maximum daily temperature and minimum daily relative humidity, followed by total precipitation and total hours of sunshine (Amelung & Viner, 2006).

With climate model output, TCI analysis can be used to project how a destination's suitability for tourism changes under differing scenarios of climate change, and an example of this is discussed later. However, TCI analysis is limited in that it only allows for climate variables and takes no account of socio-economic influences on tourist behaviour. Thus its output is with regard only to a destination's suitability to tourism; the popularity of a resort will obviously also depend on other factors such as the attractions it has to offer, the ease of getting there and its cost.

As part of the PESETA project by the European Commission (Projection of Economic impacts of climate change in Sectors of the European Union based on bottom-up Analysis), a TCI analysis was carried out for western Europe. Figure 1 shows the current baseline situation with regarding suitability of climate for summer tourism. It can be seen that, at present, the Mediterranean region, as well as much of southern Europe, is found to have 'excellent' climatic conditions. Much of England, including the East Midlands, is rated as predominantly 'very good' at current conditions.

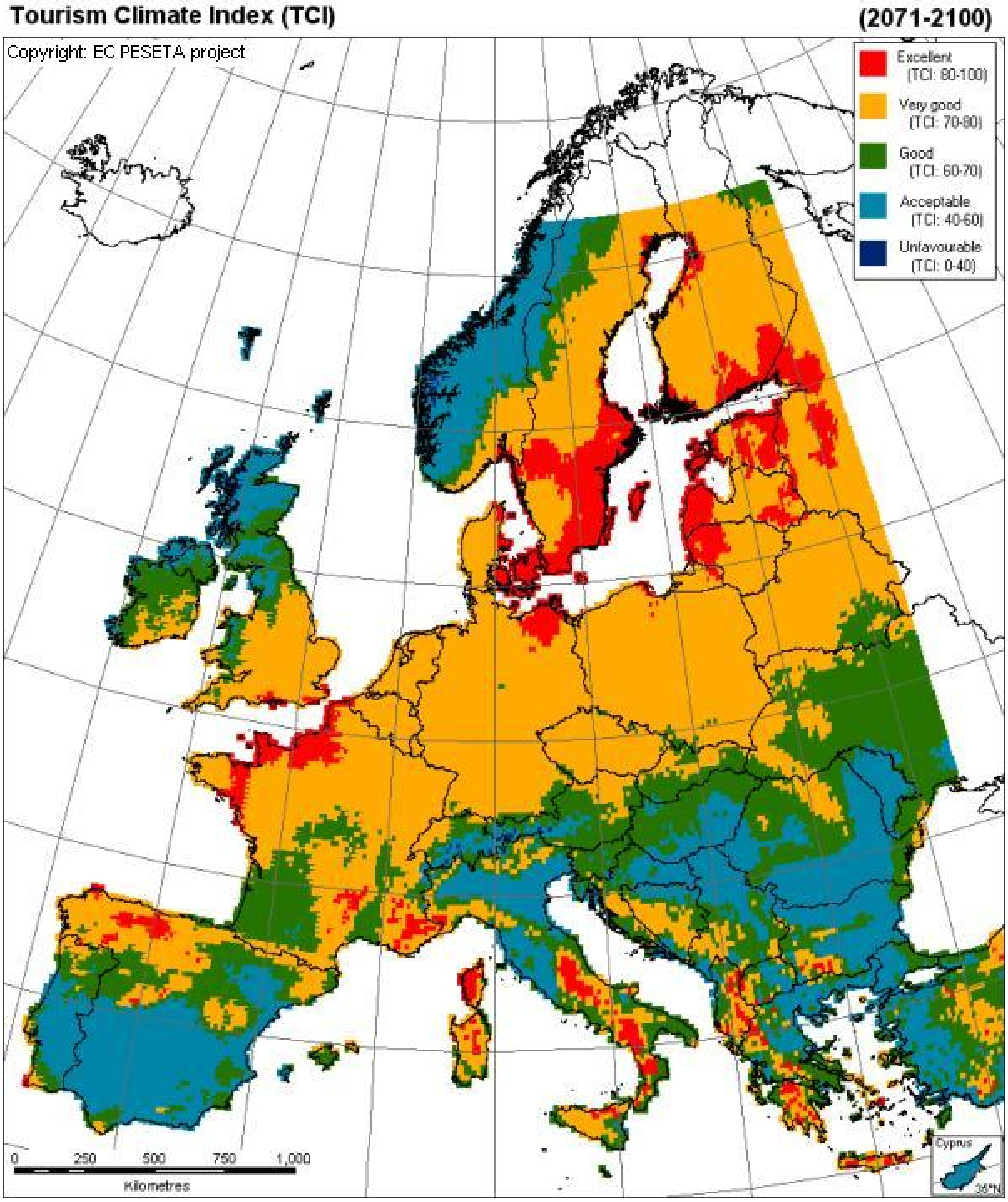
Figure 1 – European Summer TCI 1961-90 (EC JRC & IPTS, 2007)



The TCI was forced by the A2 SRES scenario; this is one of six emissions scenarios, developed by the Intergovernmental Panel on Climate Change (IPCC). The scenario describes a very heterogeneous world with continuously increasing global population and regionally orientated economic growth that is more fragmented and slower than in other storylines (Nakicenovic *et al*., 2000). It should be noted that the PESETA TCI is based on monthly climate data and therefore does not consider the impact of extreme weather events.

Under the influence of climate change the situation changes markedly for southern Europe. Figure 2 shows that, towards the end of the 21st century, much of the Mediterranean region is no longer as suitable for summer tourists. Southern Spain, for example, registers only as 'acceptable' for tourism. Britain meanwhile, shows an improvement in TCI score, including some areas of the south coast that score as 'excellent'. However, the impact of tourism on Britain will be affected less by its improvement in climate and more by the decline in suitability of the traditional holiday destinations. The overall image of Western Europe in the late 21st century shows very few areas that are classed as 'excellent' and a distinct reduction in 'very good' areas. These areas may no longer continue to offer the preferred summer temperatures, instead becoming too hot in the summer months. Demand may instead shift to northern Europe, which perhaps does not offer the 'excellent' conditions as the Mediterranean does today, but will offer an alternative for those looking for warm weather. Such as move may cause a reversal in current tourist flow, with the shift from southern to northern Europe rather than the opposite that is currently experienced.

Figure 2 – Projected European Summer TCI 2071-2100 (EC JRC & IPTS, 2007)



Such a change would provide an opportunity for domestic resorts to benefit from increasing trade and more substantial visitor spend. Coastal resorts such as Skegness have the potential to gain in this eventuality. A similar study by Amelung and Viner (2006) included a TCI analysis of Blackpool, Lancashire and The Balearic Islands of

Spain for the current conditions and Low and High scenarios of climate change. The study found that while currently the Balearics have a TCI score of over 70 from May to October (peaking at around 90 in June), this score to drops to around 50 for August in the 2050s under the high emissions scenario. The general pattern for the islands show a higher TCI score in the shoulder seasons of spring and autumn and a substantial reduction in score for the peak summer season. In contrast, Blackpool, which has a summer peak of TCI of just below 60, sees a steady improvement in TCI score for all seasons except winter. The study found a peak TCI in July of around 70 in the 2050s even under the low scenario. These results support those found by the PESETA study, but the addition of analysis of the shoulder seasons shows how the traditional holiday periods could change with climate. If the traditional summer resorts are too hot in the summer, then they may become more popular in spring and autumn, this smoothing the peaks of the tourist influx to these areas and easing pressure on transport infrastructure, water resources and energy.

3.3 Tourism motivation

Tourism motivation has been shown to follow two methods of thinking; the first is a behavioural choice of whether to take a holiday or trip, where motivation for tourism is an emotional choice or behavioural 'need' (Gnoth, 1997). Secondly, once the decision to take a holiday has been taken, a cognitive decision is required to select where to go and what activity to pursue. This is a more measured and rational decision-making process, which involves, say, knowledge or past experience of a destination. Weather has been shown to play a pivotal role as motivation in both types of decision. Sunshine has long been ascribed as a pull factor for tourism (Dann, 1981), but good weather may also cause a hedonistic response on short timescales. That is to say, good weather may not just attract holidaymakers, but actually persuade them to make the choice to travel in first place – i.e. a spontaneous decision to take a day trip because it's a warm and sunny day (McCabe, 2000).

However, a study by Lise and Tol (2002) found that choice of activity undertaken whilst on holiday is largely independent of climate; instead, the original destination is chosen because it is suitable for the planned type of activity. This suggests that under future climate change, the destination or time of year of vacations will change to accommodate the preferred activities and not the other way round. Socio-economic factors are again important here as the timing of holidays is currently driven by the occurrence of school holidays during the year.

Tourism behaviour also has a direct impact on efforts for climate change mitigation. Tourism is an energy intensive sector with regard to energy and water use, to the extent that much of the industry is presently unsustainable (Arkell *et al*., 2007). International tourism has an obvious connection with air travel, the pattern of which may change as destinations change favour. Air travel will also be affected by cost; rising fuel prices and possible changes to fuel taxation may make trains and possibly ferries better alternatives. Such changes in pricing may make domestic holiday more attractive for UK residents, thus reducing the air travel demand to the continent. However, in contrast, flights abroad may increase outside of the summer season, and the UK may become a more popular destination for those in southern Europe, seeking more comfortable temperatures during summer. Therefore, in addition to future changes in air travel regulation, it is difficult to predict how air travel may change under future climate change and how it may contribute or counteract mitigation.

3.4 Impacts of Climate Change on Tourism in the East Midlands

Milder winters and warmer year-round temperatures may make outdoor pursuits, such as walking, camping and golf, more attractive. While this brings the benefit of an increase in spending, there is a risk from more erosion and damage to walking tracks and conservation areas. While small increases in temperature may increase visitors in the short term, extreme heat such as the summer of 2003 may discourage outdoor activities. The Peak District National Park, for example, hosts thousands of hikers each year, yet high exposure to heat does not constitute desirable walking conditions.

Urban tourism such as museums, theatres, shops and nightlight will not be affected as substantially as rural and coastal attractions. In the East Midlands, for example, Nottingham, Leicester, Lincoln and Derby are all popular for shopping and nightlife and such pursuits can continue in most non-extreme weather without interruption. However, it should be noted that shopping does not tend to be a popular pursuit in hot weather, therefore, use of air-conditioning may be important.

Table 3 – Potential impacts of climate change on East Midlands Tourism

Climate Change	**Impact**	**Uncertainty**	**Timescale**
Hotter summers	Increase in domestic and international tourism Increase in outdoor activities Increase in beach visits and water pursuits Increased demand on tourism infrastructure Increased demand on natural attractions	Low	Medium
Increase risk of summer heat-waves	Heat wave conditions may deter walkers, etc	Medium	Medium
Drier summers	Increase in outdoor pursuits Increased pressure on water resources Potential restrictions on water-related pursuits	Medium	Medium
Milder winters	Opportunities for year-round tourism Increase in outdoor pursuits	Low	Medium
Wetter winters	Threat to outdoor activities Risk to outdoor sports, could cause cancellation of events Increased demand for weather-proof sporting facilities	Low	Short

Reduced soil moisture	Increased erosion from walkers and associated damage to tracks	Medium	Medium
Sea level rise	Increased threat of coastal flooding and erosion of beaches Risk of coastal squeeze reducing beach size Risk of damage to sea side resorts and infrastructure	Medium	Long
Increased storminess	Increased risk of damage to tourism infrastructure Increased risk of storm surges on the Lincolnshire coast	Medium -High	Medium
Changing Seasonality	Potential reduction in reliable tourist numbers as traditional tourism seasons become less well defined.	Medium	Long

3.4 International Actions

In October 2007, the United Nations (UN) hosted the Second International Conference on Tourism and Climate Change in Davos, Switzerland. The conference brought together a number of UN agencies with 450 delegates from over 80 countries from international organisations, the private sector, NGOs and the media (UNEP & UNWTO, 2007).The outcome of this conference was the 'Davos Declaration', a short document calling for a number of actions on climate change from Governments, the tourism industry, research establishments and consumers themselves.

The Davos Declaration calls for the following actions for the tourist industry and tourism destinations (UNEP & UNWTO, 2007):

- Take leadership in implementing concrete measures (such as incentives) in order to mitigate climate change throughout the tourism value chain and to reduce risk to travellers, operators and infrastructure due to dynamic climate variability and shift.

- Establish targets and indicators to monitor progress.
- Promote and undertake investments in energy-efficiency tourism programmes and use of renewable energy resources, with the aim of reducing the carbon footprint of the entire tourism sector.
- Integrate tourism in the formulation and implementation of regional, national and local level adaptation and mitigation strategies and implementation plans. The Nairobi Work Programme on Impacts, Vulnerability and Adaptation to Climate Change, coordinated by UNFCCC, represents an important opportunity for the tourism sector to enhance knowledge, increase capacities and stimulate action.
- Strive to conserve biodiversity, natural ecosystems and landscapes in ways which strengthen resilience to climate change and ensure a long-term sustainable use of the environmental resource base of tourism - in particular those that serve as “earth lungs” (carbon sinks), sequestering GHGs through forest management and other biological programmes, or that protect coastlines (e.g. mangroves and coral reefs).
- Seek to achieve increasingly carbon free environments by diminishing pollution through design, operations and market responsive mechanisms.
- Implement climate-focused product diversification, to reposition destinations and support systems, as well as to foster all-season supply and demand.
- Raise awareness among customers and staff on climate change impacts and engage them in response processes.

3.5 RDA Actions across the UK

While most other regional development agencies (RDAs) have produced a strategy for tourism, very few have any more than a passing reference to climate change. The following is a brief coverage of the tourism and climate change within the policies and research of other RDAs.

North West Regional Development Agency

- Strategy for Tourism – recognises climate change as part of sustainable development.
- Study on climate change and the visitor economy, based on the UK Climate Impacts Programme (UKCIP) risk and decision-making framework; research into eight issues:

  1. Understanding climate-related visitor response.

2. Exploring visitor response to climate change.

3. Changes in visitor demand under differing socio-economic scenarios.

4. Interaction of climate change and socioeconomic change on regional visitor behaviour.

5. Influence of climate change on environmental capacity.

6. Case study analysis of costed adaptation responses in 'vulnerable' locations.

7. Case study analysis of capacity building in 'less-vulnerable' locations.

8. Interaction with related sectors especially farming, forestry, health and transport.

Research was based on visitor response to climate change under different socio-economic scenarios. Adaptation responses were also identified in case studies of sand dune integrity, moorland wildfires, footpath erosion, and public space in a city centre.

One North East

- Tourism North East Changing the Climate Project – series of seminars for professionals in the tourism industry looking at climate change. Mostly focussed on mitigation rather than adaptation to impacts.
- North East Cycle Tourism Strategy – no reference to climate change.

Yorkshire Forward

- Scoping Study recognises impacts of climate change on tourism (qualitatively).
- Tourism Delivery Structure – no reference to climate change.

East of England Development Agency (EEDA)

- Living with Climate Change in the East of England – identifies that climate change will have an impact on tourism.
- East of England Tourism – no reference to climate change.

Advantage West Midlands

- West Midlands Visitor Economy Strategy – no reference to climate change.

South East of England Development Agency (SEEDA)

- SEEDA largely focused on rural tourism – Rural Tourism in the SE; a Strategy for Future Action – no reference to climate change.
- Rural Tourism Action Plan 2004-2008. Does include some policies relating to public transport and non-car travel but no direct reference to climate change.
- SEERA produced a RSS for Tourism – recognises that climate change is an issue for the tourism sector (praised by SECCP for this in their consultation response).

South West of England Development Agency

- South West Climate Change Impacts Programme – scoping study on climate change impacts on the economic sectors of the Region includes a chapter on tourism and leisure. Identifies impacts, threats and opportunities.
- A leaflet has been produced for tourism businesses identifying how climate change might affect then and what they can do about it.
- A Guide to Sustainable Tourism in the SW has been produced – this includes a checklist for sustainability (but does not explicitly mention climate change).
- The Regional Tourism Strategy to 2015 aims to develop sustainable tourism in the Region. It includes some policies that mitigate CC but little on adaptation. No direct reference to climate change impacts.

London Development Agency

- London's Warming report identifies opportunities and threats form climate change to tourism industry.
- Tourism Vision 2006-2016. Recognises climate change in the 'Objectives' section but only as one of the 4 pillars of sustainable development.
- Tourism Action Plans - do support climate change and tourism related issues as identified by the London Climate Change Agency.

- New initiative called 'Green Tourism for London'. This is an independently-audited accreditation scheme where guesthouses, hotels, attractions and venues can apply for a bronze, silver or gold award regarding the sustainability of their business practices. The aim is also visitors and businesses see the green credentials of a business before booking.

3.6 Adaptation

Adaptation options for tourism in the East Midlands are split between two themes: maximising the opportunities for an increase in visitor numbers, and minimising the negative impacts of climate change, which include direct impacts such as sea level rise and indirect impacts such as pressure on infrastructure.

As described above, climate change is likely to make UK coastal resorts more desirable in the main summer holiday, as well as in the shoulder seasons. However, while the improved weather may encourage both domestic and international tourists to the UK for their holidays, it will still be necessary to attract them to the East Midlands in favour of other UK resorts. Other areas of the Region that offer outdoor activities may also benefit from more favourable weather in the holiday season, including the Peak District National Park, Sherwood Forest and Rutland Water.

For the Region to realise the opportunity that climate change will bring, it must be capable of coping with increased demand. This includes sufficient accommodation in the peak season, and a robust transport infrastructure to provide easy access to the Region. As discussed earlier, private car is the most common transport option for visitors; therefore not only is it important for road links to cope with demand, but decent alternative public transport options should be available. The latter is essential for making tourism in the Region more sustainable by giving alternative options of trains and buses. These alternative options help mitigate traffic congestion and parking problems, and also partially insulate against socio-economic influences such as increasing fuel prices.

Transport solutions could also be incorporated into a programme promoting sustainable tourism, in a similar vein to 'Green Tourism for London'. A scheme such as this could promote the sustainable use of water and energy, as well as recommending alternatives to travelling by car. A robust accreditation and award scheme would provide incentives for businesses to apply, and reassurance to tourists that there is real benefit in choosing sustainable attractions and accommodation.

The increase in visitors may also have an impact on the maintenance of attractions in the Region. The Peak District National Park, for example, would experience increased erosion as a result of more walkers, and the risk of fire may increase; therefore more attention would have to be given to the management of paths, viewpoints and camp sites.

All of the attractions in the Region would benefit from improved marketing. It will be necessary to highlight the desirable aspects of the East Midlands and what the Region has to offer tourists. Scotland, Wales and Ireland, for example, have all experienced success by marketing their natural beauty; the East Midlands can also benefit from this, but has the added attraction of having a drier climate and being more accessible for much of the UK.

3.7 Research Gaps

For a robust quantitative analysis of tourism and climate, it is necessary to have a more substantial baseline of tourism data in the East Midlands. At present, only a small amount of data are available since the mid-1990s on tourist numbers in the Region. To understand fully how tourism varies with climate, it is necessary to be able to build a baseline of daily data not just for the Region as a whole, but for specific resorts and destinations including beaches and visitor attractions. Such data must be available in its raw format, rather than summarised into documents. This would allow tourism data to be used alongside meteorological data for the region, to help discern how visitor patterns alter with the weather, and help predict how these patterns might change on a local scale in the future.

While it is likely that improved weather conditions could make the East Midlands a more desirable location for holidays and day trips, there is not substantial evidence available to confirm this. It is important to be able to analyse tourist's motivation for choosing a destination. Therefore, it is recommended that future tourism surveys ask questions regarding a tourist's motivation for taking their trip, and why they chose that destination. It is also important to find out how important the weather conditions are in their choice and if their holiday choices would alter under climate change. Surveys should also encompass potential visitors e.g. day trippers from within the region.

The combination of a more robust dataset, and tourist opinion on the importance of climatic conditions on their choices, would allow for a much more detailed picture of tourist behaviour. Such information could help drive the tourist industry in the East Midlands in the 21st century, helping to focus on those areas needing investment, marketing or protection.

4.0 Skegness Case Study

4.1 Introduction and Background

Skegness is a popular beach destination in Lincolnshire, rated in the Top 5 holiday resorts in the UK (emda, 2003). Skegness was the 6th and 10th most visited town by UK residents for stays over one night for 2006 and 2007 respectively (UKTS, 2006; UKTS, 2007a). Situated on the East coast of England on the North Sea, Skegness lies just to the North of the Wash and is northeast from Boston on the A52. Skegness draws approximately 7 million visitors every year for day trips and inexpensive seaside breaks. Skegness is also a popular retirement destination. In addition to the six-mile award-winning beach, Skegness has a number of attractions, such as the Natureland Seal Sanctuary and the Water Leisure Park.

Originally a small fishing village, Skegness began to grow substantially with the addition of a rail link in 1873. This provided access to the coast from the Midlands, allowing Skegness to become a day trip resort. By the 1920s, the town was attracting over 450,000 day visitors per year, at times requiring 60 trains a day (BBC, 2003). In 1936 Billy Butlins opened the very first Butlins holiday camp, with which the resort has been synonymous ever since. The popularity of Skegness continued post-war and beyond; indeed, throughout the 1960s and 1970s the number of static caravans in Skegness almost doubled (Skegness-resort, undated). Since this time there has been a number of additions to the tourist attractions in the town, including an indoor swimming pool, the Embassy theatre, Britain's first indoor themed holiday resort 'Fantasy Island' and significant development and expansion of the original Butlins holiday camp (ibid).

For purposes of this case study, the assessment of climate change impacts on Skegness is largely qualitative. While TCI analysis or regression modelling would be suitable, this would require significant quantities of climate and tourism data and processing time and is therefore not within the scope of this short case study.

4.2 Current Tourism Issues

While Skegness is still a popular destination, it is not without its problems, both with regard to the tourist industry itself and inherent problems that are associated with reliance on a seasonal trade. Similar to other coastal areas of the UK, Skegness has endured difficult market conditions and, as stated in the East Midlands Tourism Strategy (emda, 2003): "*...[is] operating in a completely different environment to that which existed in their glory days. The transition has not been kind and has resulted in problems of socio-economic deprivation*."

Predominantly a beach resort, Skegness population numbers vary greatly with seasonal tourist trade. As of the 2001 census, Skegness has almost 19,000 residents (ONS, 2001) yet this number can swell to 250,000 in the peak summer period. This variation in population affects opportunities for full-time employment in the town, and puts pressure on services in peak periods – particularly the health services (Simmonds, 2007).

There are a number of transport issues for visitors to Skegness to contend with; while north-south road links in the East Midlands are generally good, east-west links – such as the A52 from Nottingham and the A158 from Lincoln – are often congested.

The train service connects Skegness to Nottingham in around 2 hours, with approximately 15 trains a day. This is comparable to the equivalent journey by car. At present an adult Saver Return fare from Nottingham to Skegness costs £22.70, and the equivalent child ticket costs £11.35. Families travelling with at least one child can save a third of adult fares and 60 percent of child fares with a Friends & Family railcard (£24 per year). Thus, a family of two adults and two children could make a return journey from Nottingham to Skegness for £38.60 when travelling off peak. However, at current fuel prices, this is still around twice the cost of the petrol for the equivalent journey in a medium-sized family car.

The 2-hour journey time perhaps prevents visitors on day trips by train from as far as Nottingham. However, sufficient local stations are served by the East Midlands line, such as Boston, Sleaford, Spalding and Grantham, that day trips to the coast are possible from much of the Region.

A new railway station, East Midlands Parkway, is planned to open in December 2008 and will serve East Midlands airport. This will provide a rail service between the airport and Nottingham, which should make the East Midlands coast more accessible for tourists arriving by plane.

In general, the transport links suffer with the seasonal nature of demand. Skegness has particular difficulty with roads as it is served by single carriageway roads that get extremely congested on busy days; while rail links to the resort are restricted by insufficient rolling stock to meet peak demand (emda, 2003).

4.3 Social Deprivation

The transition experienced by the resort has left issues of socio-economic deprivation. Figure 3 shows how the most deprived areas are concentrated in the coastal regions of Lincolnshire. Skegness falls within the Coastal Action Zone (CAZ), an area of Lincolnshire coast with high social deprivation, similar to that of inner city areas such as the London Borough of Hackney (CAZ, 2007). The following include examples of the demographic characteristics which contribute to its deprivation (ibid).

- 26 percent of residents are over 65, compared to a national average of 16 percent.
- On average, for every two people aged 18 to 24 who migrate away from the area, three people aged over 60 move in.
- Seasonal migration associated with tourism creates increased demands on the provision of medical social services within the area.
- Unemployment increased by 400 percent between August 2003 and January 2004, reflecting the reliance on the tourist season.

- 50 percent of the residents have no qualifications, compared to a national average of 29 percent.
- Almost 30 percent of residents class themselves as having a limited long-term illness, compared to a national average of 19 percent.

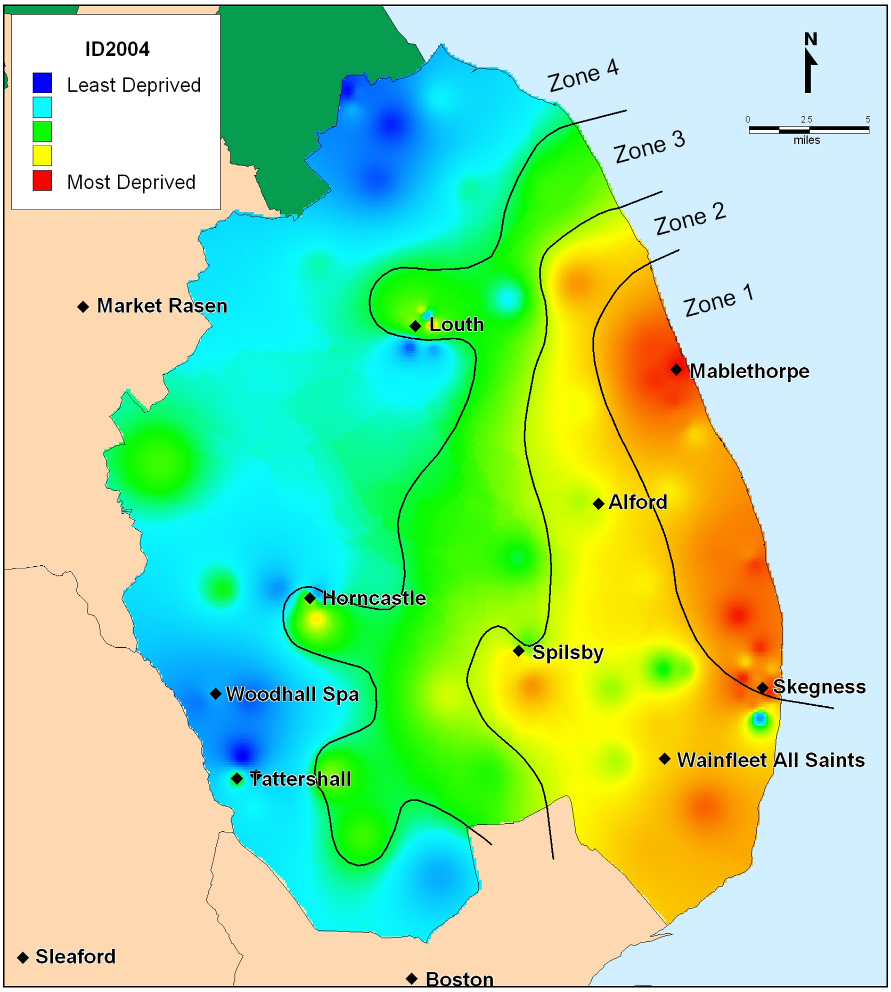
The CAZ Partnership was created to provide recognition for the issues of the zone and help secure innovation and funding for solving these issues. The CAZ was launched in Parliament in December 2004 and this was followed by a local launch in March 2005. Since its inception, the CAZ Partnership has produced an Action Plan for tackling the social deprivation problems identified. The CAZ associates the fundamental challenges of Skegness with those of other coastal resorts, such as Margate, Hastings and Morecambe. These include the following problems:

- Two economies – on and off season;
- Two workforces – summer and all year;
- Two populations – tourists and residents;
- Two landscapes – holiday and natural;
- Two communities – coastal and hinterland.

The Action Plan does not include the issue of climate change; however, this does not prevent it being an issue that needs to be considered for the long-term success of Skegness as a resort.

With high seasonal employment and an influx of people from more deprived areas of the Midlands, there is a high demand for social housing. In addition to this, the East Midlands coast has over 26,000 caravans, many of which are being used as permanent housing. By living in caravans and renting homes in Skegness for the winter months (when the caravan parks are closed), the residents avoid paying council tax (Simmonds, 2007).

Figure 3 – Social Deprivation figures for Lincolnshire Coast. The Indices of Deprivation 2004 contain indicators covering the seven domains of employment, health and disability, income, education skills and training, barriers to housing and services, living environment and crime. The domains are combined into a single overall deprivation score for each of the 32,482 super output areas (SOA) within England CAZ, 2007).



4.4 Climate Change Impacts

As discussed in Section 3, climate change is projected to improve the suitability of British holiday resorts at the expense of traditional destinations such as the

Mediterranean region. As a result, visitor numbers at Skegness may rise through the 21st century, likely to be concentrated in the traditional summer holiday season. However, improved spring and autumn temperatures may also result in a greater number of holidays in the shoulder seasons. It is likely that there will not be any substantial change in the winter season that would cause a change in tourist numbers, particularly as Skegness is largely a beach resort.

While an increasing concentration of holidaymakers in the summer may increase the on/off season dichotomy, increased visitors around Easter and around September and October could help smooth this contrast. Average September temperatures for Skegness in 2006, for example, were the highest since records began in 1659 (Charter & Watson, 2007). There is still much uncertainty regarding the overall impact of climate change on tourist destinations. Some of this is related to other destinations, which may become more favourable in the shoulder months too. Much is related to social factors e.g. the relative cost of travel and the timing of school holidays.

Skegness is also likely to experience an increase in the number of day trips to the resort. With more consistently hot summers under climate change, Skegness is likely to experience an increase in the number of visitors to the beach. This has the potential to increase pressure on the travel routes in and out of the town during weekend and particularly when a Bank Holiday Monday occurs.

In addition to potential benefits of increased visitor numbers, there are a number of risks that climate change presents. In January this year, Andy Baxendale, Area manager for the Environment Agency, made a presentation to the Skegness Town Council on the probable impacts of climate change on the Lincolnshire coast into the 21st century. With rising sea levels and falling land levels ('isostatic rebound'), the net effect will increase the mean sea level by over one metre by 2100. For Skegness' sea defences, the effectiveness of current defences to 1 in 200-year flooding events will be reduced to just 1 in 20-year (Skegness Town Council, 2008). Many of Skegness' attractions are based on the seafront and so are at risk from both sea level rise and storm surges. Skegness' pier, for example, was damaged during storms in 1978, cutting off the pierhead from the shore, which was subsequently dismantled. The existing part of the pier continued to be used and still stands today; it was extended a further 100 metres as part of a £5million development programme, which included a new pierhead (Skegness pier, 2008). The pier at Skegness is still a focal point for tourism on the sea front; further storm damage would not affect just affect businesses on the pier, but surrounding businesses could suffer from loss of associated trade.

Warmer conditions in the summer holiday season may promote a more outdoors lifestyle, increasing the numbers wishing to go camping, walking, cycling, etc. This will put more pressure on areas prone to erosion, such as coastal pathways and the countryside in and around Skegness.

Skegness is served largely by the Spilsby Sandstone aquifer. In the Environment Agency's assessment of water resources in the Anglian Region, this aquifer was classed as fully committed for licensing. The report concludes the following about the status of the aquifer: "*Concerns over sustainability are based on a continuing decline in groundwater levels. Problems are anticipated if abstraction reaches full licensed volumes*" (Environment Agency, 2001). The report show that if all the water was abstracted that was permitted under the current licences, the aquifer would be in deficit. With very hot and dry summers more likely in the 21st century, there will be increasing pressure on Skegness' water at a time of greater peak demands.

4.5 Adaptation

As with the East Midlands as a whole, adaptation for Skegness can be separated between: maximising the opportunities for an increase in visitor numbers, and minimising the negative impacts of climate change.

Marketing will play a key role in attracting visitors to Skegness. At present, seaside locations are not advertised on the East Midlands Tourism website under 'Holiday Ideas' and Skegness does not feature on the site. Skegness is included on the Visit Lincolnshire website, and there are a number of websites dedicated to Skegness and the Lincolnshire coast. Marketing the resort will depend on the target audience and how the resort is to be promoted. Currently, Skegness is promoted, and regarded, as an inexpensive beach resort ideal for families with young children. However, if the resort wishes to change this impression in a bid to attract a wider range of visitors, the marketing efforts will have to reflect this.

Skegness suffers from poor transport links, particularly by road, which become easily congested in the peak season. With the potential for increasing day trip visitors – as well as overnight stays – Skegness has to be accessible for as wide an area as possible, within a suitable journey time. It is therefore essential for the success of the resort to improve the links. Private transport currently favours the car, especially for seaside trips that may require a plethora of accessories such as cool boxes, deck chairs and beach games. However, further fuel price rises may affect this preference for the car, and provide an incentive for train travel. Convenience will also be a factor for train use; therefore, if the service is sufficiently regular, comfortable and affordable, the option becomes more desirable.

In addition to transport infrastructure, it will be necessary to ensure that accommodation is not a limiting factor at peak times. One of the problems of a seasonal trade is the requirement for a carrying capacity to meet demand in the peak periods, which requires stock to be held for the rest of the year. For Skegness, this means that B&Bs, caravan parks and holiday camps such as Butlins will have to keep up a number of beds that will be unused for much of the rest of the year. This places an economic burden on those providing accommodation, but one that is a direct result of seasonal trade.

With the potential increase in tourist numbers in the shoulder seasons there is the opportunity to extend the peak holiday period beyond the traditional summer season. The benefit is that infrastructure and services would be more extensively exploited, which helps reduce the carrying capacity problem associated with seasonal trade

(Gómez Martín, 2005). This would provide increased incentive for investment, providing a higher return for both private and public money.

Any improvements and developments to the sea front must be planned with flood risk taken into account. While this will already be the case, planning regulations may become stricter in response as the quality and reliability of climate change projections improve. For example, 2008 will see the release of the fifth generation of climate impacts scenarios for the UK ('UKCIP08'), which will eventually be incorporated into flood risk requirements by the Environment Agency.

Water resource is also an issue for Anglian Water Services, the provider for Skegness. With aquifers fully committed, there is a potential risk of shortages in peak periods if the full licensed quantity of water is required and water cannot be provided from elsewhere. With heat waves being a strong driver of visitors to the coast, it is likely that the highest periods of demand will occur in the warmer, drier periods of the year. Water resources will also become further stretched if development is planned in the area, which is also possible as a result of increasing tourism demand. The water resource management planning process provides a framework for incorporating climate change and growth impacts, but realistic scenarios are required and adaptation measures may need to be more radical in future.

As Skegness falls within the Lincolnshire coastal region, it will also be included in the current strategy for sustainable development and regeneration to address social inequality, improve the coastal economy and recognise environmental impacts such as climate change. A detailed assessment of the implications of climate change for the Lincolnshire coastal region will be included in a forthcoming project which is being programme managed by Lincolnshire County Council. This two-year project will form a sustainable strategy for adapting to climate change, improving the coastal economy and recognising environmental limits of the region.

Other events have also brought attention to the needs of Skegness. For example, the national conference for *Coastal Futures*, an organisation developed to help communities deal with coastal change, was hosted by the Lincolnshire CAZ and held in Skegness in 2006. Decision-makers in Skegness may also benefit from becoming involved in the *Seaside Network*, an organisation committed to address the challenges of regeneration of seaside communities, as founded by the British Urban Regeneration Association (BURA). The network aims to raise the profile of seaside towns, share knowledge and experiences, and influence policy and practice (BURA, 2008). The group have organised visits and conferences at seaside resorts such as Hastings, Margate, Scarborough, Blackpool and Rhyl.

5.0 Conclusions

Tourism and climate are inextricably linked. For the majority of tourists, the weather plays an important role in choice of destination and activities; indeed, it is that primary driver for the millions that fly to Mediterranean resorts every summer. With the onset of climate change, Europe can expect summers to be hotter and drier with an increased threat of heatwaves. The effect of this may be to deter visitors to the more traditional resorts of southern Europe as summer temperatures are more likely to be uncomfortably high. For the East Midlands, tourism could be an opportunity of climate change, as tourists instead seek relatively cool destinations. For the East Midlands, it is therefore necessary to ensure that it provides a realistic alternative as a holiday destination, and that it is has the capacity to cater for a larger number of tourists.

Skegness in particular has the opportunity to attract an increasing number of holidaymakers and day-trippers. While still a popular seaside resort, Skegness does not receive the number of tourists that it once did at its peak in the mid 20th century. Since that point, Skegness has suffered from the improved accessibility of mainland Europe for the tourists that may have previously stayed in the UK. As a town that relies heavily on summer tourism, it has suffered from the dichotomy of the on-off tourism seasons, and thus from the socio-economic deprivation that accompanies high unemployment and high seasonal migration. However, with an award-winning beach, and a wide range of activities for families, it is well placed for a renaissance. It will important for Skegness to ensure it remains competitive with other UK resorts that vie for both domestic and international tourists. Transport links in particular are essential for domestic demand, where good weather will push many to the coast on weekends – especially Bank Holidays. However, Skegness must also ensure that its core infrastructure and holiday infrastructure has sufficient carrying capacity to accommodate and entertain the tourists it could attract, whilst minimising social and environmental impacts.

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Case Study 11: Boston

Introduction

The Borough of Boston is located in south-east Lincolnshire, (see Figure 1.1), and has a population of 56,000. The Borough is bounded by the Wash on the east, the River Welland on the south-east and the River Witham to the north-west.

Currently, Boston has 7.37% of its population employed in agriculture and associated industries (for comparison the regional percentage is 1.88% and the national percentage is 1.45%). Many of these jobs are low skilled and low paid. The Borough has a lower than average percentage of people employed in managerial or professional occupations and a high percentage employed in routine or semi-routine occupations. There are plans for economic re-generation of parts of Boston, focused on the High Street and town centre area. The aims of re-generation efforts are to broaden the skills base and create jobs in the tourism and service sectors[55].

In order to support economic regeneration, there are plans for housing growth in the Borough. Boston serves a wider hinterland than the urban boundary and has been identified as a sub-regional centre in the draft East Midlands Regional Spatial Strategy (RSS) and Lincolnshire Structure Plan. As a result, a significant number of new homes and employment land provision are planned in the Borough between now and 2021.

Boston is at risk of flooding from a number of sources; tidal, fluvial and pluvial flooding. Tidal flooding occurs when the sea breaches tidal defences due to sea level rise or storm surge. Fluvial flooding refers to river flooding and pluvial flooding occurs when groundwater reaches the surface. The Environment Agency's Flood Map illustrates the area at risk of a 1 in 100 year fluvial flood and a 1 in 200 year tidal event. The Flood Map defines the entire Borough as being within PPS25 Flood Risk Zone 3, i.e. high risk (>0.5% per annum tidal flooding). However, this does not take account of existing defences. Boston Borough Council's Strategic Flood Risk Assessment (SFRA) classified the Borough into three categories of flood risk, taking into account existing flood defences and found that flood risk varied significantly within the Borough. In addition to being in PPS25 Flood Risk Zone 3, according to the SFRA, the town centre area and other parts of the town earmarked for development are in Category 3, high risk. It would appear that the Agency and the Borough Council are in agreement over the level of risk to the town centre but disagree over the response.

Other things being equal, the risk of tidal flooding in Boston will increase with climate change. Global warming will cause expansion of the oceans due to increasing temperatures, which, combined with a melting of land based ice, will result in sea level rise. On the east coast of Britain, the risk of tidal flooding due to sea level rise is compounded by the long term geophysical movement of the British land mass. Following unloading caused by melting of ice at the end of the last ice age, the north

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[55] Boston Borough Council 2006

and west of the British Isles have been rising relative to mean sea level whilst the south and east has been sinking. This means that the relative change in average sea level around the UK will vary, even if sea level rise caused by climate change was uniform. On the south and east coast of the UK, the impact of isostasy will be to increase sea level relative to the land.

At the East Midlands Regional Spatial Strategy (RSS) Examination in Public held between May and July 2007, the Environment Agency expressed concern over the proposed development in Boston due to the increased risk of tidal flooding caused by climate change. The Agency's view is at odds with that of Boston Borough Council (BC) who regards climate change as a future threat that should not constrain present development.

This case study provides an overview of the following key issues:

- Flood risk impacts;
- Benefits of development;
- Adaptation.

The current situation in Boston is presented qualitatively and the relative positions of the Environment Agency and Boston BC are summarised. The case study provides a framework for further quantitative analysis of the disadvantages and advantages associated with future development in Boston.

Figure 1.1 Location of Boston

Current Situation

Population and Economy

At the last census (2001) the population of Boston Borough was recorded as 55,750. Since then the Borough has experienced significant population growth due to in-migration, particularly from Eastern Europe. In 2005, there were 1,600 migrant workers registered under the Workers Registration Scheme (WRS) per 10,000 people of working age within Boston, which of the entire working population equates to approximately 5,500 migrant workers. It is highly unlikely that all migrant workers in the Borough are registered with the WRS and the Borough Council has estimated that there are 10,000 migrant workers employed within Boston[56].

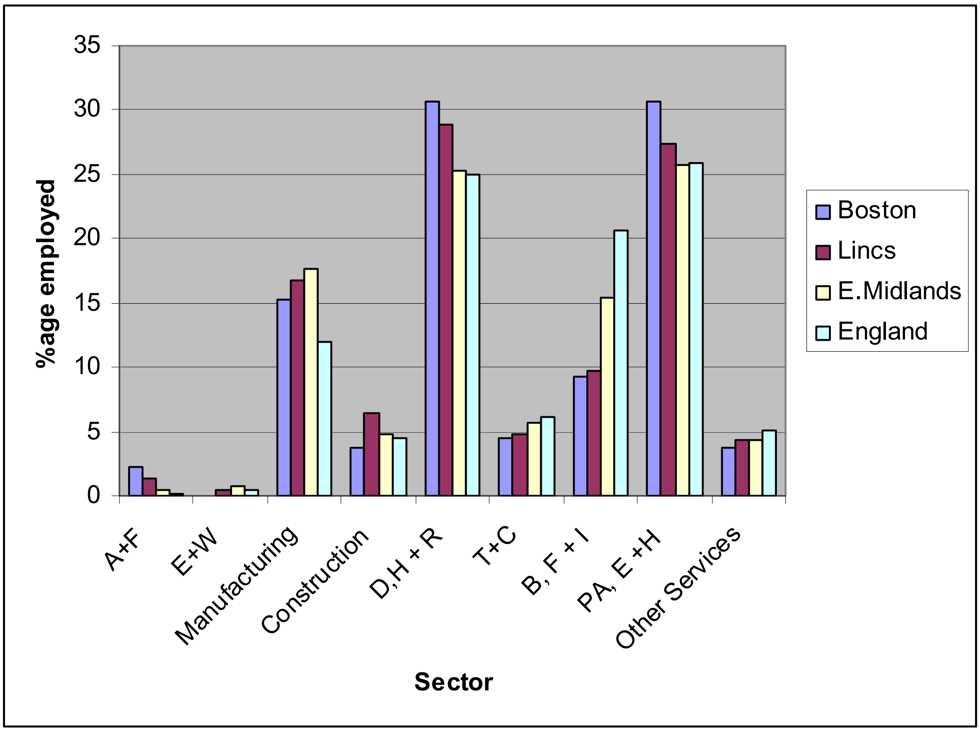
Boston is surrounded by high quality agricultural land which is some of the most productive in the British Isles. As a result, Boston's economy is heavily reliant on agriculture and associated industries (e.g. food and drink processing, packing and distribution). Whilst the Borough does not suffer from high levels of unemployment (the percentage of adults of working age claiming unemployment benefit is 1.7, the UK average is 2.3[57]), the majority of people are employed in low skilled, low wage jobs. The average gross weekly pay in the Borough is £310 which is low in comparison with the national average of £392 (Boston Borough Council 2004). In addition to agriculture and food and drink, retail and the hospital are significant employers in the Borough, (see Figure 2.1). The town of Boston has a deprivation rank within the region of 12 (1 being the most deprived, 40 being the least)[58].

[56] Boston Borough Council 2007

[57] GOEM 2003

[58] Ibid

Figure 2.1 Employment by sector



Key

A+F	Agriculture and Fishing	E+W	Energy and Water
D,H+R	Distribution, Hotels and Restaurants	T+C	Transport and Communications
B,F+I	Banking, Finance and Insurance	PA,E+H	Public Administration, Education and Health

Source ONS

Whilst being far from economically moribund, Boston is in need of economic re-generation. The Borough's Interim Plan[59] aims to '*improve the quality of life in Boston and to raise the profile of the Borough through a promotional approach to appropriate, imaginative, well designed sustainable development'.* The focus of re-generation is diversifying the Borough's skills base and increasing the number of people employed in high-skilled and service jobs[60].

Flood Risk

Sources of flooding

Boston is at risk of flooding from a number of sources: tidal, fluvial and pluvial flooding. Tidal flooding occurs when the sea breaches tidal defences due to sea level rise or storm surge. Fluvial flooding refers to river flooding and pluvial flooding occurs when groundwater reaches the surface. The Environment Agency's Flood Map show the entire Boston Borough categorised as being either fluvial or tidal floodplain and is therefore deemed to be at risk of flooding. The Borough Council have identified a number of primary sources of flooding including:

- Boston Haven (tidal
- The Wash Banks (tidal),
- River Witham (fluvial),
- South Forty Foot Drain (fluvial)[61].

Flood height

There is an additional risk of storm surges in the Wash. With a storm surge superimposed on a normal high tide, peak levels of 6 metres are theoretically possible. Since much of the land surface in the Borough is below 3 metres Ordnance Datum it is at significant risk of severe flooding[62].

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[59] Boston Borough Council 2006

[60] Ibid

[61] Boston Borough Council 2002

[62] Ibid

Current predicted flood levels from the four sources of flooding can be seen in Table 2.1. The return period is the average time between floods of a certain level occurring. The 1 in 100 year return period flood has a 1% chance of occurring in any one year – the odds of it occurring in a given year are 100:1. The 1 in 50 year return period flood has a 2% chance of occurring in any one year. The predicted heights are given in metres above ordnance datum (AOD).

Table 2.1 Current flood heights

Flood source	Return period	Predicted height (2002)
Boston Haven	1 in 100	5.95m AOD
	1 in 200	6.05m AOD
Wash Banks	1 in 200	6.01m AOD
River Witham	1 in 50	4.03m AOD
	1 in 100	4.09m AOD
South Forty Foot Drain	1 in 50	3.00m AOD
	1 in 100	3.03m AOD

Source Boston Borough Council 2002

Current flood defences

The Environment Agency's flood map does not take flood defences into account when displaying areas at risk of flooding but there are a number of flood defence structures that offer Boston some protection from tidal and fluvial flooding.

The town is protected from tidal flooding from the south side of the Haven by a silt ridge and the A16 road embankment. The tidal defences within Boston itself consist largely of concrete or piled structures, either close to the bank of the Haven or set some distance back from it. A survey of the sea defences along the Boston Haven was carried out in 1998/99. All the earth embankments were considered to have a residual asset life of twenty years or more and the hard defences through Boston town had asset lives estimated at between 10 and 50 years.

The Environment Agency has proposed installing a tidal surge barrage on the Haven, downstream of Boston as part of the Boston Combined Strategy. The primary aim of the Strategy is to improve navigation, thereby encouraging recreation and tourism. A secondary impact of the scheme would be increased protection from tidal flooding in Boston.

The Wash Banks are the first line of defence from tidal flooding from the North Sea. The defences consist of large earth embankments along the shores of the Wash, set back from an area of intertidal salt marsh which protects them from erosion by waves. Currently, the Wash Banks defences (6.0m AOD) provide a Standard of Protection (SoP) of 1 in 100 years.

There are a number of lines of secondary defences which have resulted from successive land reclamation projects. Although these may be breached in places, they remain an obstacle to the flow of flood water inland.

Existing flood structures currently protect Boston form flooding of the River Witham. The defences typically comprise steel sheet piling, concrete and masonry walls to as height of between 5.4 and 6m. The discharge of fluvial flows from the River Witham is controlled by Grand Sluice. The fluvial system operates such that fluvial flood flows are not all conveyed to the town of Boston, protecting it from flooding. In addition, the tidal defences in place along the Haven will contain fluvial flood flows far in excess of those passed through Grand Sluice. In times of fluvial and tidal flood conditions, the risk from tidal water level and surge is greater than the fluvial risk[63]

[63] Environment Agency undated

South Forty Foot Drain was constructed in 1636 and receives drainage from a large area of Lincolnshire. Water levels are tightly controlled with the aim of maximising the gravity drainage discharge into the system and providing flood water storage during winter months Black Sluice Strategy Study (2000) identified flood risk along the South Forty Foot catchment. When fluvial flows are high in the South Forty Foot and tidal water levels are high, the Black Sluice pumping station is activated to prevent flooding from South Forty Foot Drain[64].

The Strategic Flood Risk Assessment (SFRA) commissioned by Boston Borough Council presented current flood risk in the Borough, taking account of existing flood defences. It concluded that flood risk varied throughout the Borough and that some areas are more vulnerable than others. Areas at high risk include the town centre, Wainfleet Road, Wyberton Fen and Marsh Lane. New development is proposed in all of these areas.

Development Plans

The Borough Council's Interim Plan[65] sets out future development plans for the Borough. It identifies a number of parcels of land within the Borough for housing and employment land development.

Economic development

There are currently 30 areas of land classed as existing industrial/commercial areas and 5 areas of land that are intended to be developed during the plan period. The total area is 262.61ha. Planning permission will be granted for employment development in these areas subject to plans satisfying all relevant policies of the Interim Plan (e.g. infrastructure provision and flood risk policies).

[64] Ibid

[65] Boston Borough Council 2006

Housing development

The East Midlands Regional Spatial Strategy (RSS) and the Lincolnshire Structure Plan identify Boston as a sub-regional centre of the Eastern sub-region. As a result, the RSS allocates 2,750 dwellings per annum to Lincolnshire during the period 2001 – 2021. The Borough Council have a responsibility to ensure there are sufficient sites to accommodate 5 years of housing development[66]. Seven sites for housing development and five sites for mixed use development including housing have been identified by the Interim Plan. Planning permissions will be granted subject to plans satisfying all relevant policies on the Plan and PPS25.

Flood risk assessment

All significant planning applications must be accompanied by a FRA and must demonstrate that they are adequately protected from flooding for the life of the development, taking into account climate change. Under the requirements of PPS25, Development and Flood Risk, Boston Borough Council must apply the Sequential and Exception Tests to the majority of new development proposals. The Sequential Test is designed to demonstrate that there are no reasonable available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed[67].

Applying the sequential test starts with identifying the flood risk zone the proposed development is in, see Table 2.2. The second step is to classify the type of development according to PPS25, (see Table 2.3). Once the flood zone and the type of development are known, a decision can be taken based on whether the proposed location is suitable (using Table D3 in PPS25). For example, any development type may be permitted in Flood Zone 1 but only water compatible uses and less vulnerable developments may be permitted in Flood Zone 3a. For highly vulnerable developments in Flood Zone 2,

[66] Ibid

[67] CLG 2006

essential infrastructure or more vulnerable developments in Flood Zone 3a and essential infrastructure in Flood Zone 3b, a second test, the Exception test, is required to be satisfied. As Boston is classified as being within Flood Zone 3 the Exception Test is also necessary for the majority of proposed developments.

For the Exception Test to be passed[68]:

- It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk;
- The development should be on developable previously-developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously-developed land; and
- A FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

The aim of the sequential and exception tests is to locate development is areas with as low flood risk as possible whilst ensuring that any development is sustainable. PPS25 states that:

"*the overall aim of decision-makers should be to steer new development to areas at the lowest risk of flooding, preferably in Flood Zone 1. However, where there are no reasonably available sites in Flood Zone 1, decision-makers should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2, applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zones 1 or 2 should decision-makers consider the suitability of sites in Flood Zone 3, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required*".

The Town and Country Planning Act (General Development Procedure) (Amendment) (No 2) (England) Order 2006 (GDPO) has made the Environment Agency a statutory consultee for planning applications involving flood risk. Consequently, the Environment Agency needs to be directly consulted by Boston Borough Council on planning applications for future development.

[68] Ibid

Table 2.2 Flood zone classification (PPS25)

Flood Zone	Annual probability of fluvial flooding	Annual probability of tidal flooding
1 – low probability	1 in 1000 (<0.1%)	1 in 1000 (<0.1%)
2 – medium probability	Between 1 in 100 and 1 in 1000 (1 – 0.1%)	Between in 1 in 200 and 1 in 1000 (0.5 – 0.1%)
3a – High probability	>1 in 100 (>1%)	1 in 200 (>0.5%)
3b – Functional floodplain	1 in 20 (5%) or land designed to flood in an extreme (0.1%) flood	1 in 20 (5%) or land designed to flood in an extreme (0.1%) flood

Table 2.3 Development types (PPS25)

Type of development	Examples / description
Essential infrastructure	Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk, and strategic utility infrastructure, including electricity generating power stations and grid and primary substations.
Highly vulnerable	• Police stations, Ambulance stations and Fire stations and • Command Centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent.
More vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, **subject to a specific warning and evacuation plan**.
Less vulnerable	• Buildings used for: shops; financial, professional and other services; • Restaurants and cafes; hot food takeaways; offices; general industry;

Type of development	**Examples / description**
	storage and distribution; non–residential institutions not included in ‘more vulnerable’; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment plants. • Sewage treatment plants (if adequate pollution control measures are in place).
Water compatible development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel workings. • Docks, marinas and wharves. • Navigation facilities. • MOD defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, **subject to a specific warning and evacuation plan**.

Climate Change

Climate Change Projections

A summary of the major climate change projections expected in the Boston area is provided in Table 3.1. All figures are derived from the UKCIP02 scenarios[69] and are expressed relative to the 1961-1990 mean climate. Where a range is given this relates to the low-emissions (lower bound) and high-emissions (upper bound) scenarios. Spring represents the average for March, April and May; summer the average for June, July and August; autumn the average for September, October and November; and winter the average for December, January and February.

Table 3.1 demonstrates that the Boston area is likely to see an increase in annual average temperatures over the coming century. Both summer and winter temperatures are likely to increase. Annual average rainfall is projected to decrease slightly in the Boston area, with a particularly significant decrease seen in summer rainfall. The amount of rainfall in winter is likely to increase. As well as gradual changes, the Boston area is likely to see an increase in the frequency and magnitude of extreme events such as heat waves and periods of intense rainfall.

Table 3.1 Climate Change Projections for Boston Area

Climate variable		2020s	2050s	2080s
Temperature	Annual mean	0.5 – 1.0°C	1.0 – 2.5°C	1.5 – 4.0 °C
	Spring mean	0.5 – 1.0°C	1.0 – 2.0°C	1.5 – 3.5°C
	Summer mean	0.5 – 1.5°C	1.5 – 3.0°C	2.0 – 5.0°C
	Autumn mean	0.5 – 1.5°C	1.0 – 3.0°C	2.0 – 5.0°C
	Winter mean	0.5	1.0 – 2.0	1.5 – 3.0°C
	IAV[70]	Annual IAV change is 0 to +20%. Winter and spring temperatures become less variable. Summer and autumn temperatures become more variable.		
	Extremes	Extremely warm days will become more frequent; extremely warm days will become hotter. Heat waves will be more likely. The number of cold days will decline.		

[69] Hulme et al. 2002

[70] IAV = Inter annual variability. Based on model output for 2080s across the four UKCIP02 scenarios

Precipitation	Annual mean	WNV[71]	Up to -10%	Up to -10%
	Spring mean	WNV	WNV	WNV to -10%
	Summer mean	Up to -20%	-20% to -30%	-30% to -50%
	Autumn mean	Up to -10%	Up to -10%	-10% to -20%
	Winter mean	Up to +10%	+10% to +20%	+15% to +40%
	IAV	Annual IAV change in the range -20% to +30% Increase in winter precipitation variability in eastern England. Decrease in summer precipitation variability.		
	Snow	Average winter snowfall is likely to decline by between –50% and –100% (i.e. no snow on average) by the 2080s		
	Extremes	More intense rainfall days in winter and spring. Greater probability that an extreme rainfall event will occur on any given winter day. Evidence that intense summer storms may also increase (but limited by spatial resolution of model). Seasonally, there is an increased likelihood of very dry summers and very wet winters.		

Sea Level Rise

Sea level has generally been rising since the end of the last interglacial period but is likely to accelerate due to climate change. Global warming will cause expansion of the oceans due to increasing temperatures, which, combined with a melting of land based ice, will result in accelerated sea level rise. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report concluded that from 1961 to 2003, the average rate of sea level rise was 1.8 ± 0.5 mm yr^{-1} and that for the 20th century; the average rate was 1.7 ± 0.5 mm yr^{-1}[72]. The IPCC ascribe high confidence to the conclusion that the rate of sea level rise has increased between the mid-19th and the mid-20th centuries.

The IPCC project sea level to rise during the 21st century at a rate greater than that experienced during 1961 to 2003. Under the IPCC Special Report on Emission Scenarios (SRES) A1B scenario, by the mid-2090s global sea level reaches 0.22 to 0.44m above 1990 levels, and is rising at about 4mm yr^{-1}. Thermal expansion is projected to contribute more than half of the average rise, but land ice will lose mass increasingly rapidly as the century progresses[73].

[71] WNV = Within a measure of Natural Variability, i.e. no trend detected

[72] IPCC 2007

[73] Ibid

The United Kingdom Climate Impacts Programme (UKCIP) has projected global average sea level change for a number of emissions scenarios using the HadCM3 General Circulation Model (GCM) (see Table 3.2). These projections are based on the global mean sea-level rise projections as described by IPCC Third Assessment Report[74] and information on regional vertical land movement as described by Shennan and Horton (2002).

Table 3.2 UKCIP02 projections of global average sea level change (mm) relative to 1961-1990 average

UKCIP02 scenario	2020s	2050s	2080s
Low emissions	60	140	230
Medium-low emissions	70	150	260
Medium-High emissions	60	150	300
High emissions	70	180	360

Source Hulme et al. 2002

Regional sea level rise depends on natural land movements and regional variability. Land movements in the UK are a consequence of land re-adjustment to de-glaciation following the last ice age. Following unloading caused by melting of ice at the end of the last ice age, the north and west of the British Isles have been rising relative to mean sea level whilst the south and east has been sinking. This means that the relative change in average sea level around the UK will vary, even if sea level rise caused by climate change was uniform. On the south and east coast of the UK, the impact of isostasy will be to increase sea level relative to the land. The estimated rate of vertical land movement in the East Midlands is -0.8mm per year.

However, there are some scientists who believe current estimates of sea level rise are too conservative. Hansen (2007) argues that it is possible that global warming will reach such a level that a tipping point will be reached after which we will see runaway melting of the Greenland and West Antarctic ice sheets. Rapid, non-linear disintegration of these ice sheets could result in a sea level rise of several metres. The IPCC does not include these possible threshold responses of the ice sheets in its calculations of sea level rise.

[74] IPCC 2001

As well as sea level rise due to thermal expansion and melting of land based ice, climate change will contribute to coastal flood risk by increasing the magnitude and frequency of storm surge events. Storm surges are temporary increases in sea level, above the level of the astronomical tide, caused by low atmospheric pressure and strong winds[75]. The UKCIP02 scenarios project that the height of the 1 in 50 year event in the Wash in the 2080s will range from +0.3m to +1.0m[76]. The range of values represents the range of emissions scenarios modelled (low – high). This figure includes the rise in mean sea level due to climate change.

Defra (2006) has issued sea level rise allowance figures which are to be used in SFRAs and the economic analysis of flood protection schemes. The Defra figures have been updated to coincide with the publication of PPS25[77]. The allowance for sea level rise for the East Midlands coast is presented in Table 3.3. Both the UKCIP02 projections and the updated Defra allowances emphasise the exponential increase in the rate of sea-level rise anticipated through this century.

Table 3.3 a) Updated Defra regional sea level rise allowance for the East Midlands coast

Assumed vertical land movement (mm/year)	**Net sea level rise (mm/year) (PPS25)**				**Previous allowance (PPG25) (mm/year)**
	1990 – 2025	**2026 – 2055**	**2056 – 2085**	**2086 - 2115**	
-0.8	4.0	8.5	12.0	15.0	6.0

Source Defra 2006

Table 3.3 b) Total sea level rise allowance to 2115

Period	**Total allowance (mm)**
1990 – 2025	140
2026 – 2055	255
2056 – 2085	360
2086 - 2115	450
Total allowance to 2115	**1,205**

The Defra regional sea level allowances are consistent with the UKCIP02 High emissions scenario. This is important as it allows policy makers to plan for a more severe scenario regarding sea level rise due to climate change. However, the UKCIP02 projections represent only one possible scenario for the future as they are based on only one GCM. The next generation of UKCIP scenarios, due to be published in November 2008, will synthesis several GCMs.

[75] Hulme et al. 2002

[76] Ibid

[77] DCLG 2006

Impact of Climate Change on Flood Risk in Boston

The impact of climate change on tidal flood risk is largely due to sea level rise. The SoP afforded to Boston by its flood defences will decrease over time as sea levels rise (assuming no improvements are made). Currently, the Boston Haven defences (6.0m AOD) provide a SoP of 1 in 100 years. As soon as 2010, the SoP drops below 1 in 100 years to 1 in 65 years but by 2050 this is reduced to 1 in 13 years[78]. The table gives the height of the Boston Haven defences required to protect from a 1 in 50 or 1 in 100 year event with different levels of freeboard. Freeboard refers to the additional height of the defence above the calculated flood level. Freeboard is included on defences to allow a factor of safety. Freeboard tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood such as wave action, bridge openings, and the hydrological effect of urbanisation of the watershed.

The Boston Haven defences will require heightening if they are to continue giving protection against a 1 in 100 or 1 in 200 year event. Table 3.4 shows the additional height required according to the Boston BC SFRA. However, the Boston BC SFRA was produced before the updated Defra sea level rise allowances were published. Consequently, the allowance given for sea level rise in the SFRA (of 6mm yr^{-1}) is lower than the Defra allowance after 2025; updated figures are provided in Table 3.5. From Table 3.5 it can be seen that the height of the Boston Haven defences required to maintain a 1 in 100 or 1 in 200 year SoP in 2050 will be 2cm higher than was recommended by the Boston BC SFRA in 2002 (figures highlighted in red in Table 3.5).

Table 3.4 Height (m) of Boston Haven flood defences required to maintain 1 in 100 or 1 in 200 SoP

	1 in 100			1 in 200		
	0mm freeboard	50mm freeboard	100mm freeboard	0mm freeboard	50mm freeboard	100mm freeboard
2002	5.95	6.00	6.05	6.05	6.10	6.15
2010	6.01	6.05	6.11	6.11	6.16	6.21
2020	6.07	6.12	6.17	6.17	6.22	6.27
2030	6.13	6.18	6.23	6.23	6.28	6.33
2040	6.19	6.24	6.29	6.29	6.34	6.39
2050	6.25	6.30	6.35	6.35	6.40	6.45

Source Boston Borough Council 2002

[78] Boston Borough Council 2006

Table 3.5 Updated height (m) of Boston Haven flood defences required to maintain 1 in 100 or 1 in 200 SoP using Defra sea level rise allowance

	1 in 100			1 in 200		
	0mm freeboard	50mm freeboard	100mm freeboard	0mm freeboard	50mm freeboard	100mm freeboard
2002	5.95	6.00	6.05	6.05	6.10	6.15
2010	5.98	6.03	6.08	6.08	6.13	6.18
2020	6.02	6.07	6.12	6.12	6.17	6.22
2030	6.09	6.14	6.19	6.19	6.24	6.29
2040	6.18	6.23	6.28	6.28	6.33	6.38
2050	6.27	6.32	6.37	6.37	6.42	6.47

The Wash Banks are the Environment Agency's primary flood defence for Boston[79]. The SoP provided by this defence will decrease rapidly over the next 50 years if they are not heightened. Between Hobhole and Butterwick Low, the SoP in 2044 will be as low as 1 in 4 if no improvements are made[80]. The Boston BC SFRA estimates the necessary level of the Wash Banks defences if they are to continue to provide a 1 in 100 and a 1 in 200 SoP in 2044, see Table 3.6.

The implication of Table 3.6 is that the height of the Wash Banks defence will need to be increased by between 0.37 and 0.88m along the length between Hobhole and Wainfleet in order to continue to offer a 1 in 200 SoP. The greatest deficit between current height and height required to maintain the SoP at 1 in 200 by mid-century is the stretch of defences between Butterwick Low and Sailors Home.

Table 3.6 Height required to maintain 1in 100 or 1 in 200 SoP for Wash Banks defence in 2044

Stretch of Wash Banks defences	Current level (mOD)	Height required (mOD) for 1 in 100 SoP	Height required (mOD) for1 in 200 SoP
Hobhole to Butterwick Low	6.36	7.00	7.10
Butterwick Low to Sailors' Home	6.02	6.75	6.90
Sailors' Home to The Horseshoe	6.23	6.45	6.60
The Horseshoe to Wainfleet	5.38	6.10	6.25

Source Boston Borough Council 2002

79 Boston Borough Council 2002

80 Ibid

Position of the Environment Agency and Boston Borough Council

The Environment Agency has objected to the proposed growth in Boston at both the Lincolnshire Structure Plan and Regional Spatial Strategy Examination in Public (EiP). The relative positions of the Environment Agency and Boston Borough Council are described below. These summaries are drawn from written statements and other material presented by Boston Borough Council and the Environment Agency to the East Midlands RSS EiP.

The RSS Panel report neatly summarises the position of the Local Authorities (Boston BC, South Holland District Council and East Lindsey District Council) and the Environment Agency, stating that "*one approach (to coastal flood risk) is to assume that present levels of protection will continue for the foreseeable future, notwithstanding anticipated sea level rise. On this basis the planning of the areas at risk can continue as it has done in the past. This is essentially the view of the three local authorities concerned. Another assumption is that present levels of protection cannot be guaranteed and so no major development should be permitted until at least the matter had been properly studied. This was the starting point of the Environment Agency*".

Environment Agency

The Environment Agency has expressed concern over development plans in Boston due to flood risk. There is particular concern about the impacts of climate change on the Lincolnshire coast at Boston. The Environment Agency anticipates increasing costs associated with defending the Lincolnshire coast from tidal flooding. Defra's guidance to the Environment Agency is that funding is provided for flood risk reduction works which are economically justified, technically viable, environmentally acceptable and subject to an overall affordability limit[81]. However, Defra's current position is that no

[81] Environment Agency 2007

specific level of funding or defence standard relating to future flood risk management can be guaranteed[82]. This includes either upgrading defences to keep pace with climate change or maintaining existing defences.

The Environment Agency disagrees with the amount of housing proposed in Boston Borough, arguing that it will increase the likely population at high risk of flooding. In their submission to the East Midlands RSS EiP the Environment Agency recommended that the Plan should give clearer guidance for the regeneration of coastal towns which would ensure regeneration was achieved not through housing-led growth or reliance on strategic housing allocations. Boston and Grantham have been allocated almost identical amounts of development due to their similarity in size and sub-regional role. However, the Environment Agency feels that this is evidence that flood risk has not been taken not account when determining allocations. If it had, the Environment Agency would expect Boston to have a smaller allocation than Grantham. There is doubt as to whether Boston can meet both its housing allocations and the requirements of PPS25[83].

The fundamental argument put forward by the Environment Agency is that development in Boston would be unsustainable as a result of the additional flood risk posed by climate change.

Boston Borough Council

Boston BC supports the housing allocation to the Eastern sub-area (RSS) and Boston Borough (Lincolnshire Structure Plan). According to the Council, the housing allocation is justified by the town's sub-regional centre status and the need to deliver sustainable communities. In their submission to the RSS Examination in Public (EiP) the Council stress the need for new affordable housing in the Borough due to the influx of migrant workers and the need for economic regeneration[84].

Boston Borough Council disagrees with the Environment Agency's position on flood

[82] Ibid

[83] Environment Agency 2005

[84] Boston Borough Council 2007

risk in the Borough. They feel that the EA has overstated the risk posed to Boston and in some cases accuses them of inaccuracies in their assessment of flood risk[85]. In their EiP submission the Council stresses the importance of flood defences and land drainage systems in and around Boston and point out that as a result, Boston is not an area where floods are common[86]. The Council accept that climate change may increase flood risk but feel that additional mitigation measures can be taken to ensure new developments face an acceptable residual risk during their lifetime[87].

The Council argue that the cost of maintaining and improving flood defences should be weighed against the cost of inhibiting development in Boston[88]. Boston is in need of new housing and economic regeneration and the Council argues that the benefits of these would outweigh the cost of flood defence works.

East Midlands RSS Panel

The report of the East Midlands RSS Panel was published in November 2007. The Panel raised concerns over the lack of consideration of climate change impacts in the spatial strategy, identifying water resources and flood risk as particular concerns which had not been overstated.

The Panel report makes numerous references to the risk of coastal flooding in Lincolnshire and the contribution of climate change to the problem. However, it also recognises the need for economic regeneration in settlements along the Lincolnshire coast. The Panel recognise the current impasse between the Environment Agency and the local authorities and sees that action is required to resolve issues on the Lincolnshire coast. The Panel sees that action as the preparation of a Strategy for the Lincolnshire coast, as proposed by emda, GOEM and the Environment Agency. The Panel agrees that until a Strategy is completed, the precautionary principle must be invoked when

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[85] Boston Borough Council 2007b

[86] Ibid

[87] Ibid

[88] Ibid

locating development and that in the short term strategic growth initiatives should be directed away from Flood Zone 3 unless there is an express need for a coastal location and the conditions of PPS25 can be met. The purpose of the Strategy will be to guide the preparation of local development documents until such time as the regional strategy itself is rolled forward.

Whist the Panel recognised Boston BC's concern that housing figures for the district may not be sufficient to support the sustainability of self-contained rural settlements, it felt that due to flood risk, increasing the allocation would not be advisable. Until the Strategy for the Lincolnshire coast is complete, the Panel report recommends revised housing figures for the Lincolnshire Coastal area. The new figures take into account existing planned commitments only. In Boston, the annualised housing figure proposed by the Panel is 134 dwellings per year between 2006 and 2026.

Summary

In summary, the key issues facing Boston are:

- The town is in need of economic regeneration in terms of developing a wider skills base and increasing the proportion of people employed in semi-skilled and skilled jobs;
- There is increasing demand for housing in the Borough from an increasing migrant population;
- Boston is at risk of tidal flooding from the Wash, and the areas designated for housing development are at 'high risk' of flooding;
- The SoP of current flood defences will decline as sea levels rise due to climate change, increasing the risk of flooding ; and
- Boston BC and the Environment Agency disagree over the likelihood and consequences of flooding in Boston and therefore the planned housing allocation.

FRAMEWORK FOR FURTHER ANALYSIS

Introduction

To help evaluate the sustainability of the planned housing developments in Boston in the presence of climate change – and resolve the difference of opinion between Boston BC and the Environment Agency – it is necessary to appraise the dis/advantages of the housing developments and the associated economic regeneration of the area taking account of future flood risks. Part of this appraisal will involve economic analysis whereby the dis/advantages are, as far as possible, expressed in monetary terms. Guidance already exists on how to perform economic analysis of flood protection schemes (e.g. FCDPAG3 'Economic Appraisal'). However, the ultimate question that this guidance seeks to answer is whether the net social benefit of the 'do something' option(s) exceeds those of the 'do nothing' option, where 'do something' entails improving levels of flood defences. This is not strictly the relevant question to answer in the context of this case study. Rather, the problem must be approached from a development perspective, as opposed to one of flood defence improvements, the relevant question being whether the planned housing developments yield a net social benefit in future worlds defined by the current climate and climate change. The justification for adaptation (investment in flood defences, in this case) is addressed subsequently, with existing guidance.

While it is outside the scope of this case study to undertake quantitative economic analysis to answer this question, an appropriate analytical framework is provided.

Qualitative Summary

There are a number of direct and indirect advantages and disadvantages associated with (re)development and building flood defences. These are qualitatively illustrated Table 5.1; indirect advantages or disadvantages to the wider town of Boston are in italics. A simple summary of the implications of some of the develop and/or defend options are presented in Table 5.2.

Table 5.1a Advantages and disadvantages of redevelopment in Boston

Redevelopment		No Redevelopment	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Eases housing shortage *Economic regeneration*	Financial costs of new development Increase in value at risk from flooding	No increase in value at risk from flooding Avoid financial costs of new development	*Less economic regeneration* No easing of housing shortage

Table 5.1b Advantages and disadvantages of building flood defences in Boston

Flood Defences		No Flood Defences	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Reduced risk of tidal and storm surge flooding Increased SoP for existing properties Increased SoP for new properties *Decrease in insurance premiums*	Financial costs of building flood defence Residual risk of flooding	Avoid financial cost of building defences	No increase in SoP for existing properties No increase in SoP for new properties Increasing risk of flooding due to climate change *Increase in insurance premiums*

Table 5.2 Simplified implications of develop/defend options

	Redevelopment	No Redevelopment
Flood Defences	Financial costs of building flood defence Residual risk of flooding Financial costs of new development Increase in value at risk from flooding Reduced risk of tidal and storm surge flooding Increased SoP for existing properties Increased SoP for new properties *Decrease in insurance premiums* Eases housing shortage *Economic regeneration*	Financial costs of building flood defence Residual risk of flooding *Less economic regeneration* No easing of housing shortage Reduced risk of tidal and storm surge flooding Increased SoP for existing properties Increased SoP for new properties *Decrease in insurance premiums* No increase in value at risk from flooding Avoid financial costs of new development

No Flood Defences	No increase in SoP for existing properties No increase in SoP for new properties Increasing risk of flooding in future due to climate change *Increase in insurance premiums* Financial costs of new development Increase in value at risk from flooding Avoid financial cost of building defences Eases housing shortage *Economic regeneration*	No increase in SoP for existing properties No increase in SoP for new properties Increasing risk of flooding in future due to climate change *Increase in insurance premiums* *Less economic regeneration* No easing of housing shortage Avoid financial cost of building defences No increase in value at risk from flooding Avoid financial costs of new development

Key: Red – Disadvantages; Green – Advantages; *Italics* - Indirect effects

Framework for assessing economic welfare

The simple analysis of the advantages and disadvantages of various options undertaken in Tables 5.1 and 5.2 fails to capture many of the complexities. A more robust, economic analytical framework for analysing, ex ante, the economic effects of (housing) development and climate-induced flooding in Boston BC, and the net benefits of adjusting flood defences for development and existing climate variability and climate change, is shown in Table 5.3.

The framework is based on the method set out by Defra in the Flood and Coastal Defence Project Appraisal Guidance 3 (FCDPAG3). The method used to appraise options for flood defence is cost-benefit analysis. In 2006, Defra issued an update on climate change in project appraisal. The regional allowances for sea level rise (see Table 3.3a) should now be used in calculations to determine the base case and any options that are compared to the base case. In addition, sensitivity analysis should be applied to determine the sensitivity of the proposal to the impacts of climate change on peak flows, extreme rainfall, extreme waves and winds.

Economic welfare (**E**) in Boston BC can be characterised and modelled through the following objective function, **E** {C, D, R(C, D, A[C, D]), A[C, D]} where[89]:

C	=	Climate state, with subscript 0 denoting existing climate variability and subscript 1 denoting a state of climate change.
D	=	Development state, with subscript 0 denoting no (housing) development as planned and subscript 1 denoting implementation of the development proposals.
R	=	Risk of flooding – i.e. the average annual expected consequences of

[89] Since the accounting framework applies equally to costs and benefits, **E** can be thought of as the net social benefits of development proposals.

flooding in Boston BC.

Note that R is an increasing function of D (e.g. as the stock-at-risk and the value of that stock increases, so will the expected consequences); an increasing function of C (e.g. with climate change the likelihood of flooding increases); and a decreasing function of the A (e.g. as flood defences are improved the likelihood of flooding decreases).

A = The resilience of the built environment and inhabitants to flooding, through – for example – the provision of flood defences. This can also be interpreted as the level of adaptation to flood risk.

Note that A is a function of C and D. Other things being equal, as the built environment expands with development, there is a need for improved flood defences and as climate change progresses and the likelihood of flooding increases, there is also a need for more improved defences.

Note also that **E** is directly affected by A, and not solely through R. Improving flood defences is not a costless exercise. Hence, as A increases **E** will decrease by the total annualized costs of the flood defence scheme(s) implemented.

Table 5.3: Ex Ante Analytical Framework for Analysing the Effects of Development and Climate-induced Flooding in Boston BC, and the Net Benefits of Adapting to Development and Climate

Development States in Boston BC (Current Climate, C_0)		
Adjustment of Flood Defences to Development	No Development: D_0	Development: D_1
Adjusted to D_0: A [C_0, D_0]	Optimal adaptation to no development **E**[1] { D_0, R (C_0, D_0, A [C_0, D_0]), A [C_0, D_0] }	Sub-optimal adaptation to development **E**[2] { D_1, R (C_0, D_1, A [C_0, D_0]), A [C_0, D_0] }
Adjusted to D_1: A [C_0, D_1]	Sub-optimal adjustment to no development **E**[3] { D_0, R (C_0, D_0, A [C_0, D_1]), A [C_0, D_1] }	Optimal adjustment to development **E**[4] { D_1, R (C_0, D_1, A [C_0, D_1]), A [C_0, D_1] }
Adjustment of Flood Defences to Climate	No Development & Existing Climate: D_0, C_0	No Development & Climate Change: D_0, C_1
Adjusted to C_0: A [C_0, D_0]	Optimal adaptation to existing climate **E**[5] { D_0, R (C_0, D_0, A [C_0, D_0]), A [C_0, D_0] }	Sub-optimal adaptation to climate change **E**[6] { D_0, R (C_1, D_0, A [C_0, D_0]), A [C_0, D_0] }
Adjusted to C_1: A [C_1, D_0]	Sub-optimal adjustment to existing climate **E**[7] { D_0, R (C_0, D_0, A [C_1, D_0]), A [C_1, D_0] }	Optimal adjustment to climate change **E**[8] { D_0, R (C_1, D_0, A [C_1, D_0]), A [C_1, D_0] }
Adjustment of flood defences to Development and Climate	Development and Existing Climate: D_1, C_0	Development and Climate Change: D_1, C_1
Adjusted to D_1, C_0: A [C_0, D_1]	Optimal adaptation to development & existing climate	Sub-optimal adaptation to climate change, and optimal adaptation to

	E^9 { D_1, R (C_0, D_1, A [C_0, D_1]), A [C_0, D_1] }	development E^{10} { D_1, R (C_1, D_1, A [C_0, D_1]), A [C_0, D_1] }
Adjusted to D_1, C_1: A [C_1, D_1]	Sub-optimal adjustment to exiting climate, and optimal adaptation to development E^{11} { D_1, R (C_0, D_1, A [C_1, D_1]), A [C_1, D_1] }	Optimal adjustment to climate change and optimal adjustment to development E^{12} { D_1, R (C_1, D_1, A [C_1, D_1]), A [C_1, D_1] }

Note: the superscripts on the **E** solely indicate the cell reference to simplify the narrative in the text.

Table 5.3 is interpreted as follows. For example, the first panel considers two development states (no household growth and planned growth). Movement from the upper left to the upper right cell characterises sub-optimal, or partial adjustment to the planned development. That is, the development goes ahead, but flood defences are not modified accordingly. The difference between economic welfare levels in the two cells (i.e. $\mathbf{E}^2 - \mathbf{E}^1$) represents the increase (or decrease) in net social benefit due to development, without efficiently adapting flood defences to account development, or taking account of climate change[90]. Moving to the lower right cell represents the situation in which council planners and the EA optimally modify flood defences to account for the planned development, but still fail to take account of climate change. The objective function in this cell ($\mathbf{E}^4$) characterises the net social benefits of the housing developments with adequate flood protection. Thus, the net social benefits of solely adapting flood defences to the planned housing development is given by $\mathbf{E}^4 - \mathbf{E}^2$. Summing these two effects, the combined ex ante net benefits of the housing development and adjusting flood defences accordingly, assuming no climate change, are given by: $(\mathbf{E}^2 - \mathbf{E}^1) + (\mathbf{E}^4 - \mathbf{E}^2) = (\mathbf{E}^4 - \mathbf{E}^1)$.

Panels 2 and 3 in Table 5.3 are interpreted in a similar fashion. The main relationships are summarised as follows:

[90] The superscript on **E** denotes the cell reference in Table 5.3.

Economic damages of climate change = the ex ante reduction in net social benefits caused by climate change, after sub-optimal of flood defences adjustments to climate change:

- With development = $\mathbf{E}^{10} - \mathbf{E}^{9}$ which is assumed to be ≤ 0.
- Without development = $\mathbf{E}^{6} - \mathbf{E}^{5}$ which is assumed to be ≤ 0.

Net benefits of adaptation = the ex ante net social benefits of avoiding the economic damages of climate change, after optimal adjustment of flood defences to climate change:

- With development = $\mathbf{E}^{12} - \mathbf{E}^{10}$ which, if ≥ 0, the investment in flood defences is justified.
- Without development = $\mathbf{E}^{8} - \mathbf{E}^{6}$, if ≥ 0, the investment in flood defences is justified.

Residual economic damages of climate change = the ex ante reduction in net social benefits caused by climate change that cannot be avoided, given optimal adjustment of flood defences to climate change and development (if applicable):

- With development = $\mathbf{E}^{12} - \mathbf{E}^{9}$ which will be ≤ 0.
- Without development = $\mathbf{E}^{8} - \mathbf{E}^{5}$ which will be ≤ 0.

The ex ante, ex post loss of net social benefit from not optimally adjusting flood defences for climate change that does occur:

- With development = $\mathbf{E}^{10} - \mathbf{E}^{12}$ which will be ≤ 0.
- Without development = $\mathbf{E}^{6} - \mathbf{E}^{8}$ which will be ≤ 0.

The ex ante, ex post loss of net social benefit from optimally adjusting flood defences for climate change that does not occur:

- With development = $\mathbf{E}^{11} - \mathbf{E}^{9}$ which will be ≤ 0.
- Without development = $\mathbf{E}^{7} - \mathbf{E}^{5}$ which will be ≤ 0.

In the context of this case study, the relevant question is whether $\mathbf{E}^{12} \geq \mathbf{E}^{6}$ ($\mathbf{E}^{6}$ is the baseline situation in the future[91]). That is, are the net social benefits of the planned housing developments, with flood defences optimally adjusted to both the level of development and climate change, greater than or equal to the net social benefits of with no housing developments, and flood defences only optimally adapted to no developments? Boston BC believes this to be the case, whilst the EA do not. Of course, there are a host of other questions that could be asked – e.g. whether $\mathbf{E}^{12} \geq \mathbf{E}^{8}$. That is, are the net social benefits of the planned housing developments, with flood defences optimally adjusted to both the level of development and climate change, greater than or equal to the net social benefits of with no housing developments, and flood defences optimally adapted to no developments and climate change?

It should be noted that the problem is actually more complicated than this. The real issue is allocation of planned housing between locations in the area, one of which is Boston. In this case the objective function is really given by:

$$\mathbf{E} = \mathbf{E_B}\ \{C,\ p\bullet D,\ R(C,\ p\bullet D,\ A[C,\ p\bullet D]),\ A[C,\ p\bullet D]\} + \mathbf{E_O}\ \{C,\ (1\text{-}p)\bullet D,\ R(C,\ (1\text{-}p)\bullet D,\ A[C,\ (1\text{-}p)\bullet D]),\ A[C,\ (1\text{-}p)\bullet D]\}$$

> Where the subscript "B" denotes Boston, "O" denotes others parts of the area, and "p" denotes the fraction of the total planned housing developments located in Boston.

However, for ease of presentation, the decomposition of the objective function is not shown.

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[91] $\mathbf{E}^{5}$ is the present day baseline.

Note that the framework should be applied to different future time periods. This will capture the changes to economic welfare (E) through the century as C, D, R and A change. In particular, it will be important to establish whether and at what level thresholds exist.

ADAPTATION

We are already committed to some warming due to the GHG emissions released into the atmosphere to date. It is therefore essential that we take steps to adapt to climate change and the resulting rise in sea levels. UKCIP define climate adaptation as "*the process or outcome of a process that leads to a reduction in harm or risk of harm, or realisation of benefits, associated with climate variability and climate change*"[92].

Adaptation Options

Existing housing stock

There are approximately 25,000 residential properties and 1,500 commercial properties in Boston BC area[93]. Adaptation will be required to protect this existing building stock, regardless of development decisions in Boston.

Traditionally, the adaptation response to flood risk has been to build hard defences. Boston is currently defended from tidal flooding by the Wash Banks and the Boston Haven defences. If the SoP afforded to Boston by its flood defences is allowed to decline, the existing settlement is placed at additional risk of flooding, irrespective of whether new development goes ahead. The potential result of this is further economic stagnation as new businesses are unlikely to be attracted to the area, insurance premiums rise (if, indeed insurers continue to insure properties in Boston) and house prices fall. As a result of not increasing the height of tidal flood defences, the town of Boston could become 'adaptation disadvantaged' and there is a risk of it becoming an 'adaptation ghetto'[94].

However, hard defences are not the only option. An alternative response to the increase

[92] Willows and Connell 2003:11

[93] Environment Agency 2007

[94] A term described by Roger Street (Street, 2007).

in tidal flood risk in Boston is to make existing buildings more resistant and resilient to the effects of flooding. A number of measures can be retrofitted to existing buildings to reduce the impact of flooding and prevent the town becoming an ‘adaptation ghetto’. There are two forms of protection: flood resistance and flood resilient techniques. Resistance measures help prevent water getting in to buildings and resilience measures ensure minimal damage occurs if water does get in[95]. Ideally buildings should be fitted with both. Examples of flood resistance measures include:

- Increasing the floor level above the projected flood level by raising the main occupied area of buildings
- Installing pump and sump systems which drain water from below floor level faster than it rises.

Flood resilient measures include:

- Replacing timber floors with concrete, and carpet with tiles
- Replacing perishable materials such as MDF or chipboard kitchens with plastic or steel alternatives
- Replacing gypsum plaster with more water resistant materials such as lime plaster or cement render
- Raising items which can be damaged by flooding (e.g. boilers, wall sockets, meters) above the projected flood level
- Installing one-way valves on drainage pipes - decrease risk of sewage backing up into a building during a flood.

Norwich Union has carried out a project to demonstrate how to retrofit an existing property to increase its resistance and resilience to flooding. The project involved retrofitting all the measures listed above in addition to redesigning the front and back doors to incorporate flood guards to a house at risk of flooding in Lowestoft at a cost of approximately £30,000. The ABI estimate that typically costs of flood protection measures can range from £2,000 - £6,000 for dealing with flash-floods and £20,000 - £40,000 for dealing with prolonged flooding on larger individual properties[96].

[95] National Flood Forum 2006

[96] ABI undated

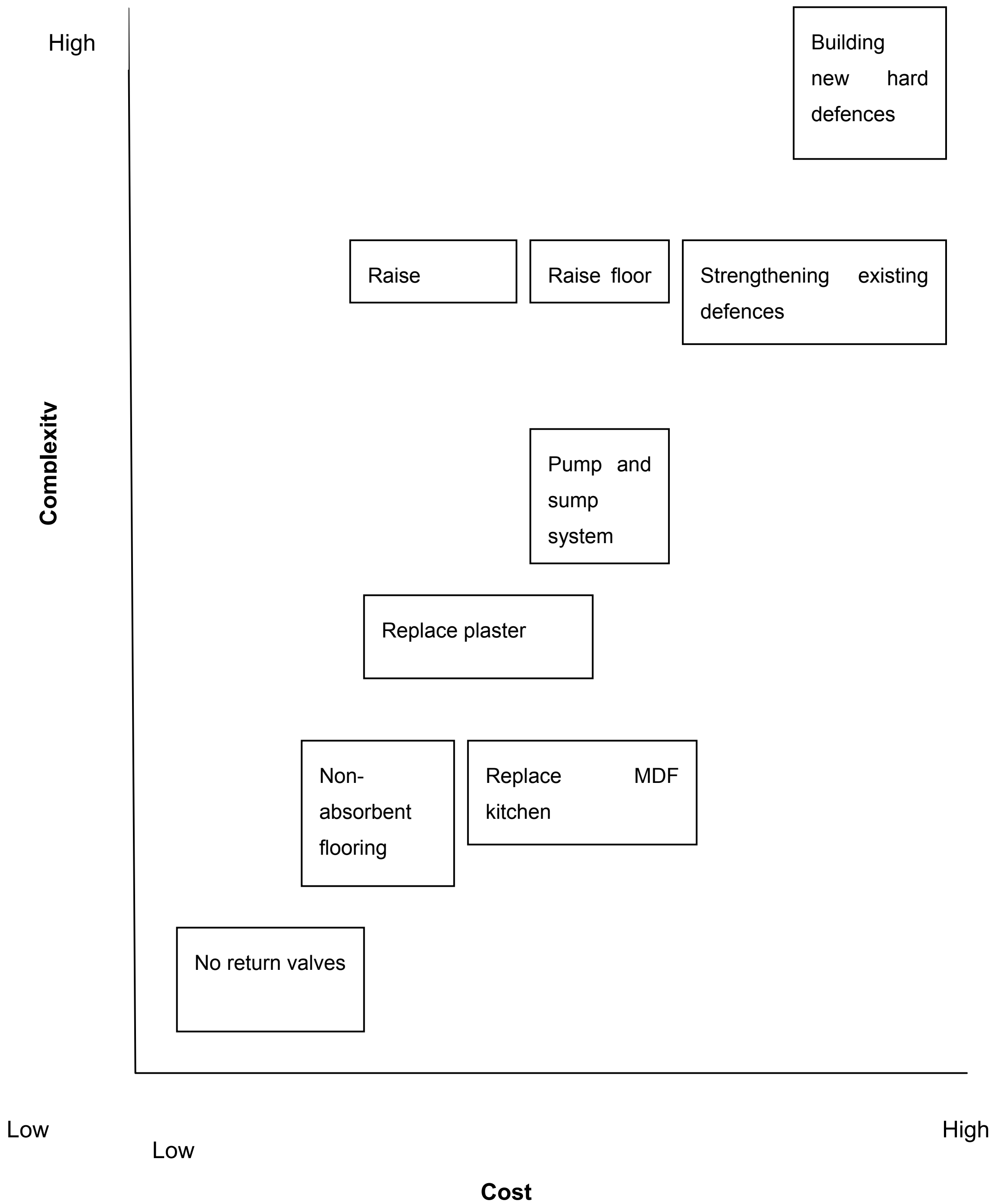
If a cost of £30,000 per house is assumed, and it is assumed that 96% of houses are at risk of flooding[97], the cost of retrofitting Boston's existing housing stock can be estimated at £720 million. It has been estimated by the ABI that installing measures such as those listed above will save between £5,000 and £12,000 each time the property is flooded[98]. These figures demonstrate that a full retrofit is only cost effective for properties likely to experience three or more floods in the remainder of its lifetime.

Whilst these costs appear high, this is the cost for a full retrofit. Most properties are unlikely to require all the measures listed above; fitting just one or two of the suggested measures are likely to significantly reduce the costs associated with flooding. Installing flood resistance and resilience measures will also reduce insurance premiums and may prevent decline in property value. Choosing the number and type of measures to include will depend on a number of factors including the type of building, its residual life and the type of flooding it is at risk from.

[97] Environment Agency 2007

[98] ABI undated.

Figure 3.1 Relative cost and complexity of adaptation options for existing housing stock



New development

If new development is permitted in the Boston area, it could be a driver for improvements to existing flood defences. Strengthening and raising the flood banks would be an option for protecting new development. The problem faced by Boston (and other locations at greater risk of flooding due to climate change) is circular; large adaptation costs are only justified if the benefits are also large. The paradox in this situation is that to maximise benefits, redevelopment must be allowed to progress, thus increasing the value at risk of flooding. Good adaptation measures increase flexibility and are associated with low or no regret actions. In this case, building additional flood defences as a means of adapting to the increase in tidal flood risk will decrease flexibility and could be associated with greater regret due to the increased value that will be put at risk. In this respect, improving flood defences as an adaptation to climate change in Boston could be seen as a poor choice.

However, there is also a need to consider adaptation measures other than raising hard defences as there is always going to be a residual risk of flooding in Boston. Even if new development goes ahead with improvements to defences to protect it, the residual risk form flooding will be increased as the stock at risk has been increased. Thus by considering residual impacts, it can be seen that the overall risk increases if development is allowed to go ahead.

Alternatives to raising existing defences will be required if development goes ahead in Boston. New developments must be planned to take into account current and future flood risk. All the measures to improve flood resilience and resistance suggested above need to be included in new properties but there are additional steps which should be taken to reduce flood risk in new developments. These measures include:

- Using ground floor spaces for non-residential uses e.g. car parking;
- Using permeable paving materials for pavements, driveways, footpaths and car parking areas to prevent high levels of run-off during flash floods;
- Using SUDS to collect and store surface water.

Whilst designing and building flood resilient and resistant buildings is likely to be more expensive than traditional buildings, the unit cost for new build is likely to be lower than for retrofitting as there are economies of scale in large developments, see Case Study 3, Construction.

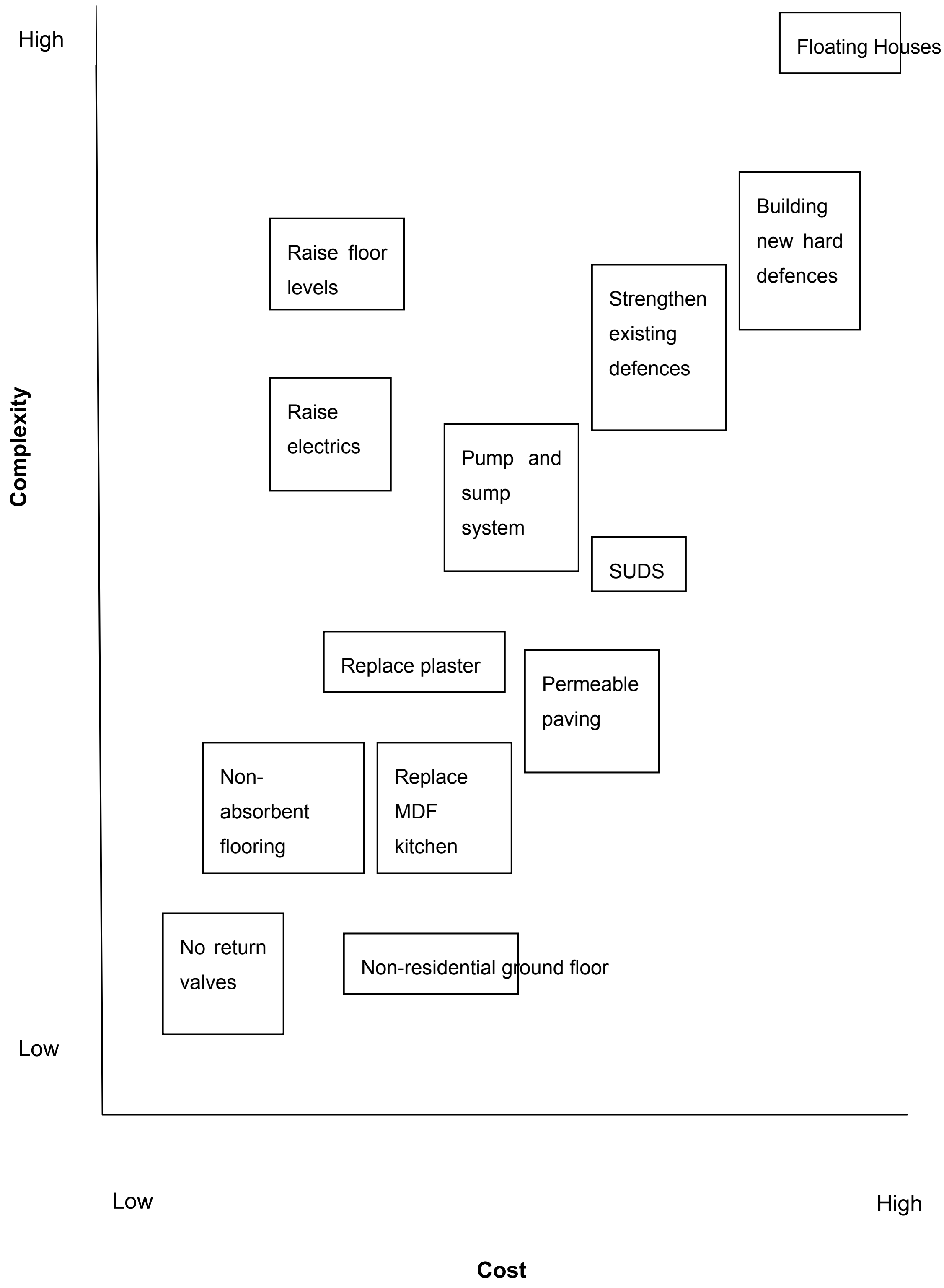
In the Netherlands, a country at increasing risk of tidal flooding due to sea level rise, more radical solutions to the traditional hard defences are being developed. A recent development of amphibious houses has just been completed in Maasbommel, Gelderland province. The houses have a hollow concrete core to give them buoyancy during floods whilst a vertical pile keeps them anchored to the land. Electricity and water are pumped in through flexible pipes. As a result of these features, the houses can withstand a rise in the water table of up to four metres[99]. The starting price of the floating houses is €260,000, €16,000 (or 6.5%) more expensive than the average Dutch house price of €244,000[100].

Figure 3.2 presents a summary of the relative cost and complexity of adaptation options for new development.

[99] BBC 1/03/07

[100] Global Property Guide http://www.globalpropertyguide.com/Europe/Netherlands

Figure 3.2 Relative cost and complexity of adaptation options for new development



Flood Hazard Mapping

One way forward in the case of development vs. flood risk in Boston may be to consider using flood hazard mapping. Flood hazard mapping assess the risk to life from flooding and can be used to identify locations within the flood zone where development may proceed. It is particularly useful in locations where large areas are considered to be in Flood Zone 3 but there is a need for development to proceed. Using modelled flood heights and velocities for events of varying magnitude, risk to life can be determined in terms of safe access and egress to buildings in times of flood.

Defra have recently carried out research looking at the flood risks to people in terms of hazard and vulnerability. Phase 2 of the Defra project, “Risks to People” (FD2321) has developed a method for assessing and mapping serious injury or fatalities from flooding during, or in the immediate aftermath, of a flood event. The ‘risk to people’ method is a form of multi-criteria assessment based on the concepts of flood hazard rating and scores of both area vulnerability and people vulnerability. Scores are combined for several Flood Hazard Zones of the floodplain in order to estimate the annual average individual or societal risk. Zones within the floodplain are characterised by different degrees of flood hazard depending on parameters such as distance from the source.

Policy implications for emda

As the regional policy making body, emda has a menu of options to draw from and provide an indication of what level, scale and type of adaptation responses are needed now, and to accommodate future growth. However, there are a number of factors that can prevent successful adaptation to climate change. Street (2007) has identified the following barriers to adaptation:

- Limited understanding of the nature and extent of current and projected risks;
- Lack of knowledge of alternative adaptation options;
- Lack of supportive policies, standards, regulations, and design guidance;
- Lack of availability or restricted access to appropriate technologies – including prohibitive costs and lack of availability of human capital;

- Short-term nature of decision-making and planning horizons
- Differences in willingness to accept uncertainties.

Emda, amongst other stakeholders, has a role to play in reducing the barriers to adaptation in Boston.

There is already an understanding of the spatial nature and extent of the current and future tidal flood risk in Boston as a result of the Borough Council's SFRA. This is likely to be strengthened by an update to the SFRA, due to be published in 2008, which will consider the impact of climate change more fully. However, businesses and individuals may not be aware of the risks they face from climate change in Boston. There is a need to communicate the potential impacts of climate change and possible adaptation strategies to people and organisations within the town in order that they can reduce their vulnerability.

The update to the SFRA should include flood hazard mapping, taking into account flood hazard and people's vulnerability to flooding in Boston. This will allow potential flood hazard 'hotspots' within Flood Zone 3 to be identified and future development can be steered away from these areas.

There may be a lack of knowledge of alternative adaptation options, see section 6.1. The reliance on hard sea defences in the past may prevent organisations recognising the benefits of alternative strategies for managing risk. There is a role for emda within its spatial planning function to promote alternative adaptation strategies including flood resistance and resilience measures.

Another barrier that emda can assist in removing is a lack of supportive policies, standards and design guidance. Previously, much of this would have fallen to the Regional Assembly but in its new spatial planning role emda has the ability to influence design through standards and regulation. Another measure emda could take is to research and produce a design guide of best practice in tidal flood adaptation, using examples of the techniques outlined in section 6.1.

Emda may also be able to address a lack of appropriate technologies and skills through the RES. If lack of skills in flood adaptation techniques is found to be a barrier to adaptation in the Region, emda can address this through the priority action to develop adult workforce skills.

Uncertainty over future climate change and its impacts is a barrier to adaptation as organisations are often unwilling to make investments in adaptation techniques based on uncertain projections of the future. The UKCIP08 projections may go some way to alleviating this problem as projections will be associated with a probability of occurrence, making the uncertainty quantifiable and providing more information to decision makers.

There are also geographically specific factors in Boston that may act as barriers to adaptation. Boston is a historic town, dating back to the Middle Ages. There are a number of important historic buildings in the town including the 14th Century St. Botolph Church with its 272 foot high tower. The town centre area either side of the River Witham is covered by a Conservation Area designation. Boston owes its existence to the historical system of flood defences and land drainage. The structures associated with these systems are now fundamental to the physical appearance, character and culture of the town. Any future development or improvements to flood defence structures would have to consider the impact on the historic features of Boston.

CONCLUSIONS

There are competing pressures on development in Boston: the need to economically re-generate the area and flood risk. Similar problems are faced by other coastal settlements in Lincolnshire and beyond which have traditionally been defended from tidal flooding.

The problem is one of sustainable development; Boston BC are committed to sustainable development[101] and economic re-generation but the Environment Agency question the long term sustainability of building in areas known to be at risk of flooding both now and in the future.

Climate change will cause sea level rise in the future which will exacerbate the risk of tidal flooding along the Lincolnshire coast. Increase in inundation levels and storm surge heights will result in a rapidly declining SoP of existing defences if they remain at their current height. The reduction in SoP and necessary improvements to flood embankment has been modelled and is presented in Boston Borough Council's SFRA. What has yet to be determined is the economic cost of undertaking this work and the relative benefits it will provide to the town of Boston.

This case study provides a framework for carrying out a quantitative analysis of the costs and benefits of defending and developing Boston. Additionally, and complementary to this, undertaking a formal stakeholder analysis would allow a clearer understanding of the positions of interested parties and perhaps facilitate a dialogue that worked towards an acceptable outcome solution.

Measures such as property resistance and resilience may prove as valuable as traditional approaches centred on engineered flood defences. Such measures would increase flexibility and may allow development to proceed whilst not increasing residual flood risk.

[101] Boston Borough Council 2002

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