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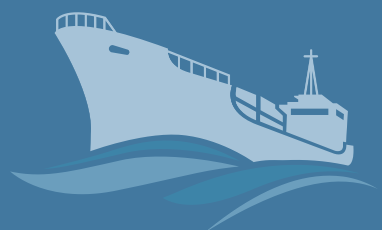

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Review of UK Shipping Emissions

Committee on Climate Change
November 2011

Acknowledgements

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Preface

The Committee on Climate Change (the Committee) is an independent statutory body which was established under the Climate Change Act (2008) to advise UK and Devolved Administration governments on setting and meeting carbon budgets, and preparing for climate change.

Setting carbon budgets

In December 2008 we published our first report, *'Building a low-carbon economy – the UK's contribution to tackling climate change'*, containing our advice on the level of the first three carbon budgets and the 2050 target; this advice was accepted by the Government and legislated by Parliament. In December 2010, we set out our advice on the fourth carbon budget, covering the period 2023-27, as required under Section 4 of the Climate Change Act; the fourth carbon budget was legislated in June 2011 at the level that we recommended.

Progress meeting carbon budgets

The Climate Change Act requires that we report annually to Parliament on progress meeting carbon budgets; we have published three progress reports in October 2009, June 2010 and June 2011.

Advice requested by Government

We provide ad hoc advice in response to requests by the Government and the Devolved Administrations. Under a process set out in the Climate Change Act, we have advised on reducing UK aviation emissions, Scottish emissions reduction targets, UK support for low-carbon technology innovation, design of the Carbon Reduction Commitment and renewable energy ambition. In September 2010 and July 2011, we published advice on adaptation, assessing how well prepared the UK is to deal with the impacts of climate change. We will also publish a review of bioenergy by the end of the year.

Foreword

Emissions from international aviation and shipping are not at present included in carbon budgets or in the UK's target to reduce emissions in 2050 by 80% below 1990 levels. Under the Climate Change Act, however, Parliament must decide by the end of 2012 whether to include emissions from international aviation and shipping in carbon budgets. To form its view, the Government is required to take account of advice from the Committee, which we will provide next Spring.

In developing our advice to Government, we need to consider the future path for these emissions. In our December 2009 report, we looked in some detail at projections of aviation emissions and the potential for abatement. Shipping has not previously been subject to such detailed assessment. That is the purpose of this report.

We use a range of methodologies to estimate the UK's share of current international shipping emissions. We also project those emissions out to 2050, under various assumptions for likely demand growth and emissions abatement potential.

The appropriate UK figure for international shipping emissions is subject to significant uncertainty. We believe that the UK should consider itself responsible for all of the shipping emissions involved in the transfer of cargos between the UK and its trading partners. On this basis we estimate that the UK's current international shipping emissions are between 12-16 $MtCO_2$, but we cannot rule out that they are substantially higher. We recommend that the Government should work with the EU and the industry to improve access to data that will provide more confidence in the underlying emission estimates.

Reflecting uncertainty in the drivers of emissions going forward, as well as the baseline, there is considerable uncertainty in future projected emissions. Nevertheless there are a number of things we can say.

We show that there is significant scope, based on a range of technical and operational measures, for abatement of shipping emissions. To deliver this potential will require new international policies, such as a cap and trade scheme.

Even with significant abatement effort, the UK's projected international shipping emissions in 2050 could account for a significant proportion of total allowed emissions under the target in the Climate Change Act. Our projected international shipping emissions of up to 18 $MtCO_2$ could account for 11% of total allowed emissions in 2050.

It is important that international shipping emissions are, at some point, included in the 2050 target. Their exclusion leaves a part of UK emissions not fully accounted for and is inconsistent with the UK's commitment to play its role in meeting appropriate global climate objectives.

However, the uncertainty over the precise level of emissions makes inclusion in carbon budgets complex and raises questions over appropriate timing. We therefore propose three options for consideration:

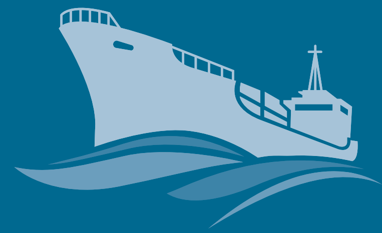
- International shipping emissions are included in both the 2050 target and carbon budgets now;
- International shipping emissions are included in the 2050 target and carbon budgets when progress has been made on a methodology to reflect more accurately international shipping emissions;
- International shipping emissions are included in the 2050 target now, but in carbon budgets only when progress has been made on that methodology.

We will look further at these options over the coming months and look forward to further discussion with interested parties. We will recommend which option should be pursued as part of the advice we will provide to Government next Spring.

On behalf of the Committee I would like to thank the Secretariat for their excellent support in producing this report.

Lord Adair Turner

Chair



Lord Adair Turner, Chair

Lord Turner of Ecchinswell is the Chair of the Committee on Climate Change and Chair of the Financial Services Authority. He has previously been Chair at the Low Pay Commission, Chair at the Pension Commission, and Director-general of the Confederation of British Industry (CBI).

David Kennedy, Chief Executive

David Kennedy is the Chief Executive of the Committee on Climate Change. Previously he worked on energy strategy and investment at the World Bank, and the design of infrastructure investment projects at the European Bank for Reconstruction and Development. He has a PhD in economics from the London School of Economics.

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Professor Samuel Fankhauser is acting Co-Director of the Grantham Research Institute on Climate Change at the London School of Economics and a Director at Vivid Economics. He is a former Deputy Chief Economist of the European Bank for Reconstruction and Development.

Sir Brian Hoskins

Professor Sir Brian Hoskins, CBE, FRS is the Director of the Grantham Institute for Climate Change at Imperial College and Professor of Meteorology at the University of Reading. He is a Royal Society Research Professor and is also a member of the National Science Academies of the USA and China.

Professor Julia King

Professor Julia King CBE FREng is Vice-Chancellor of Aston University. She led the 'King Review' for HM Treasury in 2007/8 on decarbonising road transport. She was formerly Director of Advanced Engineering for the Rolls-Royce industrial businesses. Julia is one of the UK's Business Ambassadors, supporting UK companies and inward investment in low-carbon technologies.

Lord John Krebs

Professor Lord Krebs Kt FRS, is currently Principal of Jesus College Oxford. Previously, he held posts at the University of British Columbia, the University of Wales, and Oxford, where he was lecturer in Zoology, 1976-88, and Royal Society Research Professor, 1988-2005. From 1994-1999, he was Chief Executive of the Natural Environment Research Council and, from 2000-2005, Chairman of the Food Standards Agency. He is a member of the U.S. National Academy of Sciences. He is chairman of the House of Lords Science & Technology Select Committee.

Lord Robert May

Professor Lord May of Oxford, OM AC FRS holds a Professorship jointly at Oxford University and Imperial College. He is a Fellow of Merton College, Oxford. He was until recently President of The Royal Society, and before that Chief Scientific Adviser to the UK Government and Head of its Office of Science & Technology.

Professor Jim Skea

Professor Jim Skea is Research Director at UK Energy Research Centre (UKERC) having previously been Director of the Policy Studies Institute (PSI). He led the launch of the Low Carbon Vehicle Partnership and was Director of the Economic and Social Research Council's Global Environmental Change Programme.

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Currently international shipping emissions are not included in carbon budgets or the UK's 2050 target to reduce emissions by 80% on 1990 levels. However, under the Climate Change Act, a decision is required on the inclusion of international aviation and shipping emissions by the end of 2012. Secondary legislation will be tabled in Parliament by the Government taking into account the Committee's advice.

In this report, which is preparatory work to our advice in 2012 on whether or not to include international shipping emissions in budgets, we do three things:

- We estimate current UK international shipping emissions using different methodologies.
- We project shipping emissions out to 2050 under various assumptions on demand growth and emissions abatement potential.
- We set out options for including international shipping emissions in carbon budgets.

The key messages in this report are:

- Current international shipping emissions are highly uncertain (e.g. they are likely to be in the range of 12-16 $MtCO_2$, but we cannot rule out that they are higher). This highlights the need for more accurate measures of UK shipping emissions, which would be possible if data on fuel use were collected from ship operators. We therefore recommend that the UK Government should work with the EU and the industry to gain access to this data.
- We show that there is significant scope for emissions reduction in shipping through a range of technical and operational measures. This goes well beyond the ambition targeted by the Energy Efficiency Design Index (EEDI) which was recently agreed by the International Maritime Organisation (IMO). Therefore new international policies with stronger incentives (e.g. a cap and trade scheme or a carbon tax) are required to provide more confidence that the full abatement potential will be delivered.
- By 2050, our projected international shipping emissions account for up to 11% of total emissions permitted under the Climate Change Act.
- International shipping emissions will need, at some point, to be included in the 2050 target: excluding them would leave UK emissions not fully accounted, and emission reductions would be inconsistent with the effort required to deliver the UK's climate objective. However, we note that there is a high degree of uncertainty around these emissions which makes inclusion in carbon budgets complex. We therefore propose three options for consideration:
  - International shipping emissions are included in the 2050 target and carbon budgets now.
  - They are included in the 2050 target and carbon budgets when progress has been made on a methodology to accurately reflect international shipping emissions.
  - They are included in the 2050 target now, and in carbon budgets when progress has been made on a methodology to accurately reflect UK international shipping emissions.

We will set out our views on these options when we publish our advice on the inclusion of international aviation and shipping emissions in Spring 2012.

The analysis that underpins these conclusions is summarised here in eight sections, and is set out in full in a technical paper published on our website.

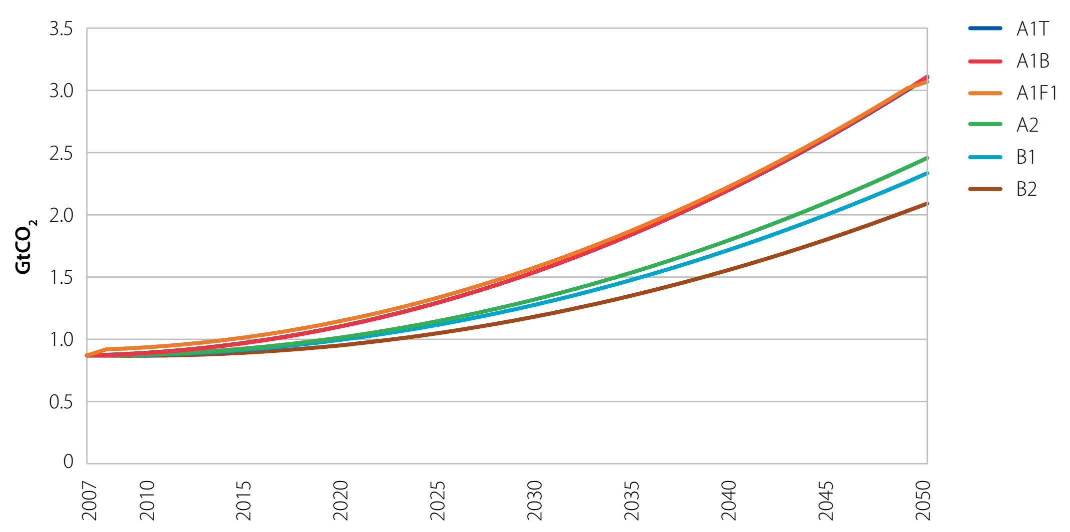
1. Global shipping emissions
2. The international policy framework
3. The approach to international shipping emissions under the Climate Change Act
4. Current UK shipping emissions
5. UK shipping demand projections
6. Abatement opportunities in shipping
7. Scenarios for UK shipping emissions to 2050
8. Including international shipping emissions in the 2050 target and carbon budgets

Global shipping emissions

Global shipping CO_2 emissions are estimated currently to account for over 3% of total global CO_2 emissions. They have increased rapidly in recent years, driven by growth in international trade, and are projected to grow by up to 3% per annum over the next four decades:

- Global shipping emissions in 2007 – domestic and international – were around 1.1 $GtCO_2$, compared to total CO_2 emissions from fossil fuel combustion of around 30 $GtCO_2$.
- The vast majority (around 80%) of shipping emissions are due to international shipping, and are therefore not included in country-level emissions inventories and associated emission reduction targets.
- Global international shipping emissions have grown on average by 3.7% per annum since 1990, driven by the rapid expansion of world trade.
- Projections by the IMO suggest a range of 2-3% for annual growth in global international shipping emissions to 2050, if unabated, driven by GDP and associated trade growth (Figure 1).

Figure 1: Global international shipping emission projections (2007-2050)



Source: IMO (2009), *Second GHG Study*.
Note: Projections assume no measures taken to abate CO_2 emissions, and are based on the IPCC SRES family of global scenarios (broadly labelled A1, A2, B1 & B2) each assuming different levels of growth, technology use and global integration. A1T, A1B and A1FI projections overlap.

By 2050, CO_2 emissions from global international shipping could account for up to 25% of total fossil fuel CO_2 emissions consistent with achieving the climate objective underpinning the Climate Change Act:

- The objective underpinning the Climate Change Act is to keep central estimates of global mean temperature change by 2100 as close to 2°c as possible, and to limit risks of temperature change above 4°c to very low levels (e.g. less than a 1% probability).
- The emissions pathway to achieve this objective requires early peaking of emissions, followed by average annual emissions reduction of 3-4%. This would result in global emissions of around 20 $GtCO_2e$ in 2050; CO_2 emissions would account for 12 $GtCO_2e$.
- Global international shipping emissions of between 2.1 and 3.1 $GtCO_2$ in 2050 would therefore account for between 17-25% of total allowed CO_2 emissions.

Shipping currently probably has a net cooling effect on the climate due to non-CO_2 emissions. CO_2 emissions from shipping will however lead to long-term global warming (Box 1):

- Shipping emissions currently probably cool the Earth, as it is likely that warming due to CO_2 emissions is more than offset by the cooling effects primarily due to sulphate aerosols.
- However, the warming effect of CO_2 lasts for centuries and will build over time as emissions continue, whereas the aerosol effect only lasts for several days.
- In future the CO_2 effect will dominate further over the aerosol effect as new regulations to improve air quality reduce the sulphur content of ship fuels.

Therefore shipping is a potentially significant source of future warming, driven by CO_2 emissions, which are our focus in this report.

Global shipping emissions (continued)

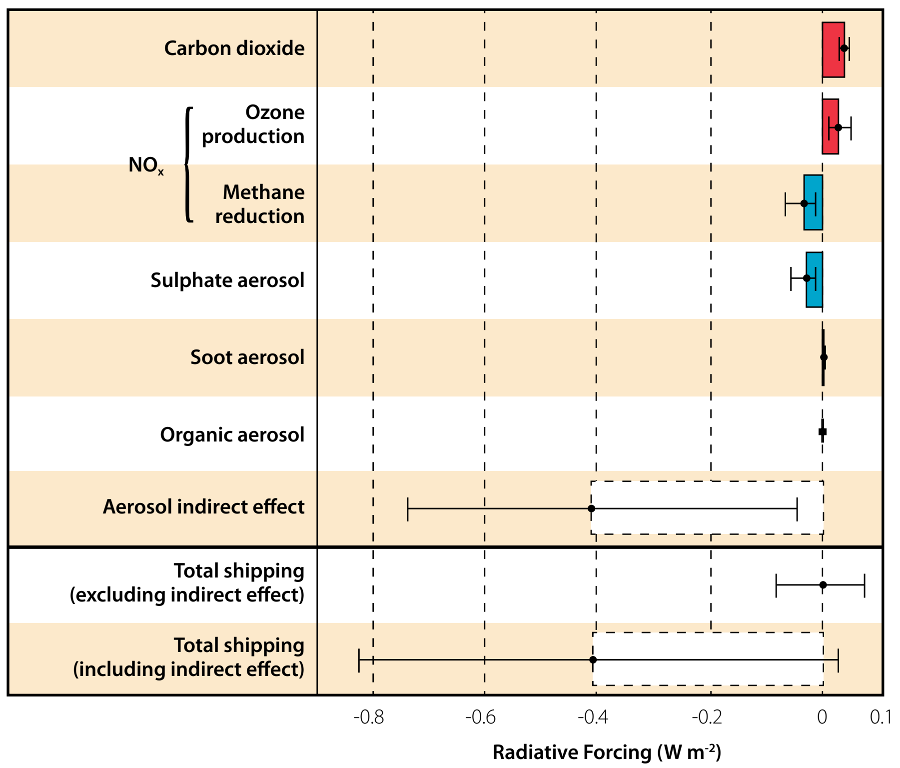
Box 1: Science of warming from ships

Shipping activity emits a variety of gases and particles which influence the Earth's climate. The most important of these are:

- **Carbon dioxide (CO_2)** which is a long-lived greenhouse gas which causes direct warming of the atmosphere and is the only gas emitted by ships covered by the Kyoto Protocol.
- **Sulphur dioxide (SO_2)** which gives rise to sulphate aerosol which causes direct cooling by reflecting sunlight, and also causes stronger (but poorly quantified) cooling through indirect effects on clouds. Other sectors also emit SO_2, although their effect has been reduced due to emission control measures.
- **Oxides of nitrogen (NO_x)** which do not have a direct effect on climate, but warm by enhancing ozone (O_3) and cool by reducing the lifetime of methane (CH_4).
- **Soot and other organic (i.e. carbon-based) aerosols** which can cause either warming or cooling, depending on the type of particle. Like sulphate particles, all particles also cause indirect cooling through effects on clouds.

These emissions act over very different scales in space and time. Taken together, the total influence of shipping on the atmosphere to date has probably caused a net cooling effect (Figure B1).

Figure B1: Global shipping radiative forcing components in 2005



Source: Eyring et al. (2010) Transport impacts on Atmosphere and Climate: Shipping, Atmospheric Environment.

The international policy framework

Given the potentially high share of international shipping emissions in total emissions, they should be included in international strategies and agreements to reduce total emissions. This would provide incentives to reduce shipping emissions, and would help to ensure that emission reductions in other sectors are compatible with achieving the climate objective.

In our 2008 report, *Building a low-carbon economy: the UK's contribution to tackling climate change*, we argued that ideally shipping would be covered by a global agreement (e.g. a global cap and trade scheme, or a carbon tax). A second-best regional approach could result in ships refuelling in other regions (e.g. in North Africa en route to the EU).

However, there has been limited progress towards a global agreement to reduce international shipping emissions:

- The Kyoto Protocol, signed in 1997, assigned responsibility for developing a framework to reduce international shipping emissions to the IMO.
- Progress has been slow as non-Annex 1 countries have sought to prevent the application of measures which they deem to contravene the UNFCCC principle of common but differentiated responsibility, and the IMO principle of equal treatment.
- In July 2011 the IMO agreed to mandate minimum efficiency levels for new ships. This will be implemented through an Energy Efficiency Design Index (EEDI), which is aimed at reducing emissions from new ships by 30% in 2025. Allowing for fleet turnover, the EEDI will deliver a 30% increase in fleet efficiency by 2050. This is less than the abatement potential we identify in this report.
- The IMO has not been able to gain agreement on market-based measures with stronger incentives, such as an Emission Trading Scheme or Climate Levy.

Going forward, there is a proposal to introduce a shipping fuel levy that will be discussed at the forthcoming UNFCCC summit in Durban. Although this is primarily aimed at raising funds for the $100 billion Green Climate Fund agreed at Cancun, it could be designed in such a way that it is effectively a carbon tax.

At the regional level, the EU has indicated that it will implement its own policies if it deems progress towards a global agreement to be insufficient. A decision on EU action is expected during 2012. If the EU decides to act, implementation is unlikely before the late 2010s.

The approach to international shipping emissions under the Climate Change Act

In our 2008 report, we recommended a 2050 target (i.e. to reduce emissions by 80% on 1990 levels) that included international shipping emissions. This was necessary to ensure that all emissions were accounted for and that the UK target level of emissions for 2050 was consistent with the UK's climate objectives; it was not a recommendation that the UK should aim to unilaterally constrain international shipping emissions, which would require international rather than national approaches.

We considered whether international shipping emissions should be included in the first three carbon budgets, but concluded that they should not, given methodological issues and uncertainties over the international policy framework. As the previous section showed, these issues and uncertainties still remain.

The Climate Change Act therefore currently includes domestic shipping emissions, but excludes those from international shipping from the first three carbon budgets and the 2050 target, requiring that this should be revisited before the end of 2012:

- Under the Act, carbon budgets and the 2050 target must be accounted for in the same way, as defined by the net carbon account.
- International shipping emissions were excluded from the first three carbon budgets because of methodological issues and uncertainties over the international framework. Given the definition of the net carbon account, this implied exclusion of international shipping emissions from the 2050 target.
- Nevertheless, the Act requires that when a budget is set, this should take account of projected international shipping emissions for that budget period.
- The Act also requires that the issue of inclusion should be revisited and that the Government take a decision on inclusion of international shipping emissions, to be agreed by Parliament, before the end of 2012.

This report therefore develops scenarios for UK international shipping emissions which could form the basis for inclusion in carbon budgets and the 2050 target, and sets out alternative options for inclusion.

Current UK shipping emissions

There is a philosophical question around the allocation of global shipping emissions to the UK, to which one reasonable answer is that the UK should be responsible for all of the shipping emissions involved in the transfer of cargos between the UK and its trading partners, either on a production or consumption accounting basis, including emissions from transhipment (i.e. where cargos are transferred between ships part-way through a journey).

Under the Climate Change Act, emissions are accounted on a production rather than a consumption basis. In general, evidence suggests that UK production emissions are less than consumption emissions; this is something we will consider in more detail in our review of carbon leakage and competitiveness, to be carried out in 2012/2013.

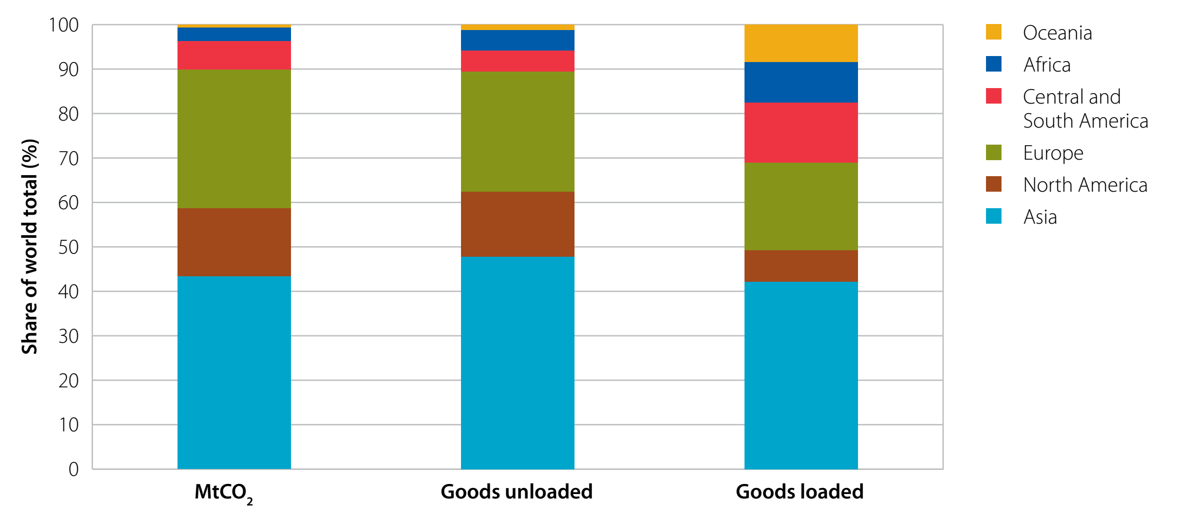
In the case of shipping each vessel that arrives at a UK port (the basis for a consumption estimate) also leaves a UK port (the basis for a production estimate), suggesting a small, if any, difference under these approaches (e.g. due to differences in load factor of arriving and departing ships).

The UNFCCC convention for reporting international shipping emissions is on a bunker fuels basis; this is also the approach to estimating domestic shipping emissions under the Climate Change Act. It may provide a reasonable estimate of shipping emissions at the regional level, but not at the global and national levels:

- At the global level, bunker fuel estimates are likely to be significantly lower than actual emissions due to differences in reporting (e.g. total shipping emissions on a bunker fuels basis were around 0.7 $GtCO_2$ in 2007, compared to the 1.1 $GtCO_2$ activity based estimate).
- At the regional level, international bunker fuel shares broadly reflect trade shares, suggesting that this approach may provide a reasonable estimate for some regions (e.g. Europe, see Figure 2).

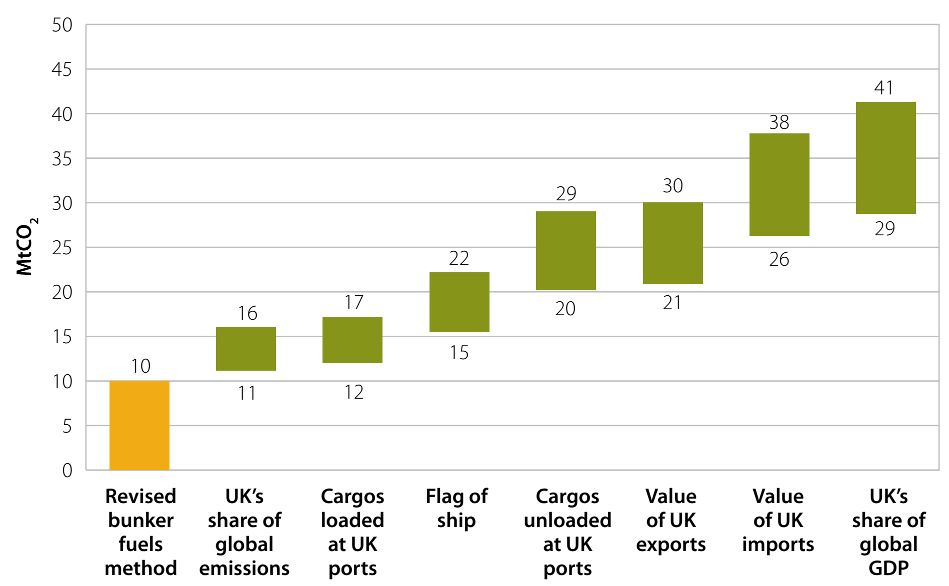
Current UK shipping emissions (continued)

Figure 2: Distribution of global bunker fuel emissions and seaborne trade (2006)



Sources: IEA Statistics; UNCTAD (2011).
Note: Reflects international emissions and trade. Emissions breakdown calculated using bunker fuels estimates.

Figure 3: UK international shipping emissions in 2006 according to bunker fuel and top-down methodologies



Sources: CCC calculations; IMO (2009), Second GHG Study; IEA Statistics.
Note: Upper end of estimates based on IMO international shipping emissions for 2006 (838 $MtCO_2$); lower end of estimates based on IEA estimate of international bunker fuels (584 $MtCO_2$).

At the UK level, bunker fuels estimates are likely to be imperfect, given that a significant amount of UK seaborne trade is transhipped via other EU ports where refuelling may take place: of the 180 million tonnes imported to the UK from non-EU trade partners in 2006, around 30 million tonnes of this arrived via EU ports and 13 million tonnes were transhipped via other non-EU ports.

Alternative top-down estimates of country level international shipping emissions allocate global international shipping emissions on the basis of trade share, and therefore allow for transhipment. At the UK level, these estimates are significantly higher than the bunker fuels estimate (Figure 3):

- International shipping emissions estimated on a bunker fuels basis were around 10 $MtCO_2$ in 2006.
- The range for international shipping emissions under more sensible top-down methods (i.e. trade rather than GDP or flag of ship based) was 12-29 $MtCO_2$ in 2006, depending on whether emissions are allocated according to cargos loaded or unloaded and the assumed global total for international shipping emissions (Box 2).

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Current UK shipping emissions (continued)

Box 2: Top-down and bunker fuel based shipping emission estimates

The UK currently reports shipping emissions on the basis of the total volume of fuel sold ("bunker fuels"). But these exclude the emissions associated with liner shipping and the transhipment of UK cargos. Ships bearing cargos bound for the UK may make multiple port stops, or transfer cargos to other ships en route to the UK. In addition the practice of recording bunker fuel sales varies by country and, when aggregated to the global level, is likely to under-report global shipping emissions.

Top-down measures take a global estimate of international shipping fuel use and then allocate to countries according to their share of a global metric, for example:

- Share of cargos loaded or unloaded, or share of world trade.
- Share of world fleet, based upon flag of registration.
- Share of world income.
- Share of land-based CO_2 emissions.

By using a single metric to allocate global emissions, top-down measures capture transhipment effects but implicitly assume that all countries follow global averages, for example on route lengths, ship sizes and technologies adopted on ships.

Some top-down approaches are difficult to estimate and their characteristics make it unlikely that they will ever be used to measure shipping emissions. For example:

- Measures based upon flag of registration are heavily influenced by the industry's perception of the UK as a regulator.
- Measures, such as share of global income or global CO_2 emissions, do not accurately reflect UK shipping activity and are invariant to efforts to reduce shipping emissions.

Cargo or trade-based measures at least attempt to allocate emissions using a metric which should relate to one aspect of ship activity. However, these measures are not based on ship movements to and from UK ports:

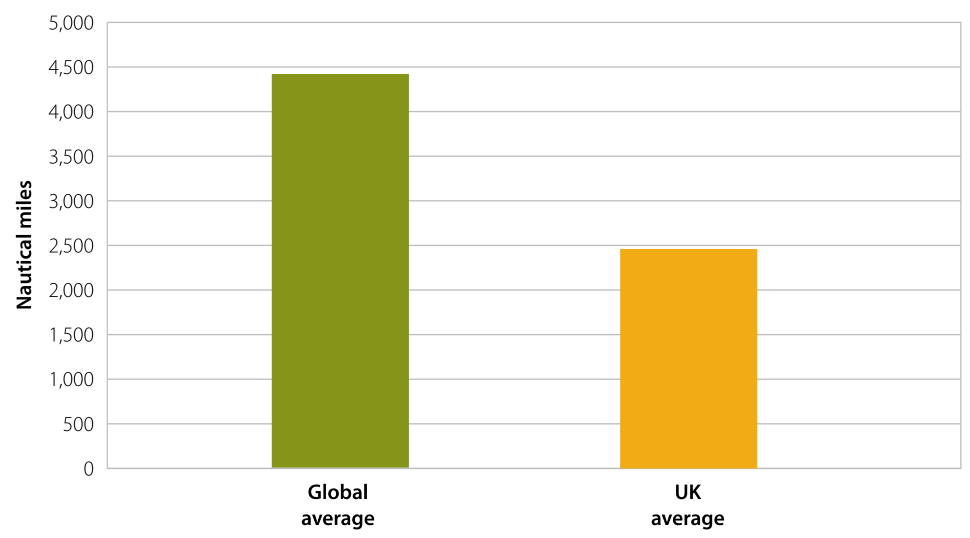
- They produce significantly higher UK estimates for imports than exports, even though the number of ships arriving is the same as the number leaving.
- Furthermore, UK trade is disproportionately concentrated on trade with Europe – a relatively short sea leg. Compared to the global average these measures will therefore tend to over-estimate UK international shipping emissions.
- Non-cargo related ship movements (e.g. fishing) are not included in the apportionment of emissions to countries, benefitting countries with larger than average fishing fleets or with large numbers of service vessels.
- Measures based on trade values suffer from an additional problem in that shares of global trade may change because of changes in the price of exported or imported goods.

Finally, all top-down approaches require a global emissions estimate which is then allocated across countries. IEA data is the most readily available source for monitoring global international shipping emissions although these estimates diverge significantly from activity-based estimates at the global level. Figure 3 presents top-down emission estimates using global estimates of bunker fuel sales and the estimate of global fuel use in international shipping presented in the IMO's Second Greenhouse Gas study.

However, these methods are problematic because they are not derived from actual ship or cargo movements. Moreover they do not allow for deviations from global average carbon intensity and journey length at the national level. Although carbon intensity appears to be broadly similar at UK and global levels, the length of UK ship journeys is a little more than half the global average, suggesting that top-down methods significantly over-allocate international shipping emissions to the UK (Figure 4).

Given problems with these approaches, in this report we use a bottom-up methodology which estimates UK shipping emissions on the basis of the miles travelled by, and the carbon intensity of, ships arriving at UK ports (Box 3). We adopt this approach to try to estimate emissions more accurately, including at a disaggregated level (e.g. by type of ship).

Figure 4: Distance travelled per tonne of international cargo (2006)



Source: CCC calculations.
Note: UK average distance accounts for transhipment by basing route lengths on distances to countries that sell goods to the UK.

Current UK shipping emissions (continued)

Box 3: CCC approach to estimating bottom-up emissions in 2006

We commissioned CE Delft to develop a model to forecast UK shipping emissions out to 2050 for different ship types and routes.

The model was designed to run off a base year emissions estimate derived from the SeaKLIM model provided by Deutsches Zentrum für Luft- und Raumfahrt and using Lloyds data on ship movements. This approach to generating base year emissions was used in a recent European Commission study.

However the SeaKLIM model generated very high estimates of base year emissions relative to those produced by AMEC in a recent study for DfT. This was particularly the case for passenger, fishing and miscellaneous vessels even though it used Lloyds data which significantly under-counted vessel movements: the implication is that differences between the SeaKLIM and AMEC results reflect differences in assumed fuel consumption. As SeaKLIM assumptions on fuel consumption appear to be implausibly high when compared to other estimates (Table B3), we therefore use AMEC assumptions on fuel consumption which are broadly consistent with estimates from the IMO.

We allow for higher base year emissions (e.g. due to transhipment) through estimating the additional distance that cargos might travel to hubs. In addition we include a sensitivity which takes a top-down estimate of UK emissions based on cargos unloaded and adjusts this for the difference between UK average journey lengths and the global average.

Table B3: Implied Fuel Consumption – International Shipping

	Fuel consumption (tonnes/nm)			
	SeaKLIM	**AMEC fuel factors**	**Defra fuel factors**	**IMO fuel factors**
Dry Bulk	0.25	0.11	0.22	0.09
Liquid Bulk	0.18	0.11	0.09	0.12
Unitised	0.21	0.12	0.14	0.10
Passenger	0.93	0.09	0.06	0.12
Fishing	0.97	0.04	n/a	0.02
Misc	0.34	0.04	n/a	0.02

Source: CCC calculations based on Amec (2011), Defra (2011) and IMO (2009).

This methodology provides a range of estimates for UK international shipping emissions:

- Using assumptions on fuel use from a study commissioned by DfT from AMEC, and on the basis of all arriving ships, we estimate that UK international shipping emissions in 2006 were around 10 $MtCO_2$, with around a further 2 $MtCO_2$ due to domestic shipping emissions (i.e. international shipping emissions account for the vast majority of the UK's total shipping emissions). Therefore this approach produces an emissions estimate which is similar to the bunker fuel estimate which the UK currently reports to the UNFCCC.
- Under alternative assumptions on fuel use from a study that we commissioned from CE Delft, international shipping emissions could be up to 25 $MtCO_2$ including an allowance for missing vessel movements. These assumptions draw on a more detailed EU level study carried out for the EC. However, our assessment is that fuel use in the CE Delft study is implausibly high, particularly for fishing, passenger and miscellaneous ship types (Table B3 in Box 3).
- Both of these estimates exclude transhipment to and from the UK. Although the extent of this is highly uncertain, it is likely to be relevant to over 20% of the UK's non-EU trade and could increase emissions by around 2 $MtCO_2$.
- The range of bottom-up estimates is therefore similar to the range from bunker fuels and top-down estimates based on cargos unloaded at UK ports.

Our approach is to project shipping emissions using the CE Delft model with AMEC assumptions on fuel use and including our estimate of emissions relating to transhipment; resulting base year international shipping emissions are 12 $MtCO_2$.

In addition, we include a sensitivity which takes a top-down estimate of UK shipping emissions based on cargos unloaded (29 $MtCO_2$), and adjusts this to reflect the difference between UK and global average shipping distances (e.g. 2,455 miles versus 4,410 miles for international trade); resulting base year international shipping emissions are 16 $MtCO_2$.

We note that with base year emissions of 16 $MtCO_2$, international shipping emissions per person are lower for the UK than the EU (i.e. 0.27 tonnes per person compared to 0.35 tonnes per person). However, we can explain this difference in terms of different trade patterns for the UK and EU with non-EU countries (e.g. a high share of UK imports is accounted for by Norway and Russia) with relatively short journey lengths.

If it were the case that the UK had emissions per person at EU levels, the implied level of international shipping emissions would be 21 $MtCO_2$; we regard this as unlikely, but do not rule it out completely.

The high degree of uncertainty over base year emissions raises questions about the appropriate approach to including shipping emissions in carbon budgets which we consider below.

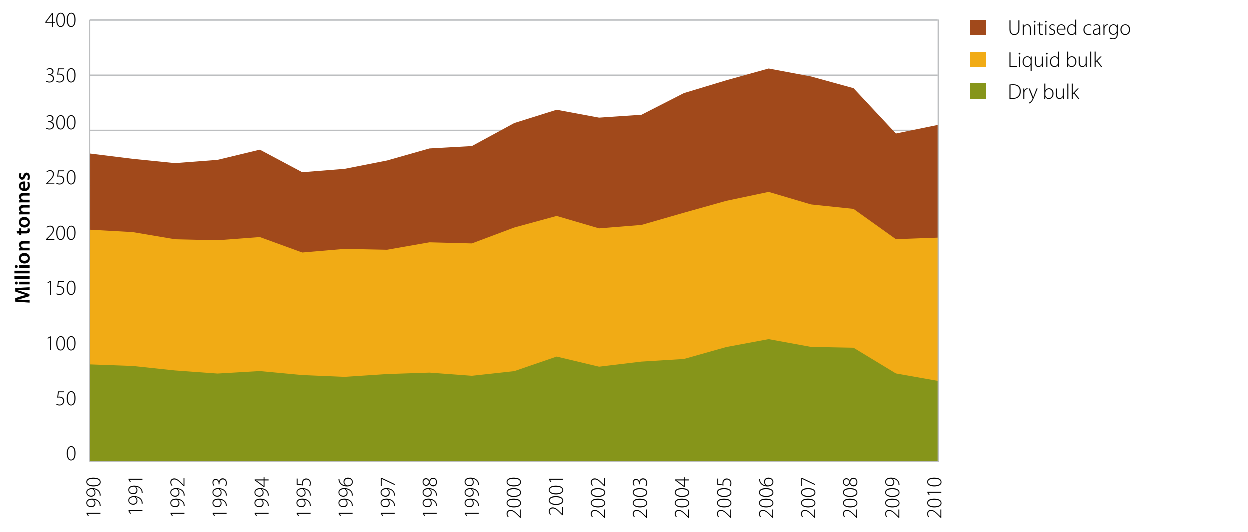
It leads us to recommend that the UK Government should work with the EU and the industry to access fuel consumption data already held by ship operators. This would resolve some of the uncertainty that we have identified, and would be necessary to implement any market-based approach to limiting shipping emissions, either at the regional or global level.

UK shipping demand projections

UK shipping demand on an arrivals basis (i.e. domestic cargo plus international imports) comprises around 99% cargo and less than 1% passenger[1]. Over the longer-term it has increased by 9% since the 1990s for cargo, and fallen by 30% for passengers, with average cargo distances increasing by 9%.

- Total cargo unloaded at UK ports, including from domestic ship movements, rose from 278 million tonnes in 1990 to 355 million tonnes by 2006 (Figure 5). The largest source of the increase was containers and Ro-Ro freight, which grew by around 4% p.a. over the period. Subsequently, largely due to the recession, cargo unloaded fell to 304 million tonnes in 2010 (Figures 5 and 6).
- The total number of passengers arriving at UK ports fell from 22 million to 16 million between 1994 and 2010. The decline was due to very large annual reductions in short-sea passenger movements (3% p.a.), which masks strong growth in long-sea and cruise passenger movements (12% p.a.) (Figure 7).
- Over the period 1990-2010 the average distance travelled per tonne of cargo increased by around 9% (Figure 8).

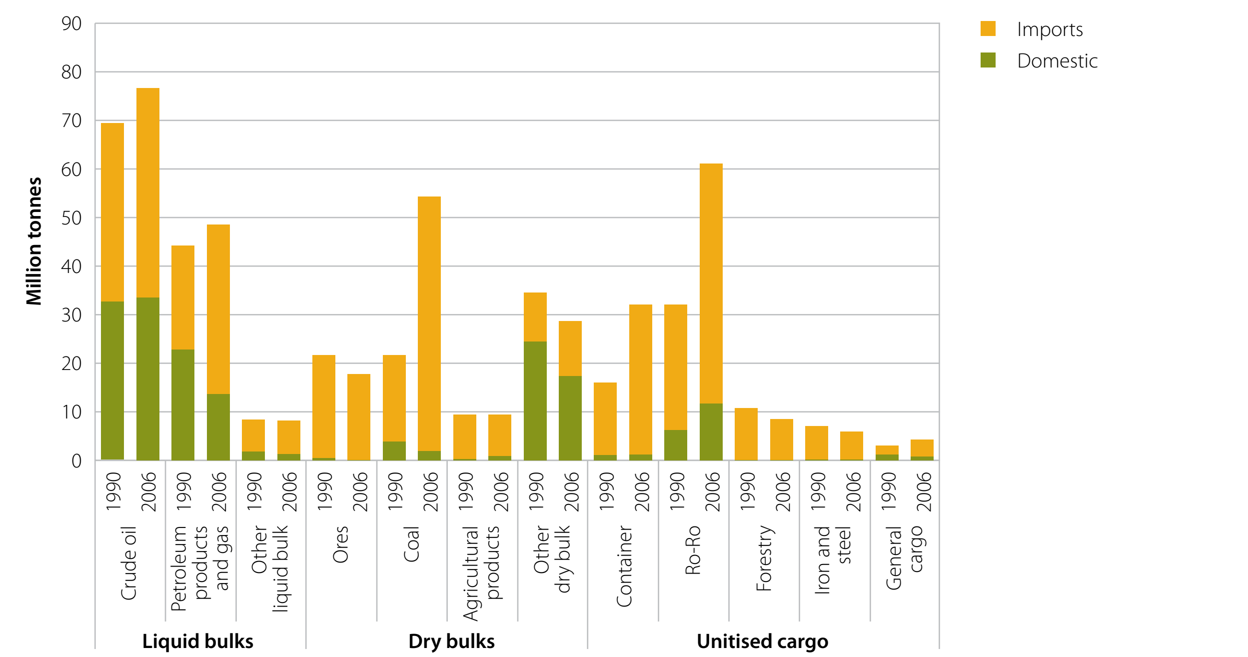
Figure 5: Historic trends in UK cargo demand by category (1990-2010)



Sources: DfT Port Freight Statistics (2011); DfT Maritime Statistics (various).

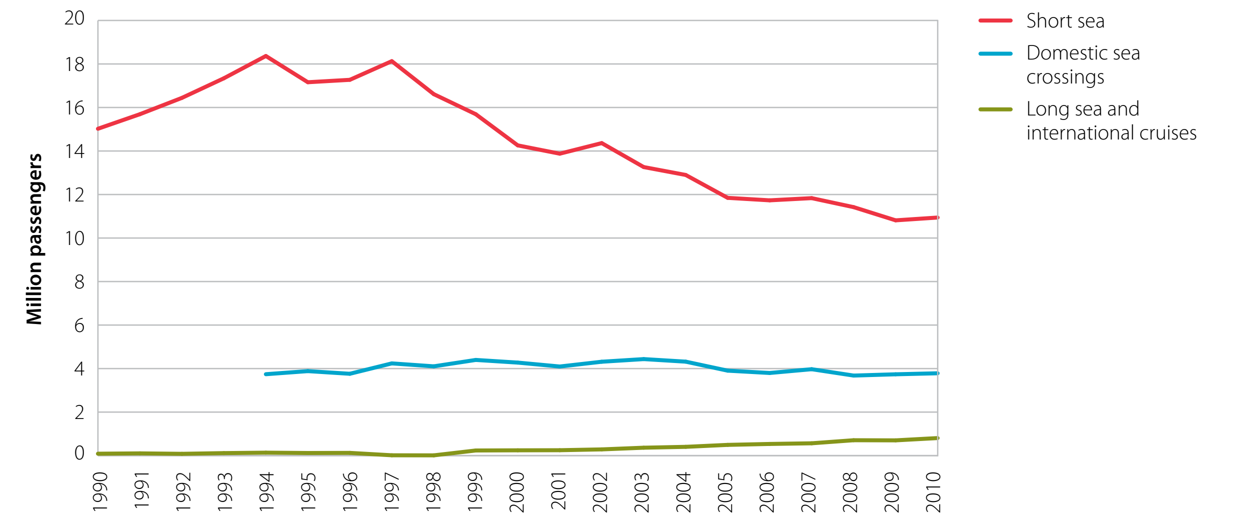
1 Passengers converted to tonnes using a conversion factor of 120kg per passenger.

Figure 6: Breakdown of cargo demand by product type (1990 and 2006)



Source: DfT Maritime Statistics (various).

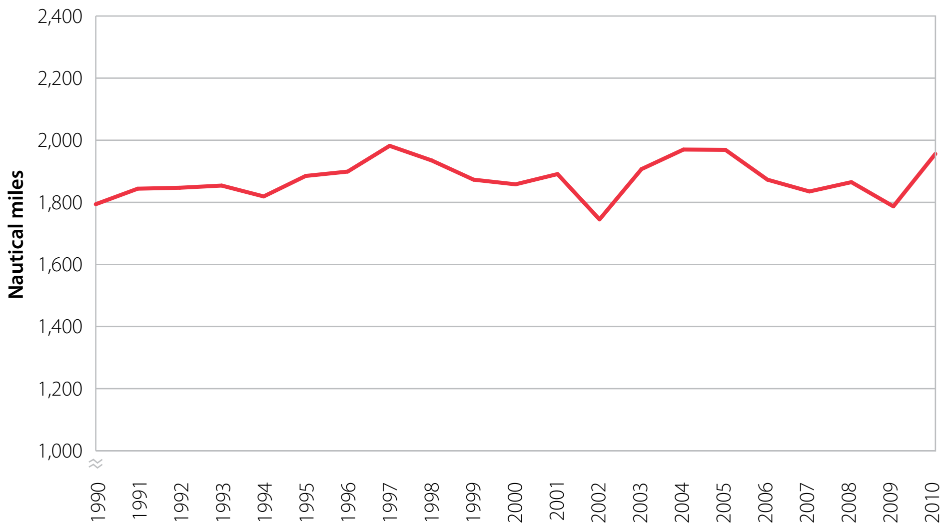
Figure 7: Historic trends in passenger numbers by category (1990-2010)



Sources: DfT Sea Passenger Statistics (various); DfT Maritime Statistics (various).
Note: Domestic sea crossings series not available before 1994.

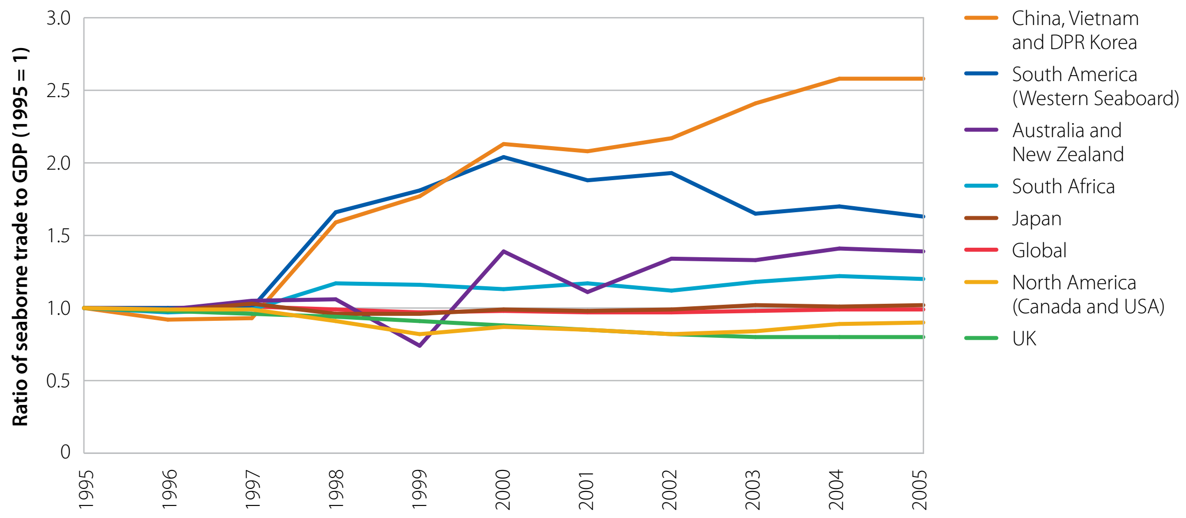
UK shipping demand projections (continued)

Figure 8: Average distance travelled per tonne of cargo (1990-2010)



Sources: CCC calculations; DfT Maritime Statistics (various).
Note: This covers domestic and international cargo and makes no allowance for transhipment effects.

Figure 9: Relationship between income and trade at country and regional levels (1995-2005)



Sources: CCC calculations; UNCTAD Review of Maritime Transport (various).

Going forward, key UK demand drivers include GDP growth, fossil fuel and carbon prices, and UK consumption of fossil fuels and bioenergy:

- **GDP**. At the global level shipping demand has historically tracked GDP suggesting that a 10% increase in GDP increases seaborne trade by around 10%. For developed countries with service based economies, such as the UK, the relationship is weaker (Figure 9). Therefore GDP growth over the next decades is likely to have some impact on shipping demand, particularly for container ships and other unitised vessels.
- **Fossil fuel and carbon prices**. Although there will be some demand response to increasing fuel prices in the future, this is likely to be limited, given the relatively low share of transport costs in total costs of imports (e.g. typically less than 10%), and evidence of relatively low price elasticities (Box 4).
- **Fossil fuel consumption**. Shipping of fossil fuels currently accounts for around a half of UK cargo demand. We would expect exports to decline over time as North Sea reserves are depleted and imports decline due to fuel switching (e.g. emissions reductions in our Fourth Carbon Budget recommendations envisage significant penetration of electric vehicles and a consequent shift away from oil).
- **Bioenergy**. There will be increased imports of biomass and biofuels over the next decade to meet EU targets (e.g. these could account for up to 2% of cargos arriving in ships in 2020). Beyond this, bioenergy imports could increase further, depending on constraints to sustainable supply; we will publish a separate review of bioenergy to 2050 before the end of 2011.

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UK shipping demand projections (continued)

Box 4: Impact of changes in fuel prices on the demand for shipping

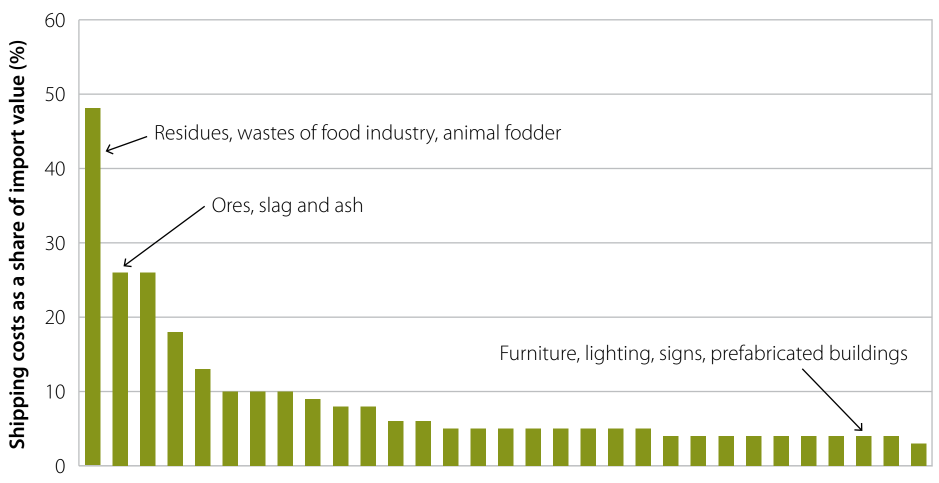
The impact of changes in fuel prices on shipping demand depends upon the following:

- The extent to which changes in fuel prices lead to changes in freight rates
- The share of maritime freight costs in product prices, which is a function of distance and transport efficiency
- The ability of importers to pass through costs to consumers.

Overall, a combination of relative insensitivity of freight rates to changes in fuel prices and a low share of freight costs in total product prices means that changes in fuel prices are likely to have a modest impact on shipping demand:

- Analysis suggests that freight rates are relatively insensitive to changes in the bunker fuels price for most cargo types:
  - Vivid Economics estimate that a 10% increase in fuel prices will increase the freight rate by between 1% and 10% depending upon the cargo. Capesize ore vessels were the most responsive, with container ships being the least responsive.
  - Analysis by UNCTAD suggests that a 10% increase in fuel prices would increase container freight rates by 2-4%, ore freight rates by 9-11% and crude oil freight rates by just under 3%.
- The share of maritime freight costs in product prices is below 10% in most cases (Figure B4), the exception being low value to weight items such as ores.
- Estimated pass-through rates can vary significantly depending upon the share of imports in total consumption and the competitiveness of local markets and imports:
  - Vivid Economics' analysis estimated pass through rates to vary between 5-100% depending on the commodity traded and the trade route.

Figure B4: Transport costs of products imported into the EU from the US by sea



Source: OECD.
Note: Reflects imports to EU15. Costs refer to shipping costs as a proportion of import value (2006 data or latest year).

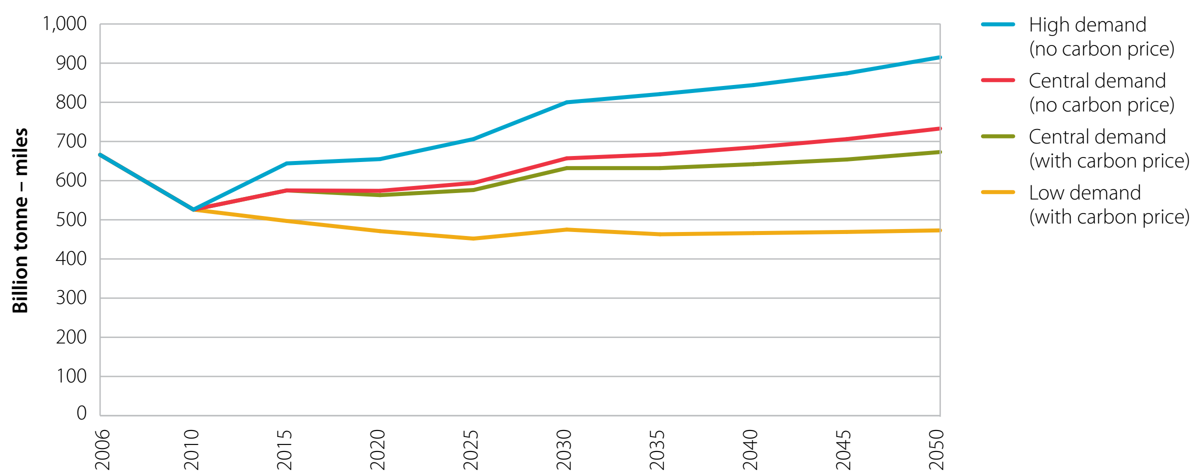
In this report, we develop scenarios by considering shipping demand in 16 individual sectors, projecting to 2050 on the basis of historical trends and taking into account likely structural breaks (e.g. all scenarios take into account that decarbonisation is likely to reduce imports of fossil fuels).

Our three key demand scenarios reflect different assumptions on demand drivers and result in a range for demand growth of between -0.8% and 0.7% p.a. between 2006-2050 (Figure 10):

- In our **Low demand** scenario, which includes a carbon price rising to £200/tCO_2 in 2050, tonne-miles fall by 0.8% p.a. between 2006 and 2050.
- In our **Central demand** scenario tonne-miles are broadly flat between 2006 and 2050 if a carbon price is introduced and increase by 0.2% p.a. if not.
- In our **High demand** scenario, which does not include a carbon price, tonne-miles increase by 0.7% p.a. between 2006 and 2050.

If there was no improvement in the carbon efficiency of ships using UK ports then this would increase total emissions (i.e. domestic and international) from 14 MtCO_2 to up to 21 MtCO_2 by 2050, depending upon the demand scenario. However, there is a range of options for reducing shipping emissions. We now consider these options and bring together our analysis of demand and abatement in a set of shipping emissions scenarios to 2050.

Figure 10: Future demand scenarios for UK shipping (2006-2050)



Source: CCC analysis.
Note: 2006 and 2010 values based on outturn cargo demand.

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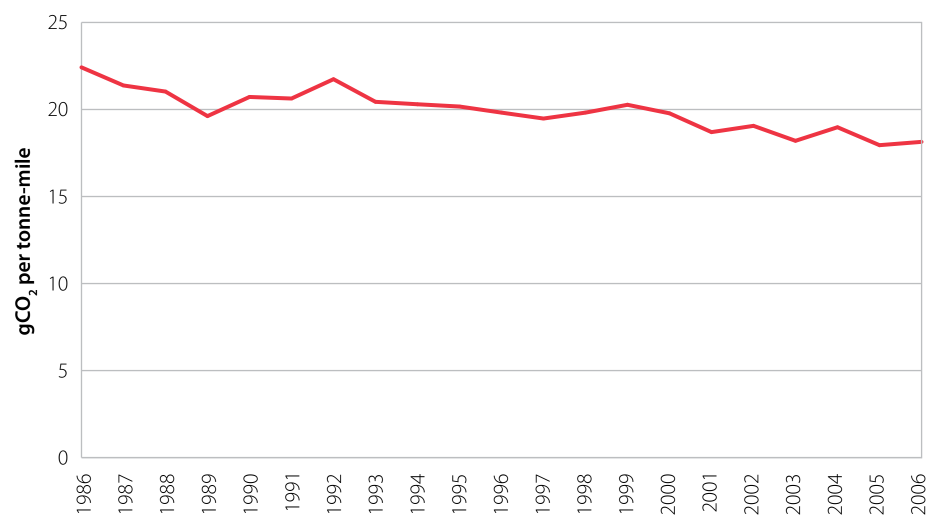
Globally, average fuel efficiency in shipping – measured as the amount of fuel used per tonne-nautical mile – has improved by around 1.1% annually. This is through a combination of increased ship size and technology and operational improvements:

- The key driver has been new ship fuel efficiency.
  - Ships built in 2000 are over twice as 'efficient' as ships built in 1940 (i.e. they use only half as much fuel per tonne-mile).
  - This is due to increased ship size and technology improvements, which would have been partly offset by an increase in design speeds.
- More efficient new ships are slowly absorbed into the fleet as the fleet expands and old vessels are retired.
  - Ships have an average life of around 30 years (i.e. ships built in 1980 will be leaving the fleet now).
  - The number of vessels in the global fleet has expanded at an annual rate of around 1% since 1980.
- The combination of more efficient new ships, fleet rollover and expansion has seen a steady fleet fuel efficiency improvement of around 1.1% per year (Figure 11).

Figure 11: Historic trend in fleet fuel efficiency (1986-2006)



Sources: CCC calculations; ISL Shipping Statistics Yearbook (2007); IEA Statistics.
Note: Emissions estimate derived from IEA international shipping bunker fuels.

In future, there is further scope for efficiency improvement through larger ships, technology and operational improvements, and use of biofuels and Liquefied Natural Gas (LNG).

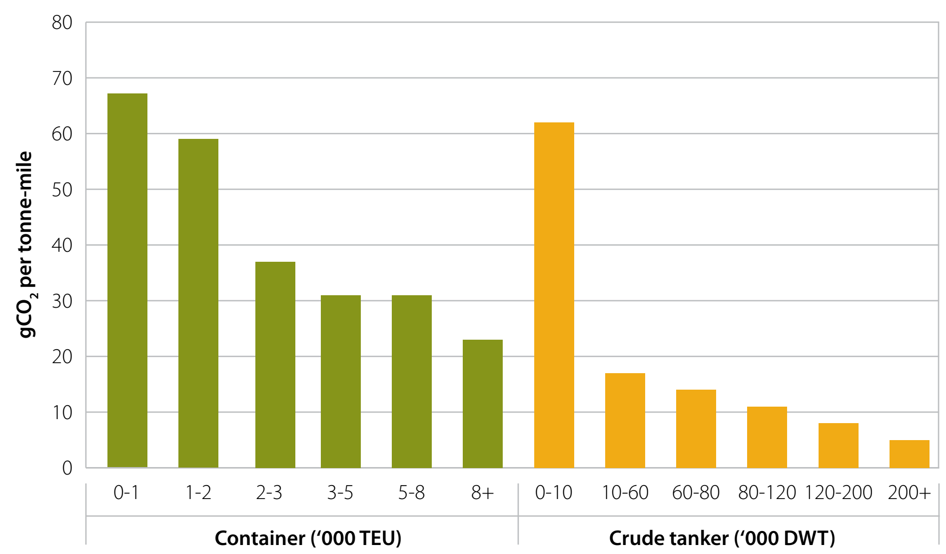
Larger ships

The carbon efficiency of ships improves significantly with ship size (Figure 12):

- For container ships, the largest ships are around three times more carbon efficient than the smallest for a given load factor.
- For crude tankers, the largest ships are a little more than ten times more carbon efficient than the smallest for a given load factor.

Globally, ship sizes have increased by 2.5% p.a. since 1990 (Figure 13). Going forward, there are limits to increasing ship sizes (related to the economics of routes and limits imposed by physical infrastructure e.g. port and canal sizes). However, IMO analysis suggests that ship sizes could increase by 0.3-1.4% p.a. to 2050 depending upon ship type. In combination with a shift towards unitised vessel types with above average emission intensities, and assuming constant load factors, operations and ship board technologies, the average carbon efficiency per ship is expected to fall from 37.1 gCO_2/tonne-mile to 34.6 gCO_2/tonne-mile in 2050.

Figure 12: Carbon efficiency of container vessels and crude tankers



Source: IMO (2009), *Second GHG Study.*
Note: Assumed load factor is 70% for containers and 48% for crude tankers.

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Abatement opportunities in shipping (continued)

Figure 13: Historic trends in average ship size growth (1970-2010)

Source: ISL Shipping Statistics Yearbook (2007, 2010).

Technology and operational improvements

There are a number of technologies and operational improvements that could help achieve further fuel efficiency improvements in new ships, or be retrofitted to existing ships. These include:

Technological

- Upgrades to **propulsion systems** and changes to engines, such as tuning to a lower power output or electric drives. Towing kites can also be employed to allow ships to use energy from the wind, weather conditions and route permitting.
- Application of **hull coatings** to reduce friction and fuel consumption, or increases in the frequency of hull cleaning.
- Changes to **auxiliary power systems**, such as improving energy efficiency, using solar or wind power and improving boiler technology.
- Optimisation of the **hull**, including the addition of bulbous bows. Although still unproven **air lubrication** of the hull for new vessels, where the ship floats on a carpet of bubbles, may reduce frictional resistance.

Operational

- **Reducing speed** which, because power requirements increase as the cube of speed, saves fuel even if the journey takes longer.
- **Software** that combines logistical planning with weather data to ensure that the ship sails the safest and most efficient route given the weather it is likely to encounter.
- Routine **monitoring** using software packages to optimise ballast and trim.
- **Improvements to port turn-around times** and access to real time port congestion information can reduce emissions by allowing ships to sail slower rather than proceeding at normal speed and waiting at anchor until a berth becomes available.

Fuel Switching

Biofuels

There is a potential opportunity for fuel switching in shipping to biofuels. These are technically feasible, and could become economically viable depending on the relative price of fossil fuels and biofuels, including whether shipping is covered by a carbon price.

Notwithstanding that biofuels are treated as zero carbon under the Climate Change Act, there are concerns over the lifecycle emissions associated with the production of biofuels (i.e. from cultivation, processing and transportation, and possible land-use change impacts).

There are also concerns over the tension between the use of land to grow food and its use for biofuel feedstock production. This is likely to become more of an issue over time as global population and incomes increase and diets in developing countries become more carbon intense.

Therefore there may be limited biofuels available for use in shipping, both because of limits on overall bioenergy availability, and the possible use of scarce bioenergy in sectors where it may be valued more highly than shipping (e.g. industry).

These are issues which we are considering in detail in our bioenergy review, to be published before the end of 2011. For the purposes of this report, we follow the IEA and assume that, at most, biofuels account for up to 15% of energy used by ships by 2050.

Abatement opportunities in shipping (continued)

LNG

There is also the possibility that LNG could be used in ships, which has a lower carbon intensity per unit of energy compared to conventional fuels (i.e. it has a CO_2 intensity around 70% of conventional fuels).

However, LNG has lower energy density than conventional fuels and requires more space for storage. Methane emissions and losses during bunkering would also reduce LNG's carbon advantage. In addition, it would require new infrastructure for ship refuelling with potentially significant investments.

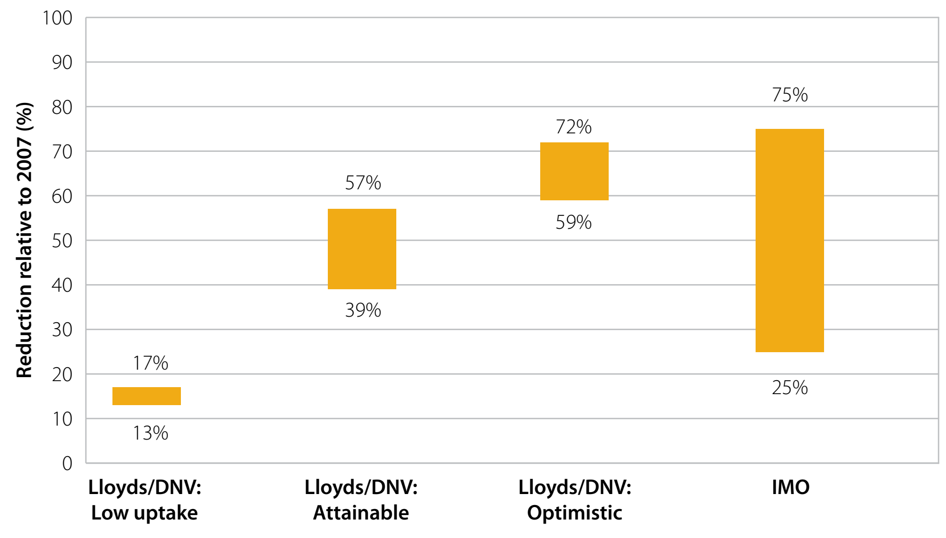
Reflecting this combination of factors, and following the IEA, we assume in our abatement scenarios that LNG remains a fuel for specialised or domestic vessels (e.g. LNG tankers), accounting for 5% at most of total energy use in ships in 2050.

Total abatement potential

Taken together, analysis by IMO and Lloyds/DNV suggests that technological and operational measures and new fuels could reduce emissions intensity by over 70% in 2050 relative to 2007 levels (Figure 14). This is however subject to a high degree of uncertainty for at least two reasons:

- Some abatement measures may not represent actual emissions savings because they are already standard in ships.
- Some measures, such as air lubrication, depend upon the technology being made to work in real sea conditions.

Figure 14: Reduction in emission intensity by 2050



Sources: Lloyds/DNV (2010); IMO (2009), *Second GHG Study.*
Note: Range in Lloyds/DNV study reflects abatement potential of different ship classes.

In addition barriers to the deployment of these measures include:

- Split incentives – the owner of the ship may place a lower premium on fuel economy than the user of the ship who pays the fuel bills.
- Some measures may be resisted by customers of shipping companies, for example introduction of slow steaming may cause disruption if there are not enough ships to maintain the frequency of deliveries.
- Uncertainty over how particular measures will perform leading to higher hurdle rates for investment.

The different levels of take-up of these measures in our scenarios below reflect different assumptions on these uncertainties and barriers.

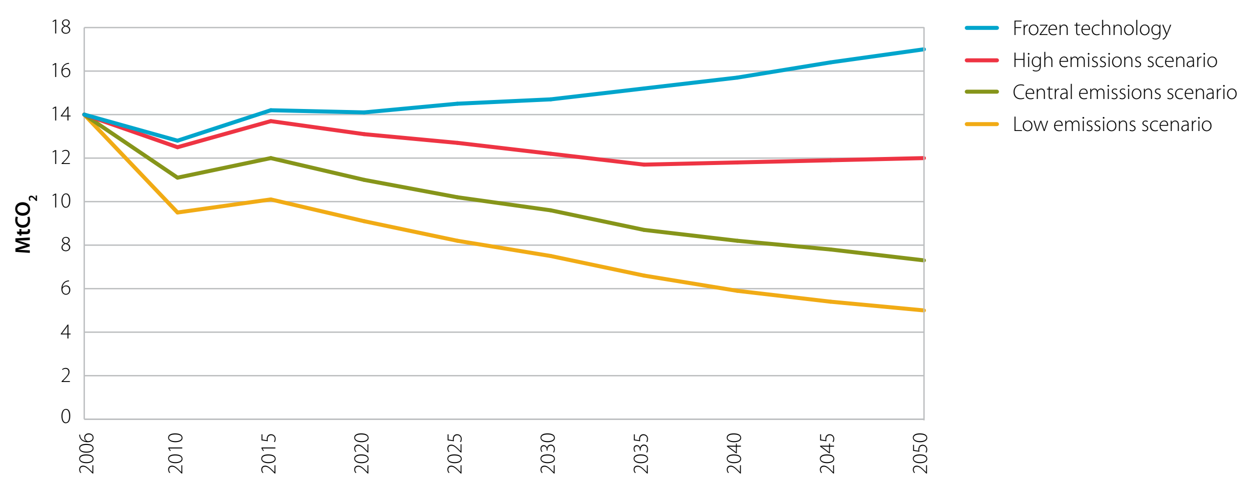
Low, central and high emission scenarios

We now set out three shipping emissions scenarios which overlay three abatement scenarios on our *central demand scenario*. These are compared to a frozen technology scenario which assumes that there is no change in ship size and no change in operations, technology or fuel use (Figure 15):

- **High emissions scenario**. This is a pessimistic scenario, where the IMO's target for its EEDI (i.e. 30% improvement of new ship fuel efficiency by 2025) is achieved, but that there is very limited further abatement, and in which total shipping emissions, including domestic, in 2050 are 12.0 Mt CO_2 (15% below 2006 levels).
- **Central emissions scenario**. Total emissions in this scenario in 2050 are 7.3 $MtCO_2$ (48% below 2006 levels). This assumes:
  - The take-up of abatement measures goes beyond that required to meet the EEDI, with 50% of technical and operational measures deployed and including slow steaming.
  - Increased demand for containerised goods means that the average size of unitised vessels arriving at UK ports increase in size in line with IMO projections (i.e. they grow in size by 1.4% annually, while the sizes of other ships remain constant). We assume that this growth is achieved by increasing the share of larger ships in the fleet, rather than increasing the size of the largest vessels.
  - 5% of energy is derived from biofuels and 2.5% is derived from LNG by 2050.
- **Low emissions scenario**. Total emissions in this scenario in 2050 are 5.0 $MtCO_2$ (65% below 2006 levels), under assumptions that:
  - There is full take-up of abatement potential from technological and operational measures, including slow steaming.
  - Unitised and dry bulk vessels arriving at UK ports increase in size in line with IMO projections (i.e. dry bulks grow in size by 0.5% annually).
  - 15% of energy is derived from biofuels and 5% is derived from LNG by 2050.

These scenarios deliver a 15-65% emissions reduction relative to 2006 levels. They highlight a potentially significant opportunity to reduce emissions, and suggest the need for new policies with more ambition and stronger incentives to ensure that this potential is delivered.

Figure 15: Future emission scenarios for UK shipping (2006-2050)



Source: CCC analysis.
Note: These projections include domestic and international shipping, take into account 2 $MtCO_2$ from transhipment and are based on our central demand scenario.

Sensitivities and uncertainties

The range above reflects only uncertainties relating to abatement opportunities. However, there are also significant uncertainties relating to demand and base year emissions with the possibility that 2050 emissions could be significantly higher:

- With high demand and our high emissions scenario, total emissions are around 15 $MtCO_2$ in 2050.
- Using an adjusted top-down estimate as base year emissions (i.e. international emissions are 16 $MtCO_2$ in 2006), with high demand and our high emissions scenario, gives total projected emissions of around 19 $MtCO_2$ in 2050.

The range for total projected emissions, including domestic, in our scenarios and sensitivities is therefore from 5 to 19 $MtCO_2$ in 2050, of which international emissions could account for up to 18 $MtCO_2$. The high degree of uncertainty and the potentially high level of shipping emissions implied by the range have an important bearing when considering approaches to including international shipping emissions in the 2050 target and carbon budgets.

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Including international shipping emissions in the 2050 target and carbon budgets

Including international shipping emissions in the 2050 target

It is crucial that international shipping emissions are, at some point, included in the UK's 2050 target to reduce emissions by 80% on 1990 levels. This target was specifically designed to include international shipping emissions. Excluding them from the target here and in other countries would leave a level of emissions incompatible with achieving our climate objective (e.g. global CO_2 emissions in 2050 could be over 20% higher than is required to achieve the climate objective).

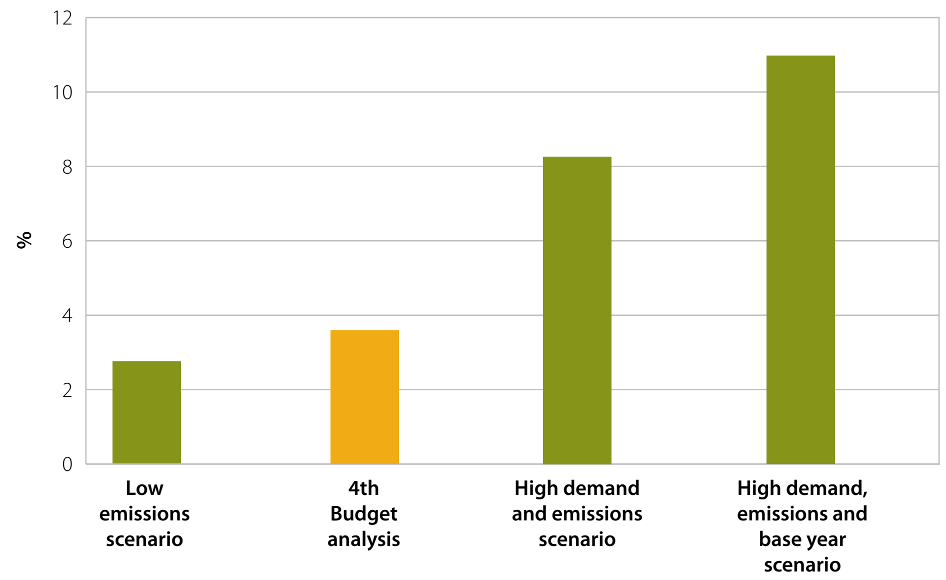
International shipping emissions are also a key factor in determining carbon budgets. For example, high levels of shipping emissions in 2050 would imply the need for further decarbonisation in other sectors, which would require more action in the period to 2050. Therefore the approach to shipping emissions will have a material effect on decisions to be taken in the next five years about the fourth and fifth carbon budgets.

Projected international shipping emissions in the context of the 2050 target

Our projected international shipping emissions could account for a significant proportion of total allowed emissions under the 2050 target in the Climate Change Act:

- The emissions limit under the 2050 target to reduce emissions by 80% on 1990 levels is around 160 $MtCO_2e$.
- This remains valid using data from our bottom-up methodology rather than a bunker fuels estimate of shipping emissions (Box 5).
- Our projected international shipping emissions of up to 18 $MtCO_2$ could account for up to 11% of total allowed emissions in 2050 (Figure 16).

Figure 16: UK international shipping's share of allowed 2050 emissions



Source: CCC analysis.

Box 5: 2050 emissions budget based on CCC emission estimates

To assess the implications of the bottom-up methodology for the UK's emission budget in 2050 an estimate of shipping emissions in 1990 is needed. We therefore re-estimated the 1990 inventory using the bottom-up method employed for the 2050 estimates. In order to do this we back-casted shipping demand and emissions intensity.

Demand

We built a time-series of tonne-miles by cargo category (liquid bulk, dry bulk, containers) and passenger-miles for each route (e.g. North America to UK) between 1990 and 2006.

- We calculate tonne-miles by combining historical data on tonnes traded by region from DfT statistics with average route lengths. As the regional split for tonnes is not available for 1990-99, we assume region shares constant at 2000 levels.
- For passengers, we use DfT Sea Passenger Statistics to allocate passengers to different routes.
- Fishing and Miscellaneous demand was back-cast on the basis of tonnes of fish landed into the UK, and an all ports UK ship arrivals measure respectively.

Including international shipping emissions in the 2050 target and carbon budgets (continued)

Box 5: 2050 emissions budget based on CCC emission estimates

Emission intensity

- We assume the emission intensity of ships using UK ports improved at the same rate as the global historical average (i.e. at 1.1% p.a.; see Figure 11).

Emissions

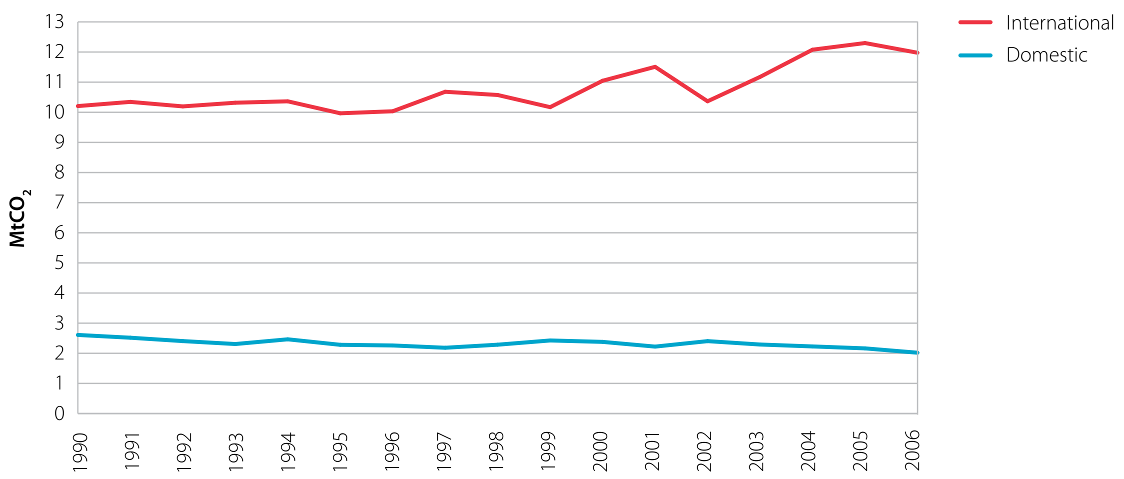
As a result of these assumptions total emissions between 1990 and 2006 increased by around 0.6% p.a. (Figure B5).

Implications for the 2050 target

The difference between our emissions estimates for 1990 and the bunker fuel estimate used to calculate the 80% target is small. This means that the 80% target still implies an emissions budget of around 160 $MtCO_2e$ in 2050:

- The CCC's recommendation to reduce emissions by 80% relative to 1990 was based on a total economy-wide emissions estimate of 797 $MtCO_2e$ in 1990 which included total shipping emissions on a bunker fuel basis, i.e. 11 $MtCO_2$.
- If total shipping emissions in 2006 were 14 $MtCO_2$ then we estimate that total shipping emissions were 13 $MtCO_2$ in 1990, i.e. total economy-wide emissions in 1990 would have been 799 $MtCO_2e$.
- If total shipping emissions in 2006 were 18 $MtCO_2$ then we estimate that total shipping emissions were 16 $MtCO_2$ in 1990, i.e. total economy-wide emissions in 1990 would have been 802 $MtCO_2e$.

Figure B5: UK domestic and international shipping emissions (1990-2006)



Source: CCC analysis.

This implies a tight limit on emissions for the rest of the economy, which becomes more pronounced when international aviation emissions are accounted for. For example, under an assumption that the target to reduce aviation emissions in 2050 back to 2005 levels is achieved, international aviation and shipping emissions could account for up to 33% of total allowed emissions, suggesting the need to cut emissions in other sectors of the economy by up to 86% relative to 1990 levels.

Although highly uncertain, international shipping emissions are material and should be included in the 2050 target, with implications for required emissions reductions in other sectors. In order to better understand and to minimise these implications, steps should be taken to reduce the degree of uncertainty and the level of shipping emissions.

- International shipping emissions are material in the context of the 2050 target, thus the need to include them in the target is reinforced.
- Potentially high shipping emissions in 2050 strengthens the case for almost full decarbonisation of power, buildings and surface transport, given the existence of hard to reduce sectors such as aviation and agriculture.
- In order to support the development of the carbon strategy, further analysis is desirable to reduce uncertainties over future shipping emissions (e.g. on base year emissions, demand and abatement opportunities).
- The burden that shipping places on other sectors in terms of required emissions cuts could be reduced significantly if abatement opportunities are addressed. This reinforces the need for international policies to encourage full deployment of abatement measures.

Given the need to include shipping emissions in the 2050 target, this raises the question of whether and how these should be included in carbon budgets.

Including shipping emissions in carbon budgets

Under the current design of the Climate Change Act, if international shipping emissions were to be included in the 80% target, they must also be included in carbon budgets. In principle, inclusion is straightforward, and would require adding projected international shipping emissions to currently legislated carbon budgets. However, this is much more complex in practice, given the range for projected shipping emissions, and therefore the uncertainty over which projection to use.

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Including international shipping emissions in the 2050 target and carbon budgets (continued)

Given this complexity, we set out three options for further consideration:

- **Option 1.** International shipping emissions are included now in carbon budgets and the 2050 target. This would raise questions about the basis for inclusion (e.g. imperfect bunker fuels or top-down methodologies versus an undeveloped and uncertain bottom-up methodology) and would introduce additional risks for meeting carbon budgets (e.g. if projected shipping emissions were underestimated).
- **Option 2.** International shipping emissions are included in carbon budgets and the 2050 target when progress has been made on developing internationally agreed methodologies for estimating emissions. This would raise questions about the treatment of shipping emissions in the context of decisions to be made on carbon budgets prior to such progress being achieved.
- **Option 3.** International shipping emissions are included in the 2050 target now, but in carbon budgets at a later date. This would raise questions about the basis for inclusion, and legal questions around re-defining the net carbon account in the Climate Change Act.

We will consider these options and discuss them with relevant parties over the coming months, and propose an appropriate way forward as part of our advice on inclusion of international aviation and shipping emissions in carbon budgets, to be published in Spring 2012.

Implications for Government strategy and policy

In the meantime, and as noted above, it is important for the Government to develop 2050 pathways and a Strategy aimed at achieving a 2050 target of 160 $MtCO_2e$ including international shipping emissions of up to 18 $MtCO_2$; we expect that the Strategy will be published at the end of the year.

In order to resolve uncertainties about future shipping emissions, better data are required about current emissions. In particular, better data are required on fuel consumption of ships arriving at UK ports. These data are held by ship operators but would require primary legislation to access them. The Government should work with European partners to gain better data on fuel consumption, with a view to estimating current emissions and projecting future emissions more accurately.

Finally, our analysis suggests that there is a significant amount of cost-effective abatement potential in shipping. To reduce economy-wide costs of abatement, the Government should argue for international policies going beyond what has currently been agreed by the IMO, such as including international shipping within an emissions trading scheme or carbon tax regime. As discussed earlier this would ideally be through the IMO, or the UNFCCC (e.g. through the proposed fuel levy to be discussed at the forthcoming Durban summit) but failing this, inclusion of international shipping in EU ETS in a way that anticipates and is compatible with a future global agreement should be considered.

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