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Tyndall°Centre for Climate Change Research

Aviation in the North West: Emissions, Economics and Organisational Flying

A research synthesis report by The Tyndall Centre, University of Manchester

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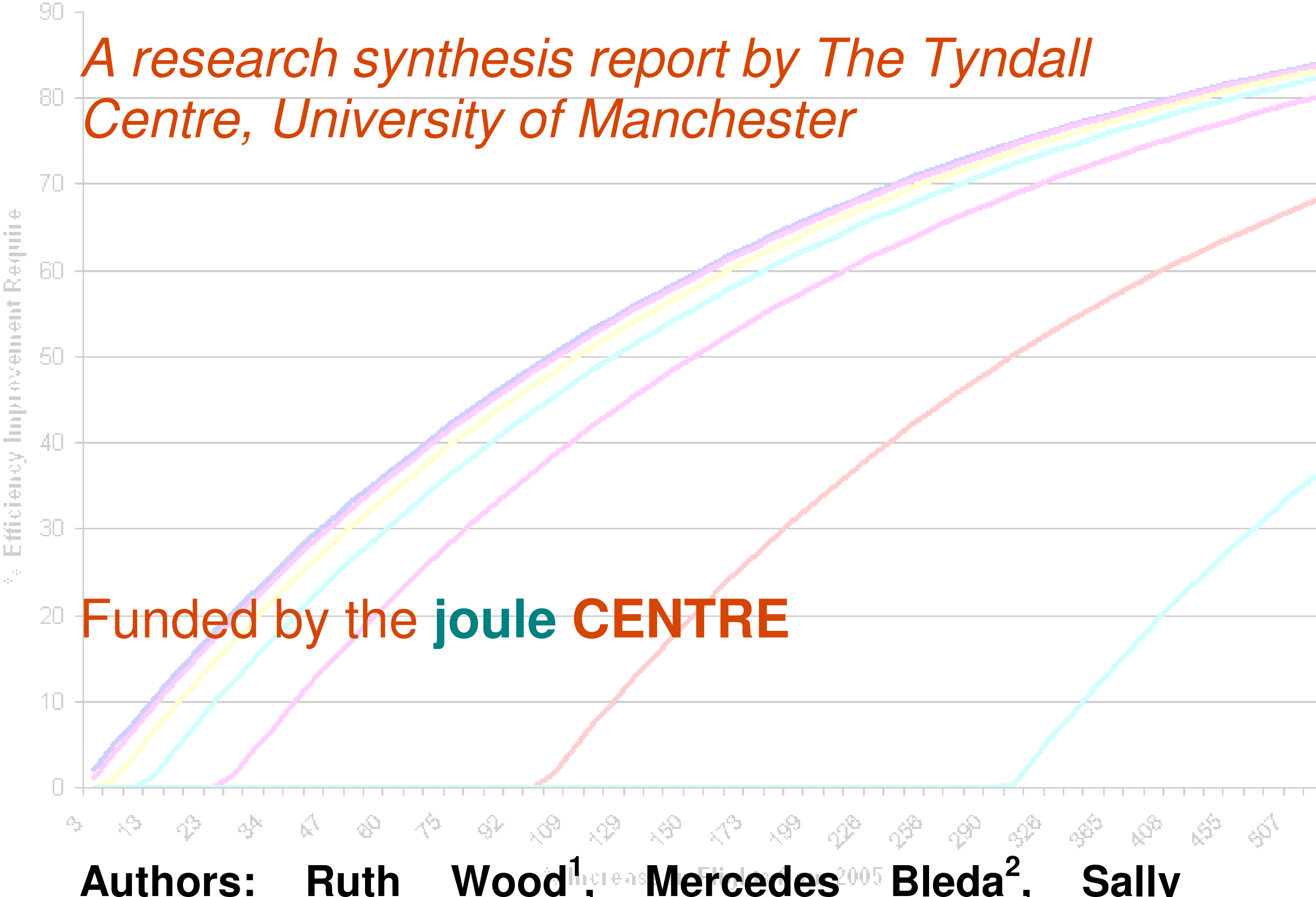

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Contents

Executive summary

The international community recognises climate change as one of the greatest threats facing the social, environmental and economic well-being of humankind. At a national level, the UK has demonstrated a clear international lead in responding to climate change by putting the need for and delivery of greenhouse gas emissions reductions on a statutory footing through the Climate Change Act 2008. This act introduced legally-binding targets to achieve emission reductions in both the short and longer term. Furthermore, and unlike previous UK emission reduction policies, the Climate Change Act includes international aviation emissions explicitly in its 80 per cent 2050 target and implicitly within the current budgets.

Accordingly, the regulatory and policy framework stipulates that the contribution of aviation emissions (and any growth in these emissions) must be deducted from (or otherwise accounted for) by alterations in the emissions budgets for other sectors[1].

For the UK as a whole, then, there is a clear need to balance the cost and overall economic impact of delivering additional reductions in greenhouse gas emissions for these 'other' sectors versus the costs and economic impact of curbing growth in emissions from aviation.

For the North West achieving an appropriate balance between these competing pressures is particularly important as the region is:

- host to three passenger airports (Manchester, Liverpool and Blackpool);
- home to aerospace industries and expertise that could capitalise on the economic opportunities of delivering emissions reductions in aviation (for example, Airbus, BAE Systems, Rolls Royce, the University of Manchester Aerospace Research Institute (UMARI) and the Centre for Air Transport Research (CATE) at Manchester Metropolitan University); and
- an area with a high density of industrial and other sectors that are already committed to making significant reductions in emissions.

Delivering reductions in greenhouse gas emissions from all sectors (including aviation) requires support and action from all tiers of government, including Regional Development Agencies (RDAs). With respect to aviation, regional bodies are able to influence the sector's emissions in conjunction with other actors through a range of mechanisms, including: funding low carbon initiatives; influencing regional strategic planning and development; and, importantly, facilitating between regional actors.

Given the North West's high exposure to potential impacts and trade-offs associated with the aviation sector's emissions, the RDA needs to give early consideration to how to balance future emissions from aviation with those from other sectors.

In order to contribute an evidence base to the North West's deliberation over these trade-offs, the Tyndall Centre for Climate Change Research, funded by the Joule Centre for Energy Research, has analysed the emissions, economics and policy

[1] Here, for example, the Committee on Climate Change identifies that "whilst aviation and shipping emissions are today both relatively small as a percent of total global emissions they are likely, if unconstrained, to grow to much larger shares. It is therefore essential either to curtail emissions growth significantly or to set more stringent targets for all other sectors which compensate for the difficulty of achieving cuts in these sectors."

implications of the region's aviation industry[2]. The objectives of the Tyndall Centre study are:

- to produce an approach for disaggregating the UK's aviation emissions to a regional scale;
- to develop a set of low carbon pathways for the North West region that include aviation;
- to review existing assessments of aviation's economic contribution and to estimate the specific contribution to the North West;
- to analyse the behavioural practices related to flying with specific reference to the North West;
- to use the results of the analyses to provide advice to the region as to how it can support socio-economic and environmental development in the region.

Key findings:

Emission apportionment
The Tyndall Centre's hybrid apportionment regime developed for this project permits aviation emissions to be attributed, using a method acceptable to a wide range of stakeholders, to a regional scale (Wood et al 2010). Consequently, the RDA is now able to apply an approach that takes into account both the producers and users of aviation services. In doing so, it provides clear links between those organisations or individuals with influence over the direct production of the emissions and the use of the services provided. In addition, it enables ongoing monitoring of emission reduction measures across the aviation system, including the impact of policies made by airports, airlines and air traffic control or those aimed at aviation users to reduce emissions from both the Landing and Takeoff (LTO) cycle and cruise emissions. By explicitly dividing the emissions burden between producers and consumers, the hybrid approach reflects fairly the benefits the region receives through hosting an airport and from the services provided to residents and visitors to the region.

Future scenarios
Within the stakeholder-led scenarios, aviation is a key sector of the North West's low carbon transition. Despite assuming improvements to fuel efficiency, increased availability of alternative fuels and a reduction in growth rates, all stakeholder scenarios resulted in aviation taking a bigger share of total emissions in the North West by 2050. This places additional pressure on other sectors to decarbonise over and above the 80 per cent reduction. Allying the industry's own ambitious ACARE targets with the stakeholder's growth rates would lessen, but not eliminate, this additional pressure from other sectors.
A clear challenge for the aviation industry is therefore to commit to and implement a strategy for delivering a **step-change** reduction in carbon intensity alongside tackling growth rates. The North West is well placed to benefit economically from such a strategy given the regional density of the aerospace industry and academic capacity.

Flying for work
There is a wide spectrum of flying practices across organisations depending on their degree of internationalisation, sustainability and carbon accounting strategies. Regardless of organisation size and type (public or private), it is the function of the organisation and their awareness of carbon and sustainability issues that influences how often its individuals fly for work purposes. Building on this, the work-related flying analysis within this report provides a framework with which the RDA can: identify

[2] The analysis has focused primarily on the services provided by aviation.

those organisations of particular economic significance in relation to their flying practices and accompanying carbon emissions; develop monitoring schemes for carbon emissions appropriate for different organisations; compare the sustainability practices across and within organisational type; and encourage and identify new training needs. Furthermore, the framework can be used to identify opportunities for substituting work-flying with information and communication technology (ICT) within organisations with a high propensity to fly, thereby reducing the pressure on other organisations to compensate for the high levels of emissions that inevitably accompany aviation. This has the potential to contribute significantly to a more diverse and resilient regional economy.

Economics

While aviation's environmental impact is well understood, evidence of the economic benefits and disadvantages of aviation remain partial and consequently the industry's overall economic impact can not currently be adequately assessed. The principal economic benefit of aviation is likely to stem from the sector facilitating improvements in the productivity of the wider economy, i.e. its catalytic positive effects by reducing cost of transportation, increasing connectivity and attracting investment and trade. These catalytic effects, unlike the direct and indirect impacts of aviation, are not normally offset by using resources that maybe otherwise be deployed elsewhere in the regional or national economy, and are therefore likely to be permanent.

Intuitively it may appear reasonable to assume these economic benefits are present and of vital importance, and certainly they have been the subject of significant analysis. However, despite this, the evidence base remains very limited in several important areas (Oxera, 2009, p. 20), and the methods used in the collation of empirical data are not universally accepted as appropriate (see for instance Delft, 2008).

In general, those analyses indicating a broadly positive economic contribution from aviation are insufficiently robust to provide a reliable conclusion. Improving future analyses requires further data; a more consistent interpretation of results; more objective and robust analysis; and more appropriate scenario methodologies. The tendency for overly-positive assumptions, for example, low oil prices and high GDP growth, to inform scenario development risks misleading policy. Furthermore, at a regional (North West) level there is insufficient data to conduct a rigorous analysis of aviation's full economic contribution (particularly regarding catalytic effects). Consequently, until economic data quality and availability is improved to the extent that it is comparable with the emissions data, a precautionary approach would be prudent in developing future aviation policies.

Regional policy recommendations:

Adopt the new hybrid producer-consumer apportionment regime.

This regime facilitates the fair inclusion of aviation-related emissions into regional emission inventories. A region can subsequently make a comprehensive assessment of how to mitigate its emissions from across *all* sectors, thereby reducing the impact to that region's overall socio-economic performance. By making use of fuel consumption data reported under the European Union Emissions Trading Scheme (EU ETS), all the region's airports should be encouraged to further develop their monitoring of LTO emissions.

Exploit opportunities for airports to mitigate LTO emissions

New and complimentary levers for implementing emission mitigation policy amongst those regional organisations - airports, airlines and regional advice contacts from National Air Traffic Services (NATS) - with influence over the LTO cycle need to be identified. This will require the chosen apportionment regime to draw a clear distinction between LTO and cruise emissions.

No further delay to cross-sector emission monitoring

The urgency and scale of the climate change challenge calls for all tiers of government to take early and comprehensive consideration of sectoral emissions. In so doing, they should determine what constitutes an appropriate balance between future emissions from aviation and those from other sectors; guided by the Government's assertion *"that average global temperature must rise no more than 2ºC"* and advice presented by the Committee on Climate Change on the role of aviation in the UK's emission reduction pathway (CCC, 2009).

Encourage immediate inclusion of airports in existing carbon schemes

Achieving cuts in emissions may, in part, be driven by rising oil prices and the inclusions of aviation within the EU ETS. Yet for reductions to be in line with the 2ºC goal (and even a reasonable probability of avoiding 4ºC), additional schemes and regulations will be necessary. Following the lead of Manchester airport, all airports should be encouraged and supported in joining the Airport Carbon Accreditation Scheme's Optimisation stage to achieve emission reductions from the LTO cycle.

Become an exemplar region in supporting step-change mitigation

For the aviation industry to make their fair contribution to the UK's emission reduction aspirations, support from all tiers of government is required. In this regard, the RDA is in a position to stimulate the North West's established and vibrant aviation sector to bring about step-changes in both technology and air traffic management. Increasing the focus on this 'difficult to tackle' sector provides an opportunity for the North West region and its airports to become an exemplar in this area.

Adopt short-term mitigation measures with urgency

With the majority of technological change likely to bear fruit over the longer-term, opportunities for short-term operational emission reductions must be exploited urgently. Examples of short-term measures include the use of the 'continuous climb' and the 'continuous descent' approaches, reducing ground congestion, encouraging airlines to taxi using only one engine and refrain from using auxiliary power units. Further short-term operational changes include the use of alternative business models that consolidate flights to increase occupancies and reduce aircraft deadweight (for example, enabling passengers to collect duty free shopping at their home airport rather than buying or carrying it on the flight). These and similar measures will partially offset the emissions implications of short-term growth in demand and could increase the attractiveness to airlines purchasing permits from the EU ETS for airports facilitating low emissions operations.

Promote local tourism & encourage high-tech video conferencing

Understanding the region's aviation users – both work and leisure flyers – facilitates the RDA in identifying areas with known high emissions but uncertain economic benefit. Local tourism is actively promoted to inbound tourists; additional work is required to examine the impacts of inbound tourism and to further encourage North West residents to use local tourism services. For those flying on work-related purposes measures to promote ICT would be beneficial. The need for aviation services is not sector specific and organisations require different levels of service at different stages of the business life cycle; ICT should be targeted to provide bespoke support across these stages. There may be a role for the Northwest Regional

Development Agency (NWDA) in conjunction with the Carbon Trust and Energy Savings Trust in delivering this support.

Encourage widespread use of carbon accounting systems

Evidence suggests that organisations with carbon reduction strategies that take a more systems-based approach, incorporating both work-related travel and ICT, benefit in terms of emission reductions and economic growth. Such systems allow management, monitoring and reporting of carbon reductions for staff members to distinguish ‘necessary’ from ‘unnecessary’ high-carbon activity.

Make ICT training and development core for public sector staff

The patchy use of ICT within public and private sector organisations undermines opportunities for decarbonising travel. Despite high levels of interest by many employees, support and training for alternative modes of communication varies widely within organisations, with a subsequent low uptake of ICT and little substitution for significant air travel.

Categorise economically-essential organisations by their function

Given that the economic category of an organisation is not closely linked to flying habits, a comprehensive assessment of how organisations use aviation within the region is necessary for the RDA to develop policies for supporting the region’s economy whilst making a transition to a low-carbon future.

Make fair comparisons between aviation and other sectors and collate comprehensive North West economic indicators

For a fair comparison to be made between aviation and other sectors of the economy, comparable indicators based on consistent data must be used for assessing both the negative impacts of emissions and the subsequent socio-economic benefits. Arguments supporting a positive or negative contribution of aviation must take into account both its environmental impacts, and the potential negative economic effects on all the other sectors as a result of the additional efforts required from them to counteract the environmental burden imposed by aviation when complying with emissions budgets. Finally, other influences such as the opportunity cost of investment in growth in aviation, negating the same investment elsewhere, and the negligible effect of reducing the outputs of the sector in the long term should also be considered.

The limitations of the use of economic indicators (e.g. Gross Value Added) are highlighted in the latest assessment of the economic value of aviation by Oxera (2009). A detailed critical review of the economic indicators commonly used to inform policy decisions at the regional level – and specifically in the North West – has been carried out by Randles *et al* (2006). The work proposes an exhaustive list of indicators more suitable for regional policy-making that should be considered for adoption in the North West.

Through the use of a set of indicators with *systemic*, *comparative*, and *process-based* dimensions (Randles *et al*, 2006) and by considering negative economic impacts across **all** regional economic sectors, the region can more confidently make policy decisions to balance the demands of climate change with those of economic sustainability.

Use of a more appropriate methodology for the estimation of catalytic economic effects

To assess aviation's true contribution to the North West, any economic evaluation must include, in addition to the direct and indirect economic effects, the catalytic or wider economic effects of the industry. These effects are likely to represent the principal economic benefit of aviation. However, currently there is no consensus on the size of these benefits, despite the existence of a significant body of literature devoted to their quantification. The quantification of these effects typically relies on general equilibrium models with input output ratios; however such an approach is unable to capture the dynamics and complexity of catalytic effects (Oxera, 2009)[3].

Dynamic input-output analysis and accounting for feedback loops, inter-sectoral dependencies (such as system dynamics computational simulation models) and a facility for incorporating economic structural changes should be central to any modelling approach if the quantification of the catalytic effects of aviation are to be considered.

Take early action to build a resilient local economy

Future climate change mitigation polices are set to become more stringent across all sectors, with climate levies, rising oil prices and potential changes in perceptions towards flying all likely to add constraints to the aviation sector. To ensure the North West has a competitive advantage over other regions, low-carbon innovation that may bring dividends to the region in the medium term must be incentivised as a matter of urgency to avoid reliance on carbon-intensive industries for future growth.

Mitigate for 2ºC whilst adapting for 4ºC

It is essential all tiers of government understand the implications for adaptation of exceeding the 2ºC threshold. Even the budgets of the UK's Committee on Climate Change, underpinning this report, are based on a high probability of exceeding 2ºC (30-78 per cent). In light of this and the possibility of insufficient action to seriously mitigate emissions, it is essential the RDA consider seriously regional adaptation to at least 4°C by as early as 2060/70.

Further Research Requirements

In order for the aviation industry to support local economic development, the relationship between aviation services and the North West's business and organisational users needs to be better understood. Additional research is required in order to examine the current requirements for aviation of the North West's corporate airport users and their future development plans.

[3] Indeed, this work, which is the latest assessment of the economic contribution of aviation, does not attempt a quantification of its wider effects.

1. Introduction

1.1 Background

The international community recognises climate change as one of the greatest threats facing the social, economic and environmental well-being of humankind. At a national level, the UK has demonstrated a clear international lead in responding to climate change by putting the need for and delivery of greenhouse gas emissions reductions on a statutory footing through the Climate Change Act 2008. This act introduced legally binding targets to achieve emission reductions in both the short and longer term. Furthermore, and unlike previous UK emission reduction policies the Climate Change Act includes international aviation emissions explicitly in its 80 per cent 2050 target and implicitly within the current budgets.

Over recent years scientific evidence supports emission reduction targets associated with 2 °C (and now 4°C) becoming ever tighter and it is now widely accepted that all sectors need to deliver significant emission reductions and, ultimately, completely decarbonise energy use.

In the UK, the need for and the delivery of emissions reductions has been put on a statutory footing by the Climate Change Act 2008 which introduces legally binding targets to achieve greenhouse gas emission reductions in both the short and longer term. The UK Committee on Climate Change has advised on the level of cuts required for the UK producing two sets of budgets[4]:

- **An Intended Budget** - requiring an emissions reduction of 42 per cent in 2020 relative to 1990 (31 per cent relative to 2005) in the event of a 'global deal' on climate change; and
- **An Interim Budget** – requiring an emissions reduction of 34 per cent in 2020 relative to 1990 (21 per cent relative to 2005) and applying irrespective of whether or not a 'global deal' is reached.

Both sets of budgets require that significant efforts to reduce greenhouse gas emissions begin now and are sustained at an unprecedented rate throughout the next few decades. However, despite the leadership being taken by the UK Government in developing the Climate Change Act, it is still far removed from delivering a high probability of not exceeding the 2ºC threshold. For the Committee on Climate Change's two pathways, total global greenhouse gas emissions and CO_2 emissions peak in 2016 with 3 per cent and 4 per cent annual reduction rates in emissions of CO_2 emissions out to 2100 (Smith, 2008). These emission pathways are associated with a 56 per cent to 63 per cent probability of exceeding 2°C (CCC, 2008). However, a more sophisticated analysis incorporating a wider set of modelling studies estimates the probabilities for the same pathways to exceed 2°C range from 30 to 78 per cent (Meinshausen et al., 2009a, b).

Clearly, if the global community wishes to achieve a lower probability range of exceeding 2°C, steeper emissions reductions will be required. According to work currently being undertaken at the Tyndall Centre (Starkey and Anderson, forthcoming), achieving a relatively 'safe' probability range of, for example, 15-50 per cent would likely require CO_2 emissions from energy to fall at around 10-20 per cent per year – well in excess of the reductions currently enshrined within the Climate

[4] The intended and interim budgets allow the UK to purchase from outside the Annex 1 nations 27% and 17% respectively of the reductions necessary to achieve its targets.

Change Act. Whereas most Tyndall work is informed by the 2°C stabilisation target, the emissions budget used to inform the aviation pathways set out in this report adhere to the budget reported by the CCC and hence a high probability of exceeding 2°C.

On the other hand unlike previous UK emission reduction policies (such as the 60 per cent emission reduction target of 2003), the Climate Change Act includes international aviation emissions explicitly in its 80 per cent 2050 target and implicitly within the current budgets. However, at present, international aviation and shipping are not explicitly quantified for the budget period 2008 to 2022. Indeed, part 1 of the Act (Targeting and Budgeting) requires the Secretary of State to make separate provision by regulation "*as to the circumstances in which, and the extent to which, emissions from international aviation or international shipping are to be regarded as emissions from sources in the United Kingdom*" or "*lay before Parliament a report explaining why regulations making such provision have not been made*" by 31 December 2012.

While the apparent effect of this is to delay specific provisions and targets in relation to aviation emissions until 2012, the Committee on Climate Change has already identified that the budgets that it has set out in relation to overall climate objectives (above) implicitly include emissions from aviation[5] and that, if aviation is not explicitly included in the UK's budgeting then "*the budget which is set for the other sectors will need, when combined with the trend in EU ETS aviation emissions, to be compatible with overall climate objectives*". [6]

Accordingly, whether targets for curbs on UK aviation emissions are identified explicitly or not in future, the regulatory and policy framework provides that the contribution of aviation emissions (and any growth in these emissions) must be deducted from (or otherwise accounted for) by alterations in the emissions budgets for other sectors[7].

For the UK as a whole, then, there is a clear need to balance the cost and overall economic impact of delivering additional reductions in greenhouse gas emissions for these 'other' sectors versus the costs and economic impact of curbing growth in emissions from aviation.

For the North West, achieving an appropriate balance between these competing pressures is particularly important as the region is:

- host to three passenger airports (Manchester, Liverpool and Blackpool);

[5] The Committee identifies that "*aviation (both international and domestic) is included in the EU's 20% and 30% GHG emissions reduction targets. Our budget proposals in Chapter 3: The first three budgets which are based on this framework, therefore implicitly take into account international aviation emissions.*"

[6] It is worth noting the UK Government's low-carbon transition plan states "to avoid the most dangerous impacts of climate change, average global temperature ***must*** rise no more than 2ºC" [emphasis added] (HM Government, 2009). This 'objective' is not compatible with the Committee on Climate Change's emission pathways and budgets. For more information, refer to Anderson et al. (2009). Furthermore, the emission caps within the EU ETS are far removed from those associated with "must rise no more than 2ºC".

[7] Here, for example, the Committee on Climate Change identifies that "whilst aviation and shipping emissions are today both relatively small as a percent of total global emissions they are likely, if unconstrained, to grow to much larger shares. It is therefore essential either to curtail emissions growth significantly or to set more stringent targets for all other sectors which compensate for the difficulty of achieving cuts in these sectors."

- home to aerospace industries and expertise that could capitalise on the economic opportunities of delivering emissions reductions in aviation (for example, Airbus, BAE Systems, Rolls Royce, the University of Manchester Aerospace Research Institute (UMARI) and the Centre for Air Transport Research (CATE) at Manchester Metropolitan University); and
- an area with a high density of industrial and other sectors that are already committed to making significant reductions in emissions.

This research was carried out prior to the release of the Committee on Climate Change's report into the scope for emission reductions from aviation (CCC, 2009). The report reiterated the importance of including aviation emissions (both from domestic and international flights) in the UK's emission reduction pathway and reviewed the potential for this sector to decarbonise. The main recommendation of the report is that UK aviation policies should limit the growth in total demand to a maximum of 60 per cent, until and unless technological developments suggest that any higher figure would be compatible with the emissions target. The Committee also highlight the potential for this limit to be more stringent if a mechanism for the inclusion of the non-CO_2 climate impacts of aviation in UK climate policy is agreed. The report can be found in full at http://www.theccc.org.uk/reports/aviation-report.

1.2 Study objectives

Delivering reductions in greenhouse gas emissions across the sectors (including aviation) requires support and action from all tiers of government, including Regional Development Agencies (RDAs). With respect to aviation emissions, regional bodies are able to influence aviation emissions in conjunction with other actors through a range of mechanisms. These include the funding of low carbon initiatives, through their role in regional strategic planning and development and importantly as a facilitator between regional actors.

In the light of the North West's high exposure to potential impacts and trade-offs associated with various aviation emissions trajectories there is a need for the RDA to take early consideration of the issues and, in so doing, determine what might constitute a more optimal balance between future emissions from aviation and emissions from other sectors.

The overall objective of this report (and the associated Joule study) is to provide an initial analysis of regional aviation emissions, issues and potential impacts/trade-offs that, in the first instance, will assist the RDA to better:

- understand the users of aviation and enable the RDA to take steps to support its key economic sectors during the transition to a low-carbon energy system;
- understand the proportion of UK aviation emissions that the region could be deemed responsible for in the near future;
- compare the quantity of aviation emissions with other emission sources; and
- determine appropriately balanced policies with respect to ALL emissions reductions pursuant of the UK statutory budgets and targets.

This, in conjunction with the inclusion of aviation within regional inventories, will enable the region to:

- monitor the impact of aviation policies on the economy;
- monitor the effects of wider policies on aviation emissions and the ETS on the aviation industry in the region; and

- make appropriate policy interventions to maintain an optimal balance between competing demands.

To deliver the necessary insights, the study had the following objectives:

1. *To produce an approach for disaggregating the UK's aviation emissions to a regional scale.*
2. *To develop a set of low carbon pathways for the North West region that include aviation.*
3. *To review existing assessments of aviation's economic contribution and to estimate the specific contribution to the North West.*
4. *To analyse the behavioural practices related to flying with specific reference to the North West.*
5. *To use the results of the analyses to provide advice to the region as to how it can support socio-economic and environmental development in the region.*

1.3 Structure of the report

These objectives form the basic structure of the report. Section 2 provides further context to the emissions from aviation and the challenges and technology changes associated with curbing aviation emissions.

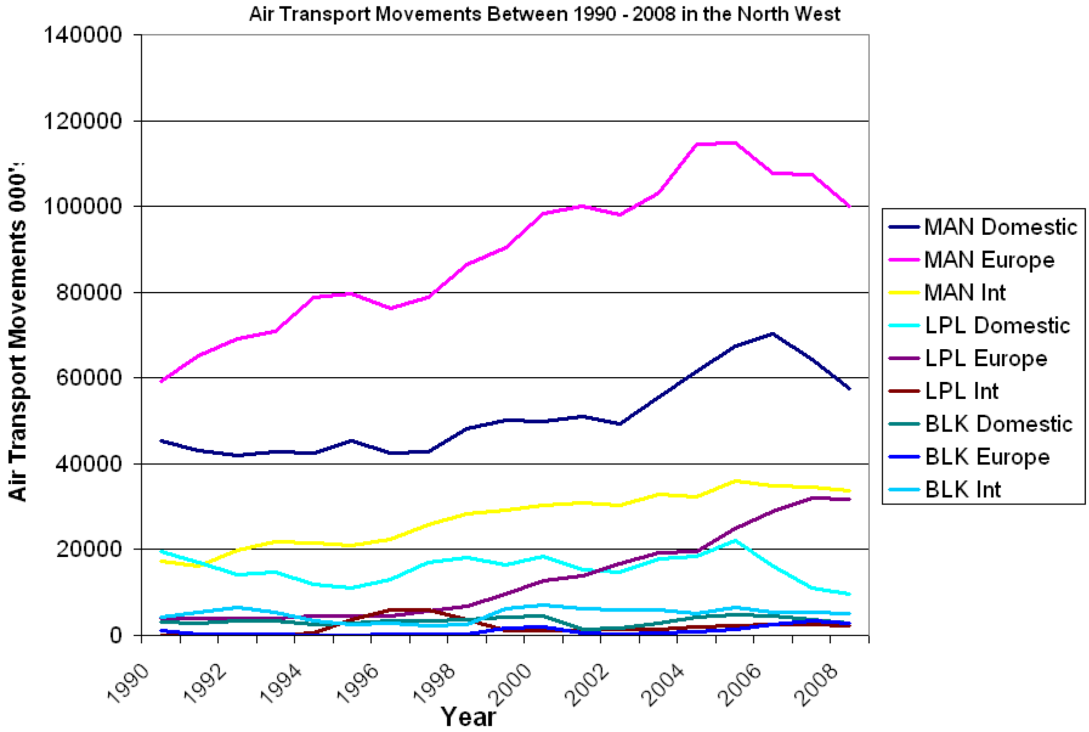
Section 3 presents the methodology developed for apportioning and estimating aviation emissions in the North West and resulting emissions estimates while Section 4 describes the development of low carbon pathways for the region that include aviation.

The analyses of the economic contribution of aviation and flying practices in the North West are presented in Sections 5 and 6 respectively. Section 7 draws the analyses together to provide conclusions and recommendations on policy interventions.

2. Aviation and the North West

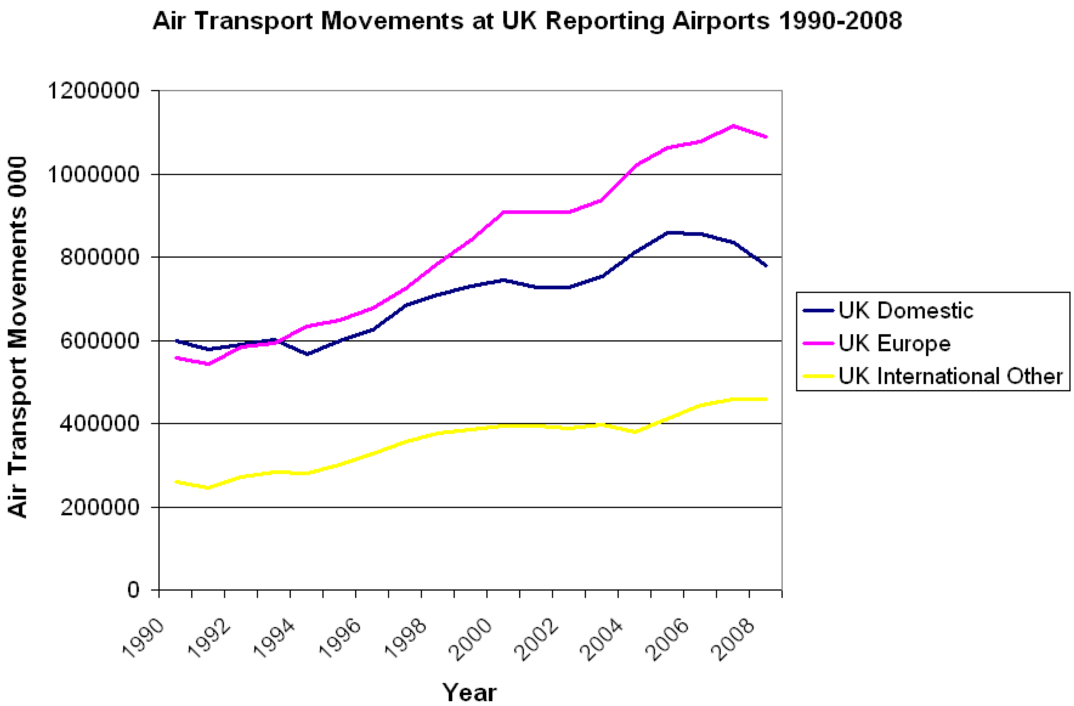
The North West of England hosts three major airports, Manchester, Liverpool and Blackpool. This section provides an overview of the services they provide and their customer base. Figure 2.1 shows the changes in flight numbers to UK, European and other international destinations over time from each airport.

Figure 2.1: Air transport movements at the North West's airports by destination 1990 – 2008 (Source: CAA, 2009a).



The pattern of growth and recent dominance of European destinations over domestic and other international destinations is mirrored in the same statistics for the UK presented in Figure 2.2.

Figure 2.2. Air transport movements at the UK's airports by destination 1990 – 2008 (Source: CAA, 2009a).



Information about the passengers using the region's airports is collected annually at Manchester Airport as part of the Civil Aviation Authority's (CAA) passenger survey (e.g. CAA, 2004). Liverpool was surveyed once in 2007/8 and Blackpool airport has not yet been surveyed (CAA, 2008). The CAA's survey collects information from passengers on departing flights including their journey origin, purpose and socio-economic data. Figures 2.3 and 2.4 provide a breakdown of the main journey purpose of passengers departing from Manchester airport between 2000 and 2008. The majority of business passengers between 2000 and 2006 cited their journey purpose as 'internal company meeting'. Such detail was not available in subsequent reports (CAA, 2001, 2002, 2003, 2004, 2005, 2006, 2007). The 2007/8 survey of passengers at Liverpool Airport identified the main journey purpose of passengers on domestic flights as: business (24 per cent of passengers); visiting friends and family (VFR) (55 per cent); and leisure (20 per cent). On international flights, passenger journey purposes were: business (9 per cent); VFR (40 per cent) and leisure (51 per cent).

Figure 2.3: Journey purposes of passengers on domestic flights from Manchester Airport 2000-2008 (Source: CAA, 2001,2002,2003,2004,2005,2006,2007,2008a, 2009b).

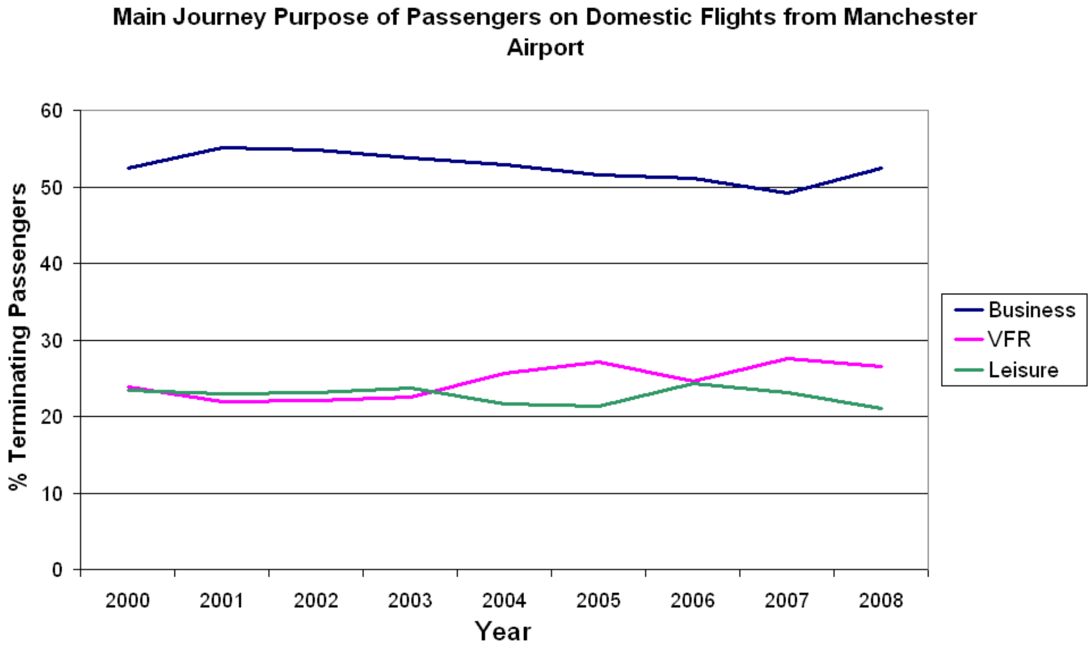
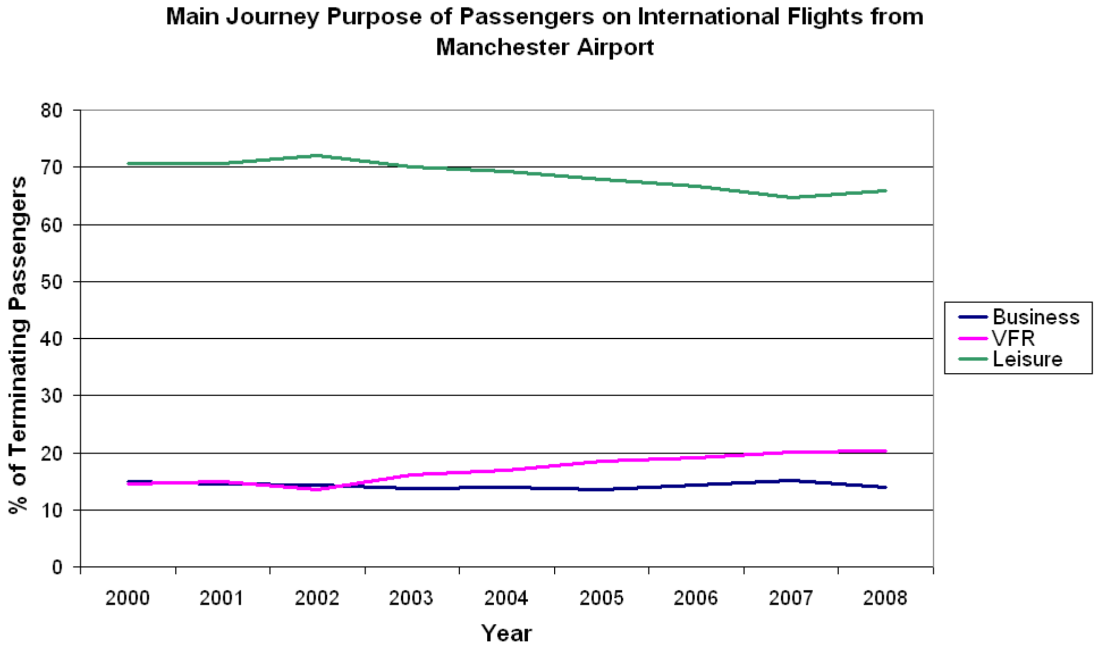
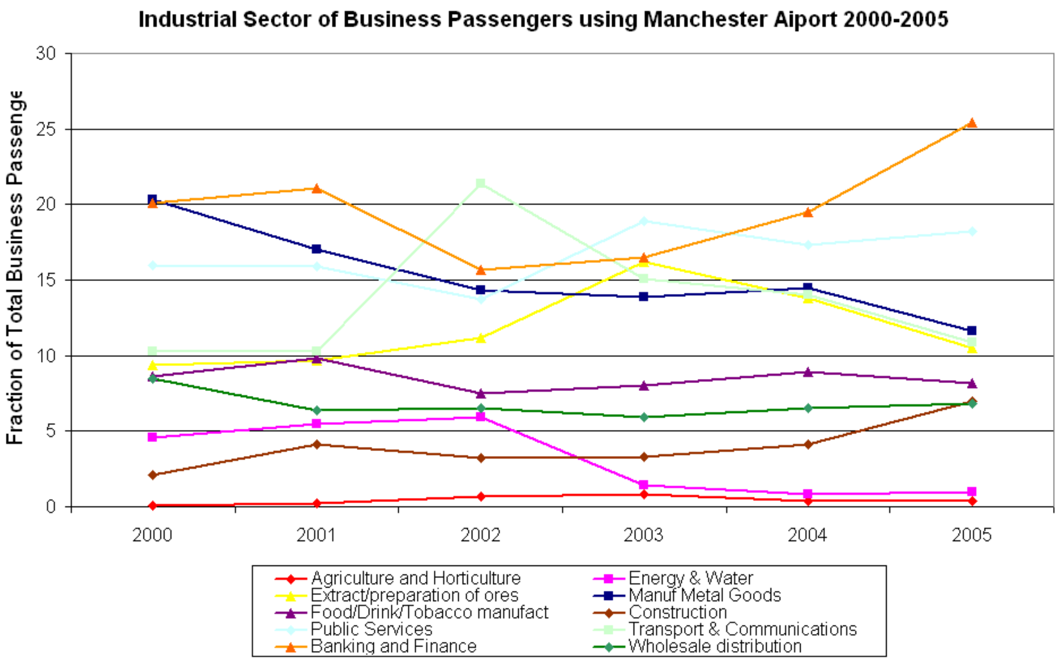


Figure 2.4: Journey purposes of passengers on international flights from Manchester Airport 2000-2008 (Source: CAA, 2001,2002,2003,2004,2005,2006,2007,2008a, 2009b).



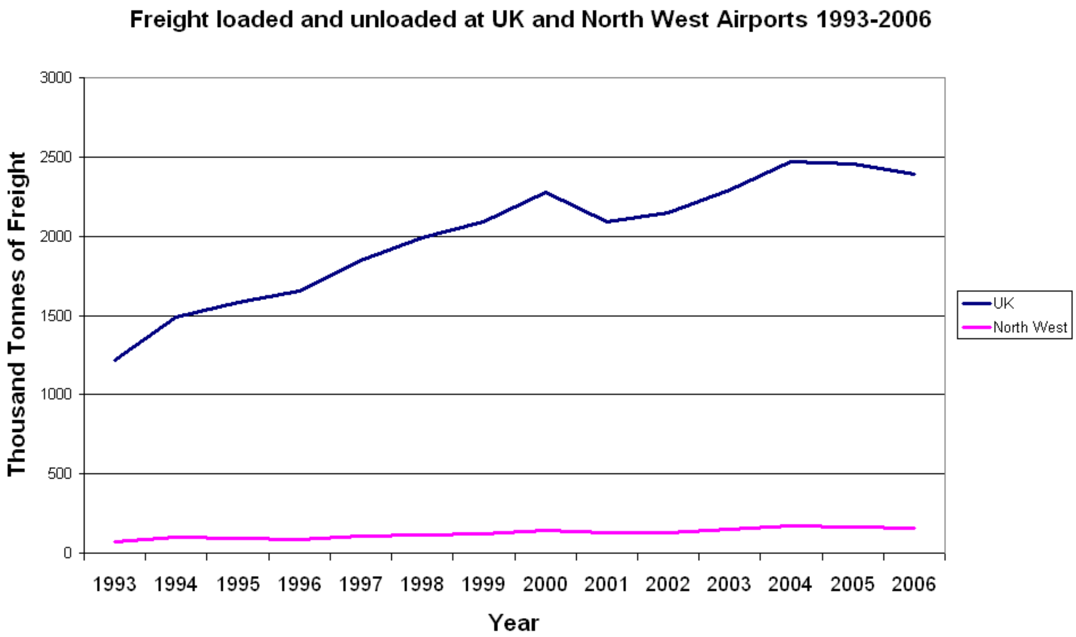
Information about the economic sector of business passengers is also collected during the CAA survey. Figure 2.5 provides an overview of the different sectors that use Manchester airport for business purposes.

Figure 2.5: The proportion of business passengers from different economic sectors that used Manchester Airport 2000-2005 (Source: CAA, 2001,2002, 2003, 2004, 2005, 2006).



Air freight is a further important service provided by the region's airports, the weight of freight lifted over time loaded and unloaded at North West and UK airports is detailed in Figure 2.6.

Figure 2.6: Tonnes of freight lifted through the North West and UK's airports.



2.1 Aviation growth and technology

Historically, incremental improvements in aviation efficiency have not been sufficient to offset the growth in demand. Despite the recent economic downturn, this situation is expected to continue (Lee et al., 2009). To begin to address this, the industry has set ambitious targets for CO_2, NO_x and noise. These are known as the Advisory Council for Aeronautics Research in Europe (ACARE) targets with a specific focus on improvements in engine performance, air traffic management, airframes and alternative fuels.

In addition to incremental technology and air traffic management improvements, major step-changes in efficiency from this sector will be needed to deliver emission reductions that both cope with increases in demand and remain within the Committee on Climate Change's target. The size of change required is illustrated in Figures 2.7 and 2.8 which present the scale of efficiency improvements required under different levels of growth and biofuel penetration to stabilise aviation emissions at 2005 levels (2.7) and 80 per cent below 2005 levels (2.8). The Figures assume the patterns of flight destinations and aircraft type used for each route remain as 2005, and are intended to provide indicative information only on the scales of change.

Figure 2.7: An indication of the efficiency improvement and percentage blend of biofuel that would be required to enable aviation emissions to be stabilised at 2005 levels according to

different increases in the number of flights.

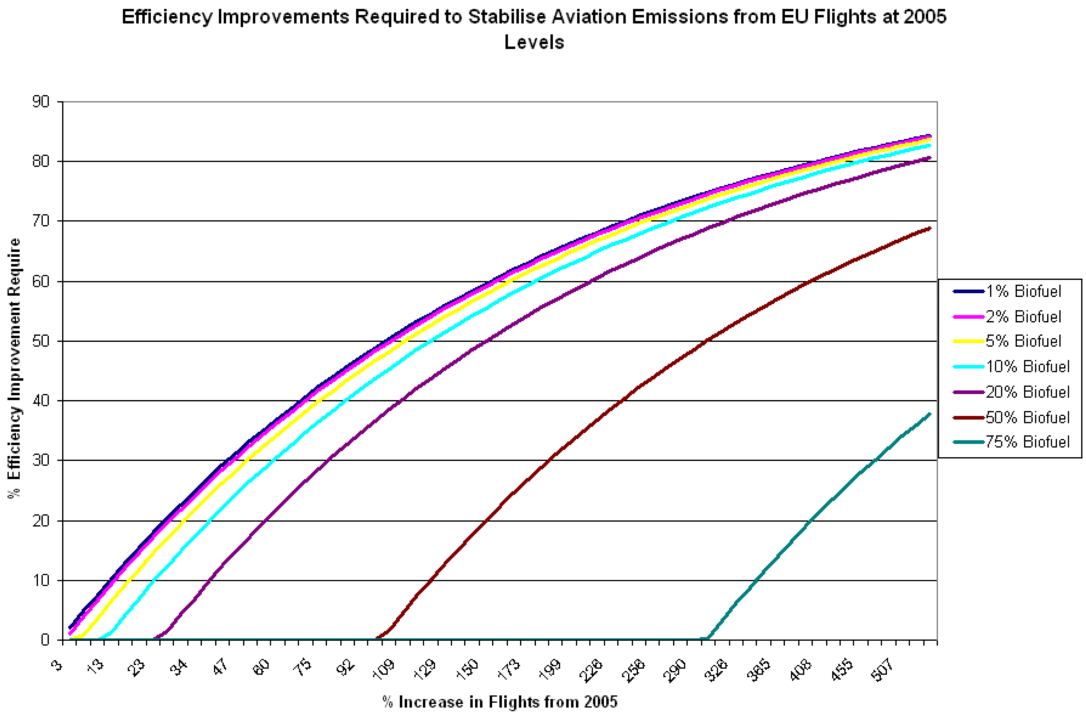
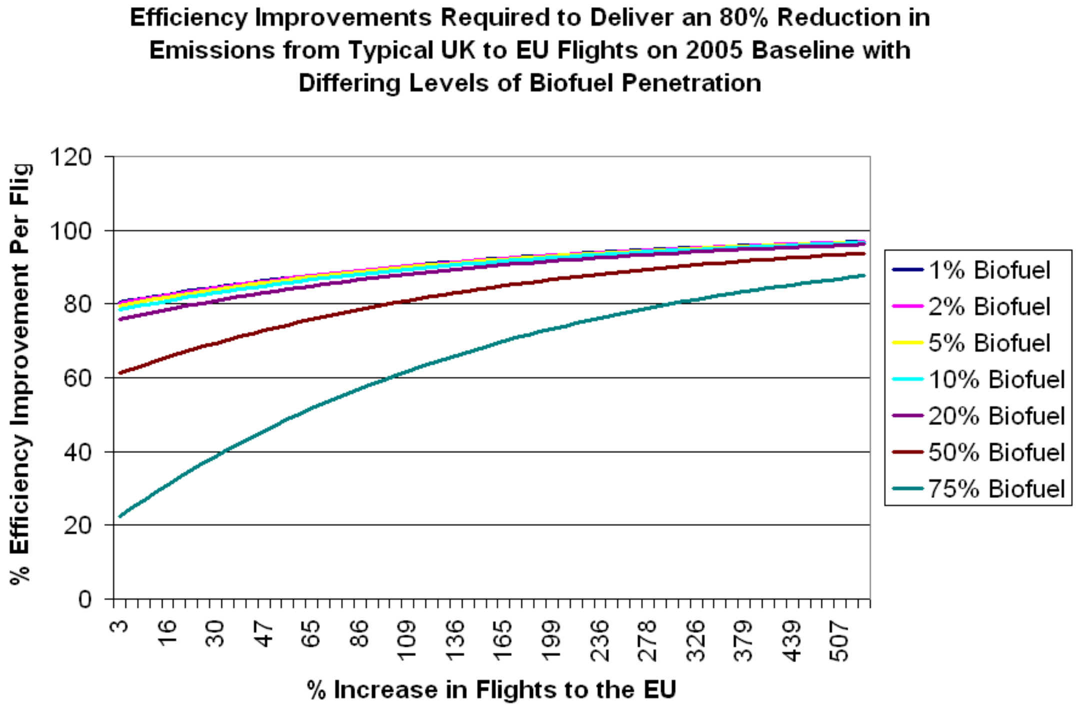


Figure 2.7 provides a schematic of the different efficiency improvements that would be required in order to stabilise aviation emissions at the 2005 level given different percentage increases in flights from a 2005 baseline at varying levels of biofuel penetration. The graph assumes the same pattern of destinations to Europe and aircraft types used as in 2005 and that biofuels are zero carbon. The schematic illustrates combinations of both biofuel and efficiency improvements that enable aviation to stabilise emissions at 2005 levels. Figure 2.8 demonstrates the same principle as Figure 2.7 but instead uses an 80 per cent reduction target for aviation by 2050 rather than assuming emissions remain at 2005 levels. The efficiency improvements approaching 100 per cent demonstrate the need for high levels of biofuels or alternative low / zero carbon fuels in future scenarios where aviation delivers an 80 per cent CO_2 emission reduction at the same time as significantly increasing growth.

Figure 2.8: An indication of the scale of efficiency improvements and percentage biofuel blend that would be required if aviation were to reduce its emissions by 80 per cent on a 2005

baseline with varying levels of growth.



3. Estimating regional aviation emissions

3.1 Overview

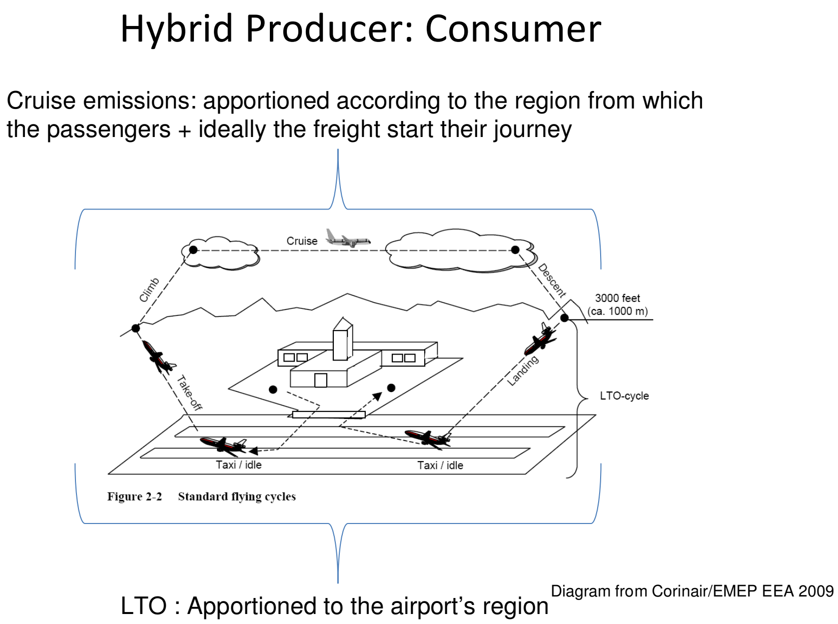
One of the first tasks for the project was to calculate how much of the UK's aviation emissions the North West could be deemed responsible for. Given there was no existing accepted method of dividing up the country's aviation emissions to the regions, a new method or 'apportionment regime' was developed. This section provides an overview of the new Tyndall apportionment regime and the resulting emissions estimates for a range of existing regimes.

The new Tyndall regime developed in this study reflects the region's role as a 'producer' of emissions and also as a service 'consumer'. While 'producers' are able to control the emissions intensity and emissions level of the service they provide, 'consumers' are able to control the amount and type of services they use. By sharing the responsibility between producers and consumers the regime provides an insight into both consumer and producers in the region and can respond to emission reduction measures targeted at both.

The regime developed is to apportion to the North West the emissions from the take-off and landing cycle (LTO) of aircraft using airports within the North West and combines this with a fraction of the cruise section of all departing UK passenger flights based on the numbers of passengers on board that start their journey in the North West (both North West residents and visitors to the region). So, for example, if a passenger starts their journey in the North West but flies to an international destination from a London airport, the cruise emissions from their flight will be captured in the methodology, however, if a person starts their journey in Leeds but flies from Liverpool Airport, their cruise emissions will be allocated to the North East region. The regime is illustrated in Figure 3.1.

This method has been developed to reflect, firstly, the potential influence on aviation emissions that the region can have and, secondly, to allocate responsibility according to the regional beneficiaries of aviation – reflecting in part both the direct economic benefit of an airport and the benefits of the services that aviation provides to users within the region.

Figure 3.1: The Hybrid Producer: Consumer apportionment regime



3.2 Rationale for the apportionment method

The method draws on the data on the LTO cycles from airports that is regularly collected for air quality assessments.

As well as providing readily available data, the emissions and influencing factors associated with each part of the LTO cycle are relatively well understood. As such, including the CO_2 from the LTO in an inventory provides greater insight into how emission reduction methods targeted at, for example, ground movements around the airport or changes in air traffic control practices might produce reductions in emissions from the cycle as a whole.

The number of flights from an airport is proportional to the passenger numbers or tonnes of freight lifted through the airport. The passengers and freight users bring direct economic benefits to the region's airport and the airlines that use them. Hence, incorporating the emissions from the LTO cycle in part reflects these direct economic benefits.

Furthermore, the 'optimisation step' of the European Airport Carbon Accreditation Scheme (recently launched at Manchester Airport) incorporates the LTO cycle emissions into an airport's carbon footprint. Guidance is available on how these emissions can be reduced through co-operation with third parties (ACI Europe, 2009).

Dividing the emissions from the cruise section of departing UK flights between the regions according to the proportion of passengers[8] (both residents and visitors) that begin their journey in the region, gives an indication of how frequently people residing in the region fly, and the number of visitors to the region that travel by air. This regime acknowledges the wider catchment area of airports. By dividing up the cruise emissions between regions, those without an international airport would share the emissions burden corresponding to their residents' propensity to fly and the visitors the region attracts that travel by air.

The method enables a region to consider how it can intervene to reduce emissions from this sector. Firstly, LTO emissions can be addressed through negotiations with airports, local spatial planners, airlines, national air traffic control and national government for example through the airport carbon accreditation scheme (ACI Europe, 2009). Secondly, the cruise emissions can be reduced through efficiency improvements, availability of alternative fuels as well as measures to slow the rate of growth in demand for air travel. Although growth in demand for aviation has slowed in recent years, in part, due to the economic downturn, analysis by the CAA suggests that this slowdown is likely to be short-lived and growth rates are expected to recover in the longer-term (CAA, 2008b). Action to reduce growth rates is particularly contentious, although until improvements in technology and management are able match this growth in demand, it is likely to be necessary to meet Government emission (and temperature) targets. Thus policies to manage demand through the regions and other sub-national administrations could include promoting local tourism.

3.3 Resulting emissions estimates for the North West

Applying the hybrid method to the North West using passenger surveys and UK flight information supplied by the CAA gives a value of 2.2MtCO_2 for 2005. This figure is lower than the emissions associated from departing flights from the North West's airports, which equated to 3.4MtCO_2 in 2005 and uses an approach that scales the UK emissions based on the journey origin of passengers.

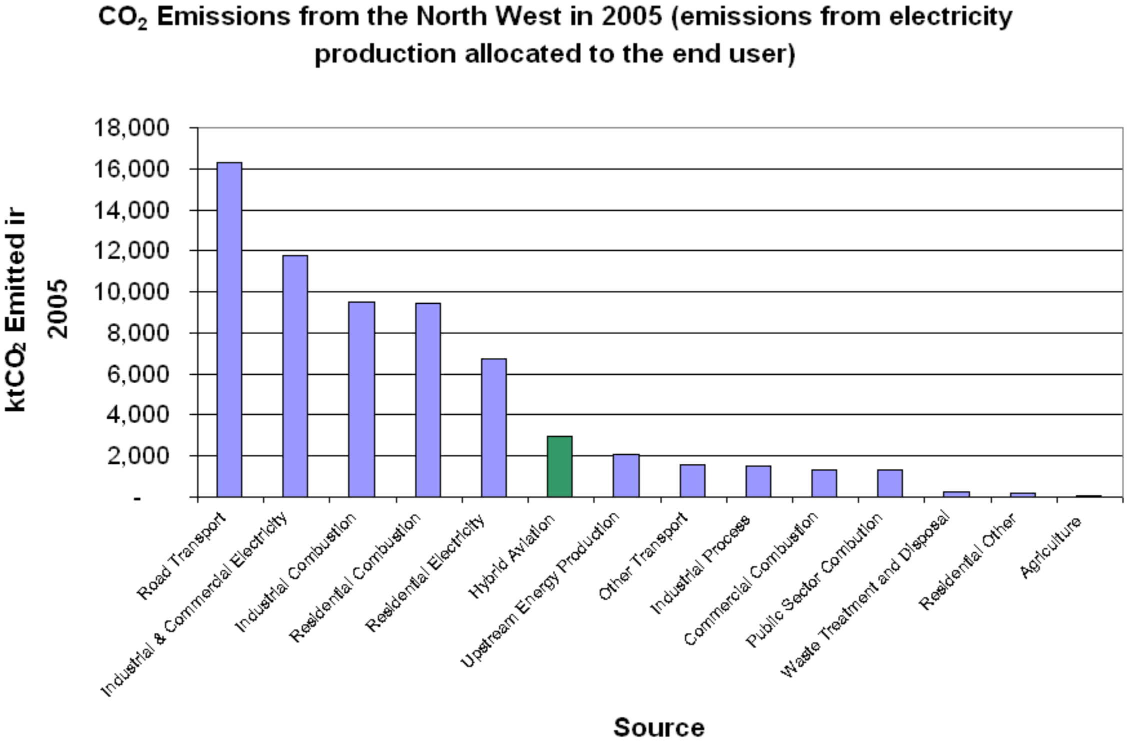
[8] *Without information on the origin of freight lifted from UK airports, applying a consistent 'consumer' approach for freight transport is not possible at present. Instead, in order to ensure consistency with the national emissions total for aviation, emissions from freight only flights could be allocated to the region of origin until further data is routinely collected.*

Table 3.1: Results of the application of different aviation emission apportionment methods to the North West

	2005 Total Mtonnes CO_2	per cent of Total UK Aviation Emissions
Scaling by Gross Value Added (GVA) data i) Air Transport ii) total NW GVA	i) 1.98 ii) 3.72	i) 5.3 per cent ii) 10 per cent
Scaling by Number of Landing & Take-Offs at Regional Airports	5.3	13 per cent
Scaling by Number of Passengers Using Regional Airports	5.25	13 per cent
Scaling by the Number of Passengers who start their journeys in the North West that use UK airports	2.1	5.6 per cent
Emissions from Outbound Domestic and International Flights from the Region's Airports.	3.1	8 per cent
Hybrid Consumer: Producer Methodology	**2.2**	**5.9 per cent**

The total for aviation can be compared with other sources of emissions from the North West as reported by Peace and McCubbin (2009) for 4 North West for the baseline year of 2005. Peace and McCubbin estimate the region's emissions (including the landing and taxiing of domestic flights in the region's airports) at 56.7 Mtonnes, of which the new Tyndall hybrid apportionment regime for aviation would equate to 4 per cent of this total.

Figure 3.2: CO_2 emissions from aviation in the context of other sources from the North West taken from Peace and McCubbin
(2009).



4. Developing low-carbon pathways for the North West

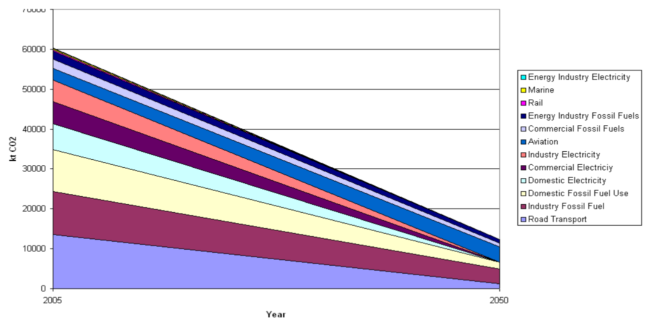
4.1 Overview and approach

As noted in Section 1 (and elsewhere), there is interplay between growth in aviation emissions and the emissions reductions required from other sectors where this depends on levels of growth in aviation sector as a whole as well as penetration of lower carbon options and technologies into the aviation sector. To explore this interplay and options for aviation within the context of the wider energy-system driving towards a low-carbon future, a set of stakeholder-led emission pathways for the North West were developed using the ‘Greenhouse Gas Inventory Protocol’ (GRIP) scenario process (Carney, 2006).

Three different aviation end-point scenarios for the North west in 2050, a wider energy system scenario for 2050 and one aviation scenario for 2025 were developed by independent stakeholders (including representatives from the aviation industry, local government and an aviation academic not associated with the research team).

In each case, each of the 2050 end-point scenarios are geared towards pathways to achieve an 80 per cent reduction in CO_2 emissions from the region by 2050 based on a 2005 baseline year[9] (illustrated in Figure 4.1).

Figure 4.1: Example pathway to 2050 developed by the stakeholders



[9] A 2005 baseline was selected as it corresponds with the baseline year used

In terms of aviation variables, stakeholders selected and altered key model inputs including:

- the growth in flights from the region;
- growth in passengers starting their journey from the region; and
- improvements in efficiency and changes in the carbon-intensity of aviation fuel.

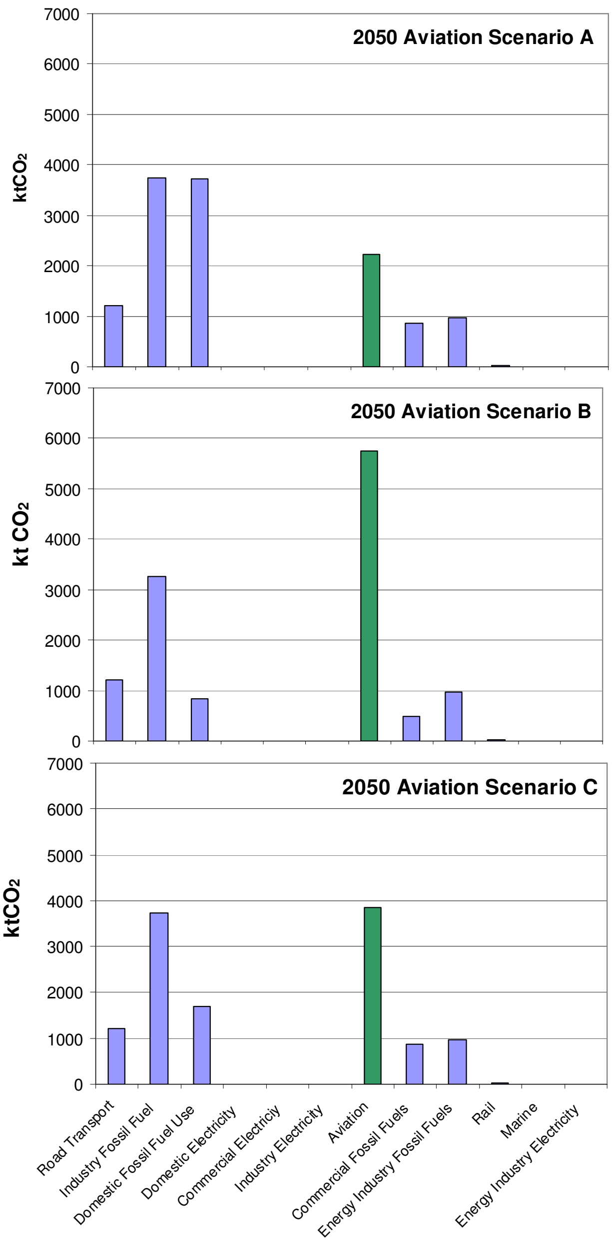
As such, the model inputs include changes in the number of landing and take-offs from the region's airport as well as changes in the travel patterns of passengers that start their journey from the North West.

Clearly, the benefits of such a stakeholder-led approach are that it enables:

- the sharing of knowledge, using GRIP to facilitate discussion between the participants;
- consideration of a broader context of the energy system and the development of the individual sectors within it; and
- external stakeholders to develop their visions into quantitative descriptions of possible futures for the North West.

In this way, the resulting scenarios can serve as a discussion point amongst a wider audience, providing an important first step for considering trade-offs and identifying how, and under what conditions, aviation could be incorporated into wider energy system low-carbon scenarios[10].

Figure 4.2: Comparison of sectoral emissions between scenarios

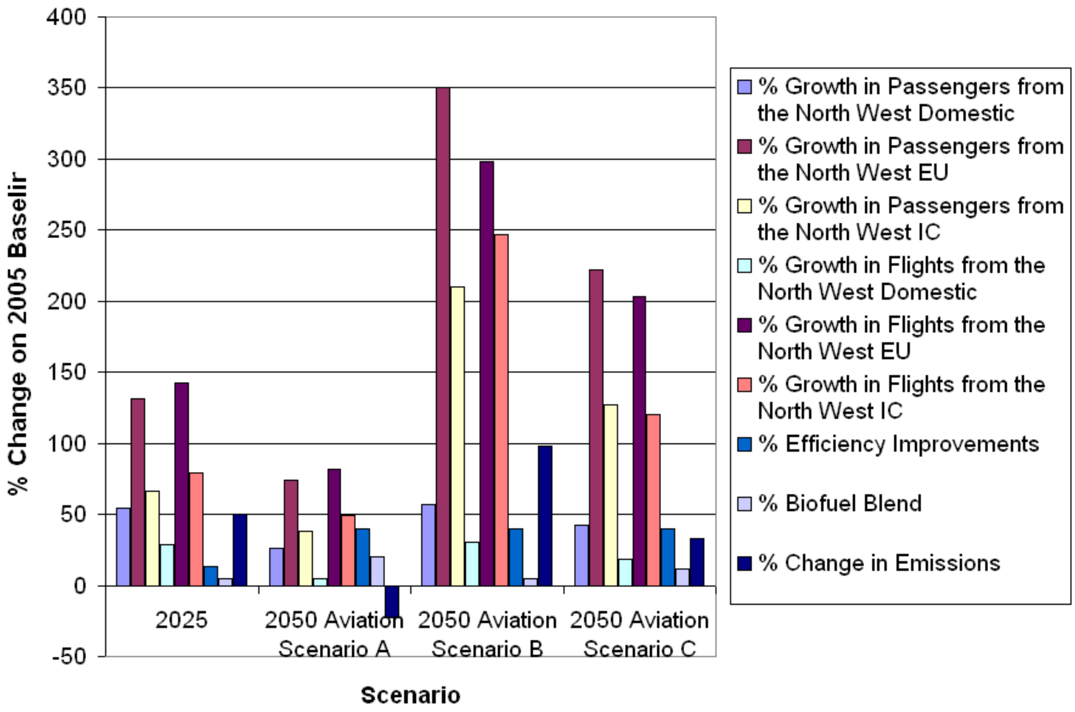


4.2 Results and outcomes

within existing regional documents (e.g. Peace and McCubbin, 2009).

[10] A scenario study using a slightly different approach for constructing aviation scenarios for the EU scale can be found in Bows et al., 2009.

Figure 4.3: Key inputs to the aviation scenarios developed by the stakeholders



Scenarios for 2050

Figure 4.2 provides a summary of the apportionment of emissions/emissions reductions for different sectors (including aviation) for the three scenarios (A, B and C) developed by stakeholders. As can be seen from the chart, the higher aviation emission levels in Scenarios B and C are countered by additional reductions in the domestic and commercial sectors compared to Scenario C.

It should be noted that the overall emission reductions from the non-aviation sectors are in line with existing UK wide scenarios for the energy sector. For example, the Committee on Climate Change's example pathways for energy CO_2 and the scenarios recently published by the UK's Energy Research Centre (UKERC, 2009). However, the latter's set of scenarios describe pathways that deliver up to a 90 per cent CO_2 emission reduction from all sectors excluding international aviation and shipping on a 1990 baseline. Delivering this size of reduction is challenging, and will require very significant technological application and behavioural changes.

Changes in Aviation in the Scenarios

As noted above, stakeholders provided a number of model inputs describing their views on the future changes in aviation as well as other sectors. Figure 4.3 summarises the aviation sector inputs and the differences between the various scenarios[11].

When considering the annual percentage changes in flight growth and efficiency changes that could result in these scenarios, in general the stakeholders felt growth

[11] Passenger numbers are illustrative only – they assume that current average aircraft seat capacity remains the same out to 2050 and the aircraft are at 80% capacity.

in flight and passenger numbers was likely to plateau beyond 2030, after which the full benefits of efficiency and operational changes would deliver significant emission reductions. Table 4.1 provides a comparison across scenarios and with current UK trends.

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Table 4.1: Average per annum growth and efficiency changes for each stakeholder scenario compared with current UK trends / targets

		Efficiency (%)	Annual growth rate of Total Flights from the North West (%)		
			Dom	**EU**	**IC**
Stakeholder Inputs	**2005 to 2025**	0.7	1.3	4.5	3
	2025 to 2050 Scenario A	1.1	-0.8	-1	-0.7
	2025 to 2050 Scenario B	1.1	0.1	2	1.7
	2025 to 2050 Scenario C	1.1	-0.3	0.9	0.8
Comparable UK Data		0.8-1.5[a]	0.2[b]	4.2[b]	3.7[b]

a: Source: projected annual efficiency improvement on a seat-km basis incorporating engine and airframe innovation, ATM and operations cited by the CCC (2009) the lower estimate cited as 'likely' the upper end as 'speculative'.
b: Source Table 5 CAA Airport Statistics trend of 1990-2008 (2009a)

Shortly after the research was published the Committee on Climate Change launched an assessment of the scope for emission reductions from the aviation sector (CCC, 2009). The assessment included a review of the efficiency savings that could be obtained from engine and airframe innovation and operational improvements. The report presented a range of 0.8 – 1.5 per cent seat-km efficiency improvements that could be obtained from these measures, depending on the rate of technology development and the uptake of new aircraft. The CCC assesses the lower figure as 'likely', the upper end as 'speculative'. Policy intervention is required to promote efficiency improvements of 1.1 per cent seen in our stakeholder-led scenarios. The industry-led Advisory Council for Aeronautics Research in Europe (ACARE) has a strategy that aims for efficiency improvements of 1.5 per cent (ACARE, 2008).

The growth rates in flight number and passengers are considerably lower than the average annual growth rate between 1990 and 2008. To stabilise emissions at 2005 levels efficiency improvements (and decarbonised fuels) must compensate for growth. The CAA, predicts the reductions in passenger and flight numbers seen in 2008-9 will return to pre-2008 growth rates once the country is no longer in an economic recession (CAA, 2008b).

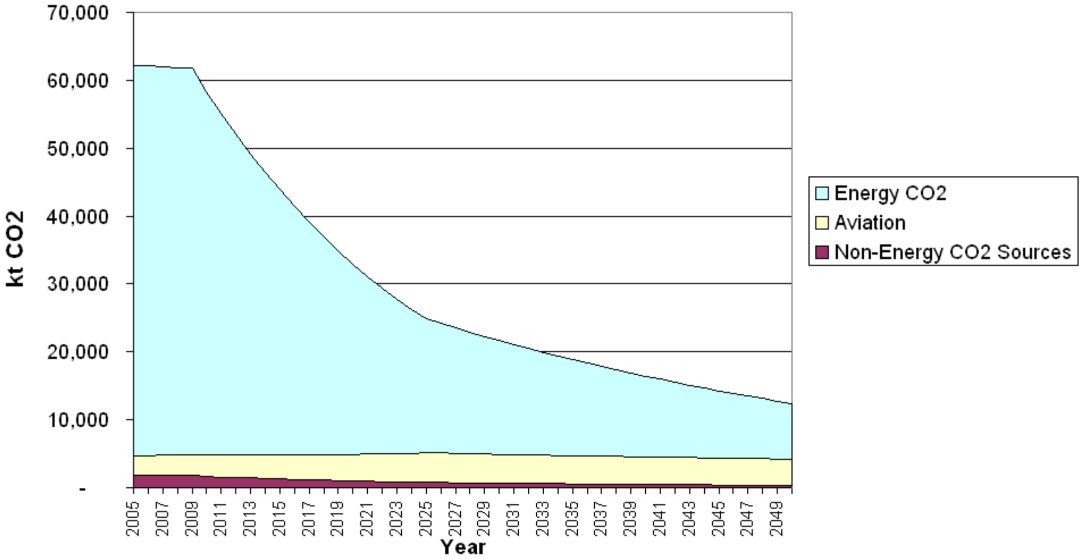
This, in turn, suggests that measures to moderate growth rates in air transport would be necessary in the near future in order to be consistent with the emission scenarios presented. If, however, additional efficiency improvements were delivered in line with the ACARE targets set by the industry, emissions from higher growth rates would be offset. See Figures 2.6 and 2.7 for guidance.

End-point versus cumulative emissions profiles

While the end-point scenarios provide a helpful demonstration of the scale of change needed from different sectors to deliver an end-point target over a longer timescale, the timing of actual emissions reductions needs to take account of cumulative emissions. Here, to conform with a cumulative emissions budget, steeper annual emissions reductions are required in the short- to medium-term compared with the longer-term.

To examine its impact on scenarios, a cumulative emissions budget was estimated for the North West based on existing budgets and emissions trajectories given by the CCC (2008). Here, the 80 per cent emission reduction target for 2050 recommended by the CCC (which formed the basis of initial scenario development) is accompanied by guidance on the cumulative emissions associated with the probability of exceeding 2ºC (discussed in Section 1).

Figure 4.4: Example cumulative CO_2 emissions pathway based on a budget derived for the North West from CCC, 2008 detailing the contribution of aviation from scenario C and non-energy CO_2 sources.



The Committee's end-point target and intended budget to 2022 (which, as noted in Section 1, implicitly include emissions from aviation and shipping) have been used to develop an emissions budget for the UK that has been used to allocate an appropriate budget for the North West based on the region's projected share of the UK population (~11 per cent)[12].

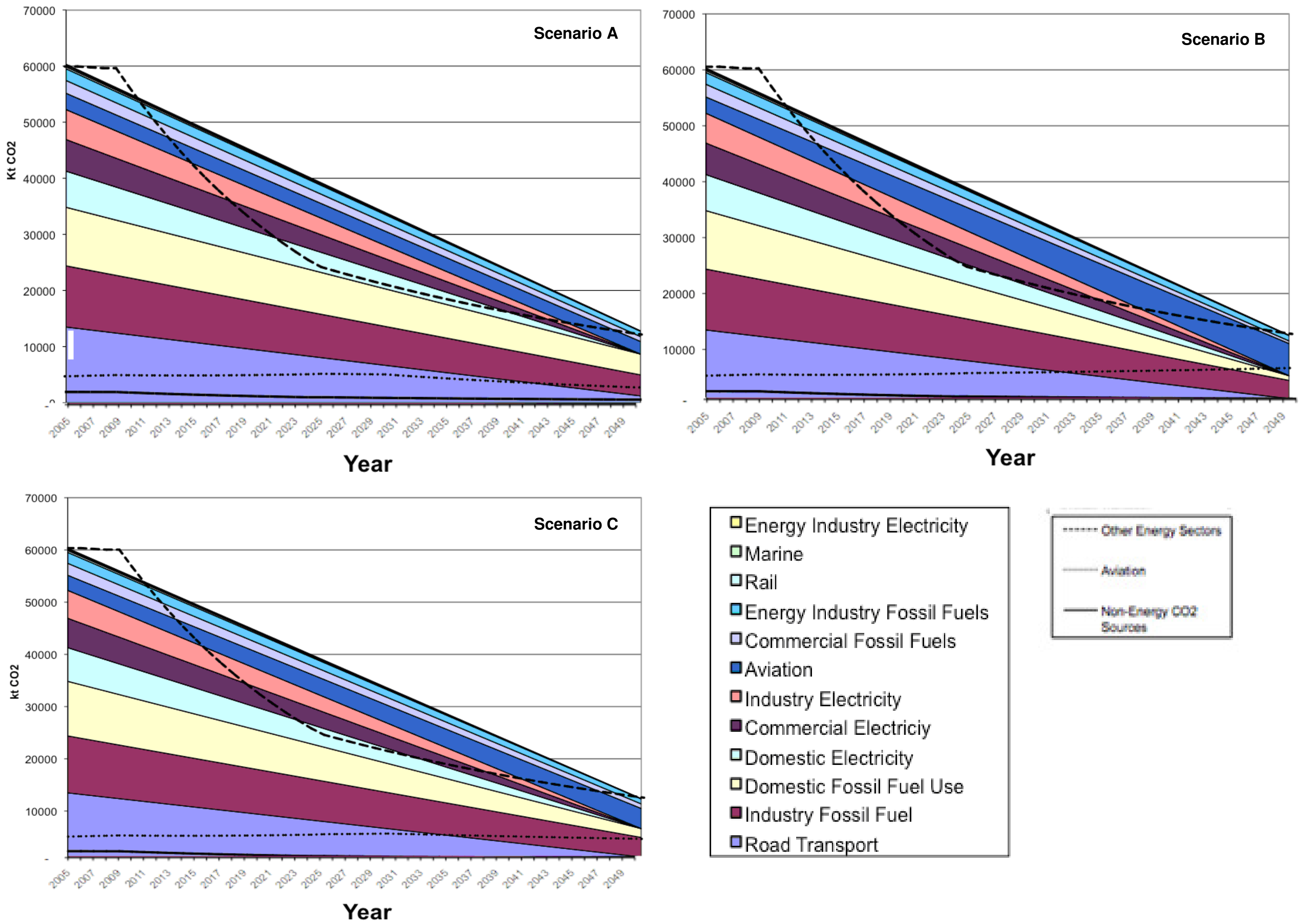
This suggests a North West cumulative emissions budget of ~1,400MtCO_2 for energy and process CO_2 emissions between 2005 and 2050. An emissions pathway that corresponds to this budget is presented in Figure 4.4 where this incorporates emissions under the Aviation C Scenario and projected reductions in non-energy CO_2 sources (80 per cent by 2050).

Figure 4.5 presents an overlay of the cumulative emissions pathways on the stakeholder aviation end-point scenarios A, B and C. The pathway for aviation is given in the diagram, with the remaining budget shared between the other energy sectors. The diagrams illustrate the emissions reduction pathway that would need to be followed for the North West to comply with the CCC's guidance.

While the delivery of the cumulative pathway may vary between different scenarios, the important point to note is that the area under the curve of the graph must remain the same. For example, if the North West was not able to deliver the large scale reductions required by 2025 as illustrated in Figure 4.5, more stringent reductions would be required in future years.

[12] The CCC's expected reductions from non- CO_2 greenhouse gases – 70% reduction by 2050 and a low emission scenario for international shipping reported by Bows *et al.* have been used to take into account of the share of the UK budget that should be reserved for these sources.

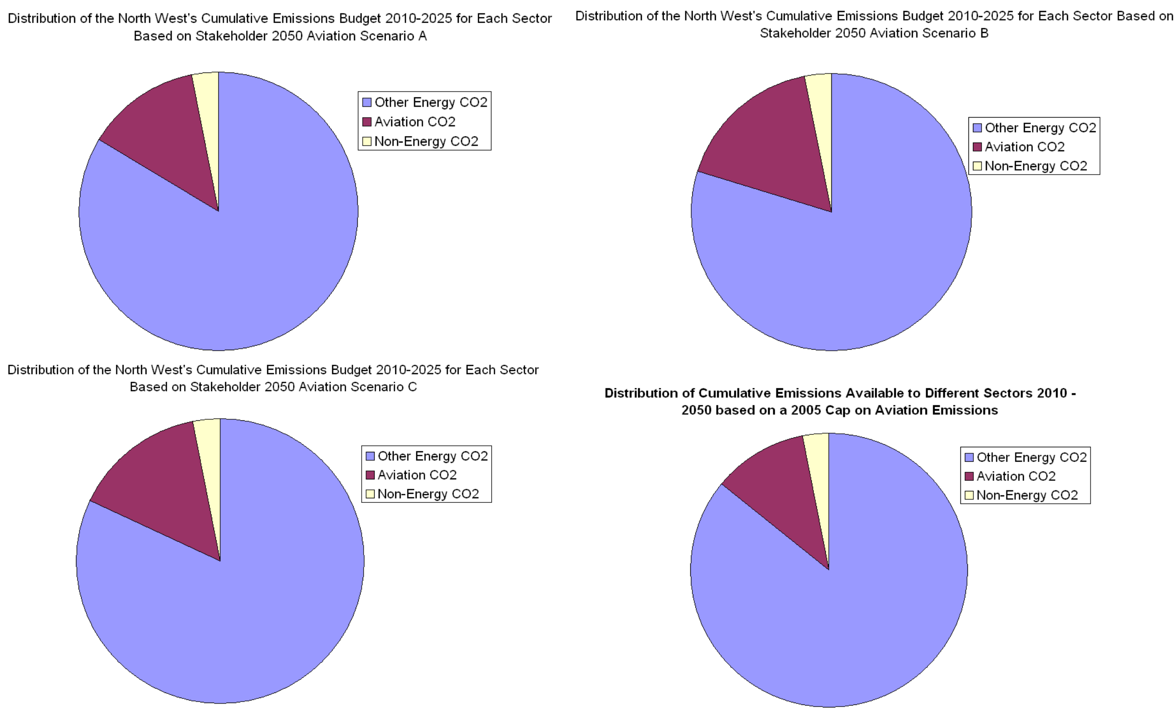
Figure 4.5: The cumulative emissions pathway for the North West compared with the 'end-point' stakeholder scenario trajectory for Aviation Scenarios A, B and C.



As noted above, the cumulative budget available for the North West to spend between 2010 and 2050 is approximately 1,072MtCO_2. Subtracting the aviation CO_2 emissions and non-energy CO_2 emissions pathways from the total CO_2 budget profile for the North West gives an indication of the budget available for all other energy sources in the North West. Figure 4.6 shows the distribution of the cumulative emissions budget for each sector based on the scenarios.

A comparison can then be made with the cumulative emissions if annual aviation emissions remained at 2005 levels ~ equivalent to the EU-ETS proposed cap for aviation and the recent CCC aviation report (CCC, 2009). However, it should be noted if the industry were to go over this cap by purchasing permits outside the aviation sector, they would still effectively be taking a larger share of the cumulative budget. Other sectors that trade would be not only delivering their own expected reductions but also offsetting aviation growth. In this way, the EU-ETS provides an economically-efficient method of delivering emission reductions across the traded sectors in the short term. However, given the size of emission reduction to which the UK has already committed to delivering, the available emissions space which non-aviation sectors are left to trade with is likely to become ever smaller, effectively constraining the availability of permits in the medium- to long-term. To date, the EU ETS has not been delivering levels of emissions reductions commensurate with the 2ºC goal owing to a combination of low carbon price and allocation decisions. Bringing aviation into line with other sectors using the ETS would require supplementary requirements on the industry until aggregate emission reductions are commensurate with the 2ºC target.

Figure 4.6: Distribution of Cumulative Emissions Budget for Each Sector



4.3 Key findings

Key findings from the scenario studies can be summarised as follows:

- the lower passenger and flight growth rates identified in the scenarios, when combined with existing projections of efficiency improvements and significant biofuel use, can (in principle) enable the North West to meet an overall 80 per cent CO_2 emission reduction target on 2005 levels. That said, a failure of the biofuel market would require an equivalent increase in efficiency improvements of between 5 (Scenario B) - 20 (Scenario A) per cent by 2050 to maintain the same emissions profile;

- all three aviation scenarios would require other sectors to combine to deliver an 81 per cent to 88 per cent overall CO_2 emission reduction on a 2005 baseline by 2050;

- cumulative budgets for aviation developed from the end-point scenarios provide an emissions allocation for aviation in the North West. These budgets range from 16 per cent (Scenario A) to 22 per cent (Scenario B) of the North West's total between 2010 and 2050;

- the remaining budget for non-aviation CO_2 sources is tightly constrained under these cumulative pathways. Rapid deployment of low-carbon technology, combined with large scale efficiency changes and behavioural change would be required for the non-aviation sectors to deliver these challenging emission reduction pathways;

- this represents a significant problem from the perspective of ensuring equitable distribution of the emission reduction efforts between non-aviation versus aviation sectors.

5. Economic impact of constraining aviation emissions growth

5.1 Overview and approach

Several studies have sought to quantify the economic benefits of the aviation sector (defined in this work as a service sector composed by airports and airlines)[13] both at the national and the regional level. Given the difficulties for any study looking at economic impacts of a sector in isolation, it is a general feature of sectoral economic assessments that they tend to focus on a sub-set of indicators and interactions and catalytic effects where positive effects on downstream sectors can be identified. This is particularly the case for sectors where the economic contribution of the sector in its own right is relatively small. Any scope for quantifying and adding in wider catalytic benefits, in these situations, may change the estimated value substantially.

A key area of difficulty for these wider economic studies is that, when estimating the catalytic effects, it is always hard to disentangle the contribution of the sector that is

[13] Airports and airlines constitute a higher source of CO_2 emissions in comparison to the aerospace manufacturing industry, and also it is aviation as a service sector that is claimed to have the most significant positive contribution to the regional economy as a support to other sectors.

the focus of study from all of the other effects and influences. There is often a tendency to assume that all catalytic benefits are conditional on the sector being studied and, therefore, all downstream benefits can be attributed to the sector of interest. Studies on the aviation sector are no exception to these problems and tend to focus on the positive contributions of the aviation sector, namely:

- this is a growing sector in its own right – measured in terms of employment creation and its contribution to regional and national GVA;
- it has catalytic effects in the economy as a support for tourism, investment, international trade, growing sectors (air intensive); and
- it is a trigger of growth and productivity in general.

Building on identified evidence of current benefits and interactions, future projections of economic gains and losses from changes within a given sector tend to extrapolate existing evidence of economic contribution to a future scenario. Typically, such future scenarios are based on extended 'business as usual' cases for economic contexts characterised by very specific assumptions regarding oil prices and GDP changes, as well as on particular assumptions regarding the structure and future growth of air passenger demand.

In this respect, the challenges of climate change represent something of a 'special case' both in terms of the challenges themselves, but also in terms of the economic complexities that meeting these challenges introduces across all economic contexts. As noted in Section 1, the delivery of the greenhouse gas budgets and associated target reductions requires the investment of significant resources from all sectors of the economy which, in turn, is likely to change economic contexts very significantly across all sectors in the future.

In terms of aviation and its inter-sectoral links within these different economic contexts, the wider economic picture is made even more complex by the interplay between emissions from aviation versus emissions from all other sectors. As noted in Section 1, emissions from the aviation sector are included in the statutory budgets (but with no explicit targets as yet), which means that any growth in emissions from aviation within budget periods will have to be offset by similar magnitudes of emissions reductions in other economic sectors. As noted in Section 4, all three aviation scenarios developed in the Joule study require other sectors to deliver an 81 per cent-88 per cent overall CO_2 emission reduction. In simple terms, then, there are two ends of the spectrum in terms of outcomes and economic impacts:

- on the one hand, net growth in aviation emissions will act to increase the magnitude of emissions reductions for all other sectors leading to an increase in their cost burden (whether connected or not connected with the aviation industry). Clearly, this has the potential not only to affect the other sectors directly (in cost terms), but in so doing, alter some of the economic contexts that support future growth in aviation.

- on the other hand, constraints on the growth of aviation to reduce emissions may have a impact on sectors most directly related to the aviation sector. Adding complexity to the 'problem', these impacts might be comprised of a mixture of potentially adverse impacts on aviation-connected sectors but also potential benefits to other sectors that may be able to capitalise on the delivery of solutions (such as the aerospace industry).

What constitutes the 'right' balance economically between these two ends of the spectrum is clearly a very complex issue. It requires consideration of the impacts on aviation (and associated sectors) and impacts of additional cost burdens on all other sectors (from increased emissions reduction commitments) simultaneously. It also requires consideration of how these impacts interact to produce a future economic context that will inevitably diverge from the economic contexts and related assumptions currently used in the construction of economic scenarios for aviation.

Clearly, while it is difficult to quantify all of the complexities in a single and relatively short study (such as this), it is possible to begin to piece together some of the core elements of the issue at hand. The starting point here has been an analysis of what the current studies suggest might be the contribution of aviation to the economy of the North West and, where possible, how this may change in the future. This has been the focus of effort in Theme 2 of the Joule study. The approach to the economic analysis is summarised in Box 5.1.

Box 5.1: Summary of the approach to the economic analysis

- **Evaluation of existing studies on the economic contribution of aviation –** studies on the economic contribution of aviation (at UK and regional levels) were identified and evaluated thoroughly in terms of the main results, empirical evidence, metrics, quantification and methodology used.

- **Identification of appropriate regional data -** in conjunction with in depth analysis of the methodologies and empirical evidence used in existing regional assessments, a number of regional data bases and sources were examined to obtain the data for a regional economic assessment.

- **Catalytic effects of aviation in the North West -** an overview of the North West economy was carried out to identify the relative contribution of different sectors to the regional economy and likely sensitivity of economic performance and growth in these sectors on aviation (both now and in the future).

- **Consultation with key sectors and actors in the North West -** based on the above, a number of large and small business organisations and government institutions were selected for interview to assess 'air intensiveness' in terms of factors including the degree of dependency on aviation and the dynamics of their flying practices (reported in section 6).

- **Exploration of alternative methods of scenarios development–** a number of alternative methodologies for the construction of scenarios for the assessment of the future contribution of aviation in the region were examined.

5.2 Results of the analysis

The analysis identified a number of methodological issues and problems in relation to existing studies on the economic contribution of aviation as well as more general conclusions concerning the likely scale of this contribution.

Methodological and technical issues in existing studies

The review of existing studies on the economic contribution of aviation identified a series of shortcomings that were shared by one or more of the studies concerning:

- the use and presentation of empirical evidence resulting in the overestimation of the value of the aviation sector;
- presence of simple assumptions and lack of consideration of other counterfactual alternative responses (in relation to, for example, employment and GVA/GDP) tends to maximise the 'cost' side of limits on aviation growth;

- similarly, interpretation of empirical outcomes and impacts in some cases tends to overvalue the sector;
- links between cause and effect are not always backed up by robust evidence presenting problems for econometric analysis; and
- the assumptions used in the construction of future scenarios do not necessarily reflect deviations from 'business as usual' and do not take into account among other things: the current and potential future economic downturns, large fuel price fluctuations or climate constraints (Bleda, 2009).

These are described in more detail in Table 5.2.

Table 5.2: Methodological and technical issues in existing economic studies	
Use and presentation of empirical evidence	In some cases, the empirical evidence provided is robust but is presented in a way that overestimates the economic value of aviation. Examples include definition and measurement problems in establishing the size of the sector (different use of metrics), the boundaries and appropriate definition of employment direct, indirect and induced effects (leading sometimes to double counting), and the use of upper limit estimations.
Counterfactual – consideration of alternatives	Studies tend to ignore possible alternatives and often apply simple links between losses and gains. For example, the assumption that 'less aviation equals more unemployment' ignores that in absence of structural unemployment people occupying jobs in a given sector will not become 'jobless' if the sector ceases but will be employed in other sectors. 'Less aviation equals smaller GVA' - if there were less aviation, value added would be generated in other sectors, money currently spent on air travel can be spent in alternative ways and induce impacts in other sectors contributing to employment and GDP.
Interpretation of outcomes	In several instances, outcomes and evidence appear to be interpreted in favour of aviation. For example, tourism deficit is interpreted as a reflection of increased living standards. In addition, the potential growth of outbound tourism (which would increase this deficit in the future) is not considered.
Links between cause and effect are not always backed up by robust evidence	The analysis found that the significance of some survey results is questionable due to the small size of the data sample; econometric parameter estimation is performed with a lack of sufficiently robust data and, in some cases, the estimate has been carried out through the use of data mining. The econometric methodology also present some problems regarding the direction of correlation and causal relationships.
Issues with construction of future scenarios for the estimation of future contribution	Scenarios are based on the same econometric model used for estimation of current contribution and issues described above are carried through into scenario modelling. In addition, GDP growth projections do not take into account the effects of recession or the potential reduction in GDP owing to projected higher oil prices (although mitigation measures can reduce demand of oil and therefore its price). It is also assumed that increases in GDP results in increases of air travel demand (i.e. air travel is quite elastic to income). However, there is evidence of falling income elasticities of demand particularly in mature markets. There is also a high degree of uncertainty concerning passenger response to future changes in income, tastes and preferences, behavioural changes achieved by information policies, use of video conferencing. Inter-modal shift (from air to rail) are not considered in the scenarios Conservative estimates of oil price increases and fluctuations are employed affecting estimated effects on passenger demand and fares. Studies assume that the low air fares trend is set to continue yet there is significant uncertainty about future changes in costs influenced by oil prices and the incorporation of factors related to climate change in aviation costs (which are not taken into account).

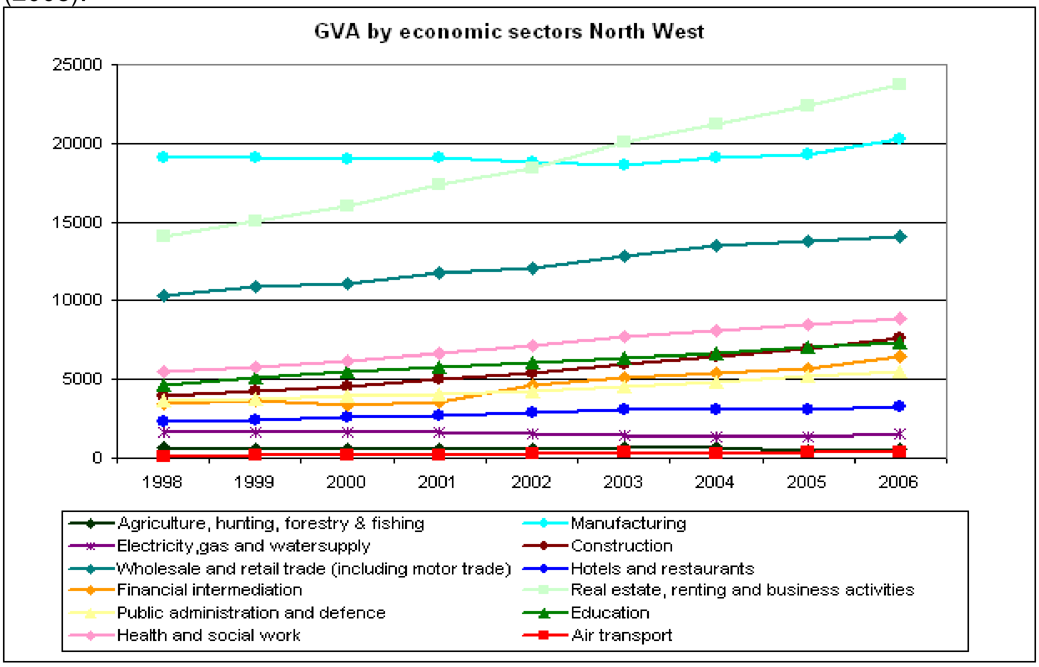
Analysis of economic impacts and contribution

A complete evaluation of the economic contribution of aviation to the North West regional economy can not be performed at present due to a lack of the necessary data (in particular data from input output tables for regional sectoral inter-connectivity) and the absence of an appropriate and agreed methodology for the construction of scenarios to assess the future contribution of aviation in the North West.

In addition, a number of cost elements for the aviation sector are 'hidden' and therefore difficult to account for in any analysis. Such hidden costs include tax breaks, subsidies, ill health, and costs of environmental clean up. Such costs are generally very difficult to quantify and, as such, have not been included in any of the existing economic assessments.

While a complete assessment is not possible at this time, the available data on the current contribution of the aviation sector, in terms of GVA and employment generation, show that, although considerable, this contribution is relatively small when the sector is defined narrowly (solely airline and airport GVA) and when it is compared with other sectors in the North West. Contribution of different sectors in the North West (measured in terms of GVA) is provided graphically in Figure 5.1. It should be noted that the regional aerospace industry will also make an important economic contribution (this is included in the contribution of manufacturing to GVA in the North West, see Figure 5.1).

Figure 5.1: GVA by economic sectors in the North West taken from ONS (2008).



5.3 Conclusions and key messages

In summary, the evaluation identifies that current assessments of the economic contribution of aviation need further refinement and, at present, tend to overemphasise the contribution of both aviation currently and in future scenarios. The effect of this is to overemphasise the costs and economic impacts of curbs on future growth in aviation. At the same time, defined narrowly in terms of the airlines and airports to which emissions might be attributed, the aviation sector makes a relatively small contribution to the regional economy of the North West compared with other sectors.

As noted previously, all three aviation scenarios developed in the Joule study (Section 4) require other sectors to deliver up to an 88 per cent overall CO_2 emission reduction. This in turn suggests a need to look closer at the balance between the costs and economic impacts of curbs in emissions from the aviation sector versus the costs and economic impacts of the further reductions in other sectors that, evidence suggests, clearly contribute (more) substantially to the economy of the North West.

When considering the costs of curbs in future aviation emissions it will also be worth considering potential economic benefits, not just in terms of costs avoided to other sectors, but also in terms of potential economic opportunities for the aerospace industries in the region. For example, there are a range of technological solutions for which the North West is very well positioned to capitalise upon (as home of, for example, Airbus, BAE Systems, MMU, Rolls Royce and UMARI). These include improvements to existing aircraft (e.g through the fitting of winglets and riblets as well as other design modifications), short term options that reduce operating costs from reduced fuel burn, as well as new airframe and engine technologies.

While, as noted above, the total value of aviation seems to have been overvalued in existing studies, there is a need to consider indirect benefits of aviation, and particularly the catalytic (multiplier) effects, in more detail. The focus here does not necessarily need to be on assessing total value, but rather on identifying those sectors (and parts of sectors) that are likely to be sensitive to changes in the aviation sector. This in turn permits the development of targeted intervention to prepare and assist these sectors to make an early transition towards alternative markets where such intervention is very much part of the role of RDAs. Early action will make local economy more resilient to future changes.

6. Organisational consumption: Understanding flying for work

6.1 Overview

The proximity and ease of access for organisations to (particularly) international flights and airports is often identified as one of wider economic benefits of aviation (both in the North West and more widely). From a regional economic perspective, access to transport connections (including airports) has, at least historically, been an important factor in organisational decisions concerning office location. This in turn influences the provision of transport services (including airports) through organisational demand for those services.

Given the links between organisational demand and the supply of services and, in addition, ongoing shifts in attitudes and information and communication ICT, Theme 3 of the Joule study sought to examine:

- what drives the demand for flying in the North West?
- what is the relationship between physical mobility (flying) and use of ICT in the travelling and communicating practices of organisations?
- what role might greater use of ICT play in transitioning to low-carbon pathways in the North West?

To examine these issues, the study examined the influence of organisational policies and environmental strategies and sought to identify other vectors that explain and determine staff flying practices and the use of ICT in both large organisations and small- to medium-sized enterprises (SMEs) in key economic sectors of the North West.

6.2 Large organisations and factors influencing flying and the use of ICT

Approach

Extended open-ended interviews were conducted with a number of large organisations with a significant presence in employment and economic weight terms in the North West. In addition to selection on the basis of regional economic importance, organisations were also selected to represent a *variety* of roles and activities from both the private and public sectors.

One interview[14] was conducted per organisation and, where possible, the interviewee was a senior (or middle management division/team leader) that:

- had knowledge of the environmental policies of the organisation and climate change and decarbonisation issues within that; and
- was in charge of a significant budget and able to influence decision making around transport, aviation and the use of ICT.

The organisations, interviewees and interviewing methods are summarised in Table 6.1.

Table 6.1: Large Organisations Interviewed

Organisation	Method	Number Interviewed
Manchester City Council	Face to Face	2
NHS Primary Care Trust	Telephone	1
University of Manchester	Face to face	2
Manchester City Football Club	Telephone	1
Tesco	Face to face	1
The Co-operative	Face to face	1
Unilever Best Foods	Face to face	1
BBC Radio Regional News	Face to face	1
Mersey Partnership	Face to face	1
	Total Interviews	11 (target 10)

Key findings for large organisations

A summary of key findings from the interviews is provided in Table 5. From the table it can be seen that the dynamic influencing travel demand for a given organisation is a function of three key factors/vectors:

- the international orientation of the organisation;
- the propensity to introduce (or have in place) serious top-down sustainability/carbon reduction strategies;

[14] The majority of interviews were carried out by two members of the Joule research team and all interviews were recorded and/or detailed notes were taken.

- organisational capability in terms of 'management accounting systems' and the transfer of data/information to carbon monitoring/reporting.

Within the latter two, the level of penetration of ICT as a travel alternative tends to depend on the extent to which links are made between communication systems/budgets and travel budgets.

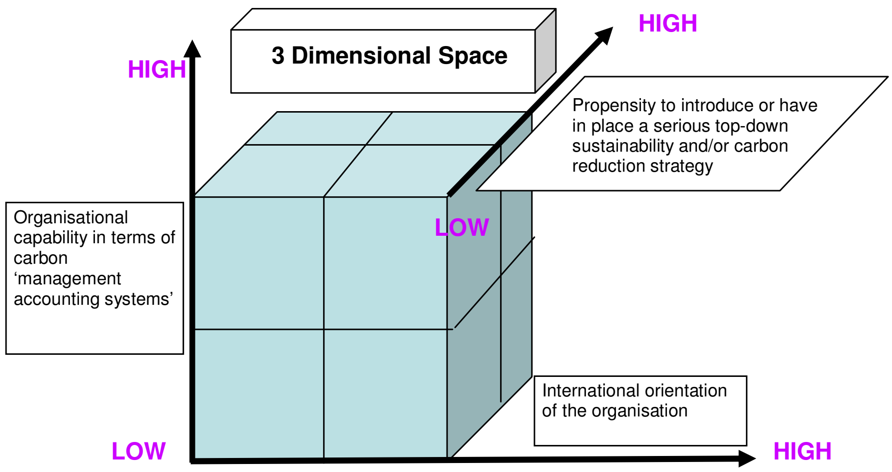
In short, internationalisation places upward pressure on the need to fly, while financial efficiency, environmental values and policy imperatives exert downward pressure on flying practice. Establishing links between travel and ICT tends to enhance the uptake of solutions that help to relieve this pressure by provided a travel alternative in many (but not all) circumstances.

Table 6.2: Key findings for large organisations	
Role of institutional international orientation	The more international the orientation of an organisation, whether it is private or public, the greater the propensity for staff to fly. For example, a city council or a hospital/NHS trust serves a 'local' audience and, as such, the propensity for workers to fly is very low and, for executives and management staff, opportunities to fly are limited to diplomacy or overseas study/training trips/overseas experiences and case studies. In contrast, a university is more internationally oriented by virtue of, for example, the need to recruit large numbers of overseas students or the need to ensure that academic and research staff develop an international reputation. Accordingly, frequent flying is seen as the norm within the University of Manchester and, given the existing Higher Education funding regime and the financial importance of 'internationalising', it is hard to see how this will change in the short- to medium-term.
Travel monitoring and behavioural change	The use of alternatives to flying or other modes of transport (such as ICT) was patchy within all branches of the public sector, including the University. In contrast, however, organising flights is easy to do and allocation of travel budgets is devolved to relatively junior or administrative levels with few powers or responsibilities to question the 'need'. In the university context flying is generally considered an unquestionable norm at all levels of the organisation and, while there is a sustainability strategy (including measures for energy and carbon reduction) agreed by the most senior personnel, the issue of transport (especially flying) is a thorny nettle that is yet to be grasped. In contrast to the public sector, business organisations were much more likely to have instituted a travel monitoring system, whether as part of a sustainability/carbon management system, or for cost monitoring purposes (where this includes staffing efficiency in relation office absence and jet lag as well as the cost of transport itself). A number of organisations (including Co-operative, Tesco, and Unilever) take the implementation of an 'accounting' and monitoring system seriously and methods and procedures are standardised and instituted at the top of an organisation or business unit and cascaded down through the organisation. In a number of instances, the data from these processes provide inputs to carbon and sustainability monitoring reports (for example, Co-Op, Tesco and Manchester City Football Club). Importantly, however, regardless of the existence or sophistication of carbon monitoring methods/sustainability strategies, as soon as an organisation makes a step-change towards a more international orientation this tends to take priority and emissions are likely to ratchet upwards significantly, at least in the short- to medium-term.
Establishing links between ICT and travel	While there are obviously links and synergies between the use of ICT and travel management, the study found that, with few exceptions, organisational units and management systems controlling (or not) budgets for flying were completely separate/independent from ICT considerations. Hence, potential links/synergies are not made and opportunities for cost or carbon reduction are missed.

	This lack of use and engagement with ICT solutions represents a lost opportunity for cost savings across the organisations interviewed. Reasons given for lack of engagement include: unfamiliarity of the technologies available; the perception that systems are unreliable; and a lack of agreement concerning the best/most appropriate software/hardware and associated cost. A notable exception to this was Unilever Best Foods where a single senior manager is responsible for all aspects of operational efficiency (including overall responsibility for the operational, communications, and travel). Here, ICT is routinely and systematically seen as a tool to manage mobility and communications in a more co-ordinated and holistic way and appears to be managed and facilitated (in terms of administering ICT hardware and software for video conferencing) from Unilever Headquarters.
Roles of ICT versus flying	In terms of attitudes to distance travel, one Unilever respondent identified that, whilst junior executives may still view flying as a 'perk', this was no longer true for the older/more experienced managers. The latter group viewed travel as representing a tiring, time-consuming, uncomfortable, period away from family members and home. Within the branch of Unilever interviewed, flying was identified as appropriate in the following circumstances: • for the annual international social conference where wives/partners participated (an opportunity for building social-capital); • for meetings of same-function executives to come together across business units and national borders in best-practice and learning context (an opportunity for building knowledge-capital); and • in the first stages of meeting new clients in high-level negotiations around large, non-routine, contracts where knowledge is co-produced in team settings. Face-to-face communication may then reduce if contracts/relations crystallise into more familiar, routine or standardised settings. The clear articulation of these three distinct settings highlights that ICT is not a substitute for all business/organisation communications and that there will always be some circumstances where 'only face-to-face meetings will do'. Clearly, however, organisations are beginning (even if in a generally patchy and uneven way) to recognise that reducing flying has a number of financial and environmental benefits.

Drawing on the three vectors discussed above could allow the development of self-evaluation framework for organisational learning with outputs mapped on a three dimensional graphic such as that provided in Figure 6.1.

Figure 6.1: Travel practice/business model



With further development, such an approach and output could be used in a number of ways including:

- providing a means for an organisation to self-diagnose and provide an underpinning for a ‘future target trajectory’ including the setting of carbon-reduction targets;
- as a means to monitor progress over time; and
- providing a means of comparing performance and attributes of several organisations (or parts of the same organisation).

The tool is named the *ISCAS* model as it comprises:

> ***I*** : ***International orientation***: whether the organisation ‘faces outwards’ to overseas markets and clients; or ‘faces inwards’ to local markets and buyers.
>
> ***S*** : The presence of a carbon reduction strategy, perhaps within a wider ***sustainability strategy*** including targets and activities the delivery of which illustrate different practices across organisations. Into this category could be added the systematic ***development of ICT*** to substitute for flights where appropriate.
>
> ***CAM***: The presence or introduction of a ***Carbon Accounting System***; paralleling existing monetary accounting systems. With training and support this could assist in the management, monitoring and reporting of carbon reductions at the level of individual staff members, aggregated to teams and divisions, with the aim of reducing the proportion of employee flying and thus potentially reducing the aviation portion of work-related carbon footprints.

It is therefore the function of the organisation, and the amount of carbon or sustainability awareness that is embedded within the organisation, rather than the particular organisational type that governs high and low propensity to fly.

6.3 Small- and medium-sized firms in key economic sectors

Method

A small telephone survey of 100 ‘key sector’ SMEs was undertaken to identify and analyse flying behaviours/practices and to investigate the propensity to use ICT alongside flying as an alternative mode to travel.

The 100 SMEs were identified from on the basis of a list of six key sectors identified by the NWDA as having strategic importance by virtue of their being sectors on which the economy North West disproportionately depends. The six sectors identified by the NWDA were: food and drink, environment and energy, advanced engineering and materials, digital and creative, biomedical and business and professional services.

The NWDA believes that there are significant opportunities for these sectors to grow and provide one plank in a series of strategies representing the current and future economic backbone of the North West's economy both in terms of contribution to GVA and employment, and in terms of contribution to the future robustness and resilience to shocks to the North West economy. The NWDA was also anxious to consider SMEs in this sector as a means of identifying any potential negative impacts on connectivity and business development resulting from any policy decisions that might serve to constrain levels of flying by personnel in these firms.

A sampling frame comprising separate lists of firms in each of these sectors was produced and from these a stratified random sample was drawn by selecting every 'nth' firm in each sector list. In this way, the resulting sample was designed to reflect the weighting of that sector within the total population of key sector SMEs.

In each case we sought to communicate directly with either the managing director and/or budget holder for flying/ICT for the firm. Often all of these decisions resided in a single MD figure. In terms of communications with 'frequent flyers', where such individuals were unavailable, we substituted personal assistants and secretaries where they had a thorough knowledge of the flying practices, reasons for flying, and destination of the main flyers in the SME, etc. In these cases our results in terms of questions about attitudes to flying (and attitudes and propensity to introduce ICT) were uneven.

Key findings

In common with the larger organisations, the greater the degree of international orientation of a given SME, the greater the propensity to fly.

Where there is greater diversity of flying practices *within* key sectors, this appears to be a function of the role of the SME within the overall production-consumption system rather than the sector of the SME per se. For example in the manufacturing sectors (such as engineering and life sciences) some functions are inherently more international in their orientation (e.g. selling hi-spec engineering solutions to international clients) and others, despite being labelled 'key sector', actually carry out routine services for local markets, including large local businesses and clients (e.g. lab-testing diagnosis services).

As such, frequent flying is clustered within the sample reflecting those firms with the greatest level of international orientation around non-standardised (often knowledge-intensive) business services and international sales functions.

In terms of procuring and/or using ICT to complement or substitute for flying, the main differentiating factor appears not to be sector-orientated but rather a sense of entrepreneurial capability and openness to continual change and improvement. Such firms (or firms led by such personnel) were already using ICT communications extensively, but it appears that so far ICT use is in addition to frequent flying rather than a substitute for it.

Overall, SMEs were less likely than their large organisation counterparts to wish to be involved in follow up initiatives to the survey, citing busy workload as the main reason. However, a group of around 20 respondents expressed interest in being re-contacted as part of a more in-depth qualitative study, and in potentially participating in follow-up activities.

7. Conclusions and recommendations

7.1 Conclusions

Any sector of the economy reliant on fossil fuels emits CO_2 and thus contributes to climate change. Aviation is no exception. However, its treatment within the Kyoto agreement has led, until very recently, to aviation's exclusion from the range of mitigation polices applicable to other UK sectors. This differential treatment has stemmed, firstly, from debate over how to allocate emissions from aviation to sub-global scales and, secondly, from its perceived economic importance in driving growth, job creation, inward investment and tourism. By including aviation, the Committee on Climate Change's emission budgets are likely to demand support from additional tiers of government for absolute and comprehensive reductions to be achieved with minimum compromise to a regions' economic performance. In light of the government's commitment to absolute emission reductions from across the UK, this Tyndall Centre study, funded by the Joule Centre, has explored the quantitative contribution of aviation to both the North West region's CO_2 emissions and economy. Building on this, policy levers available to the region to mitigate emissions from aviation have been considered alongside their potential socio-economic impacts.

Key findings:

Emission apportionment
The Tyndall Centre's hybrid apportionment regime developed for this project permits aviation emissions to be attributed using a method acceptable to a wide range of stakeholders on a regional scale (Wood et al 2010). Consequently, the RDA is now able to apply an approach that takes into account both the producers and users of aviation services. In doing so, it provides clear links between those organisations or individuals with influence over the direct production of the emissions and the use of the services provided. In addition, it enables ongoing monitoring of emission reduction measures across the aviation system, including the impact of policies made by airports, airlines and air traffic control or those aimed at aviation users to reduce emissions from both the LTO cycle and cruise emissions. By explicitly dividing the emissions burden between producers and consumers, the hybrid approach reflects fairly the benefits the region receives through hosting an airport and from the services provided to residents and visitors to the region.

Future scenarios
Within the stakeholder-led scenarios, aviation is a key sector of the North West's low carbon transition. Despite assuming improvements to fuel efficiency, increased availability of alternative fuels and a reduction in growth rates, all stakeholder scenarios resulted in aviation taking a bigger share of total emissions in the North West by 2050. This places additional pressure on other sectors to decarbonise over and above the 80 per cent reduction. Allying the industry's own ambitious ACARE targets with the stakeholder's growth rates would lessen but not eliminate this additional pressure from the other sectors. A clear challenge for the aviation industry is therefore to commit to and implement a strategy for delivering a **step-change** reduction in carbon intensity alongside tackling growth rates. The North West is well placed to benefit economically from such a strategy given the regional density of the aerospace industry and academic capacity.

Flying for work
There is a wide spectrum of flying practices across organisations depending on degrees of internationalisation, sustainability and carbon accounting strategies. Regardless of organisation size and type (public or private), awareness of carbon and sustainability issues have a major influence on how often its individuals choose to fly. Building on this, the work-related flying analysis within this report provides a framework with which the RDA can: identify those organisations of particular economic significance in relation to their flying practices and accompanying carbon emissions; develop monitoring schemes for carbon emissions appropriate for different organisations; compare the sustainability practices across and within organisational type; and encourage and identify new training needs. Furthermore, the framework can be used to identify opportunities for substituting work-flying with information and communication technology (ICT) within organisations with a high propensity to fly, thereby reducing the pressure on other organisations to compensate for the high levels of emissions that inevitably accompany aviation. This has the potential to contribute significantly to a more diverse and resilient regional economy.

Economics
While aviation's environmental impact is well understood, evidence of the economic benefits and disadvantages of aviation remain partial and consequently the industry's overall economic impact can not currently be adequately assessed. The principal economic benefit of aviation is likely to stem from the sector facilitating improvements in the productivity of the wider economy, i.e. its catalytic positive effects by reducing cost of transportation, increasing connectivity and attracting investment and trade. These catalytic effects, unlike the direct and indirect impacts of aviation, are not normally offset by using resources that maybe otherwise be deployed elsewhere in the regional or national economy, and are therefore likely to be permanent.

Intuitively it may appear reasonable to assume these economic benefits are present and of vital importance, and certainly they have been the subject of significant analysis. However, despite this, the evidence base remains very limited in several important areas (Oxera, 2009, p. 20), and the methods used in the collation of empirical data are not universally accepted as appropriate (see for instance Delft, 2008).

In general, those analyses indicating a broadly positive economic contribution from aviation are insufficiently robust to provide a reliable conclusion. Improving future analyses requires further data; a more consistent interpretation of results; more objective and robust analysis; and more appropriate scenario methodologies. The tendency for overly-positive assumptions, for example, low oil prices and high GDP growth, to inform scenario development risks misleading policy. Furthermore, at a regional (North West) level there is insufficient data to conduct a rigorous analysis of aviation's full economic contribution (particularly regarding catalytic effects). Consequently, until economic data quality and availability is improved to the extent that it is comparable with the emissions data, a cautionary approach would be prudent in developing future aviation policies.

7.2 Regional policy recommendations:

Adopt the new hybrid producer-consumer apportionment regime.
This regime facilitates the fair inclusion of aviation-related emissions into regional emission inventories. A region can subsequently make a comprehensive assessment of how to mitigate its emissions from across *all* sectors, thereby reducing the impact

to that region's overall socio-economic performance. By making use of fuel consumption data reported under EU ETS, all the region's airports should be encouraged to further develop their monitoring of LTO emissions.

Exploit opportunities for airports to mitigate LTO emissions
New and complimentary levers for implementing emission mitigation policy amongst those regional organisations - airports, airlines and regional advice contacts from National Air Traffic Services (NATS) - with influence over the LTO cycle need to be identified. This will require the chosen apportionment regime to draw a clear distinction between LTO and cruise emissions.

No further delay to cross-sector emission monitoring
The urgency and scale of the climate change challenge calls for all tiers of government to take early and comprehensive consideration of sectoral emissions. In so doing, they should determine what constitutes an appropriate balance between future emissions from aviation and those from other sectors; guided by the Government's assertion *"that average global temperature must rise no more than 2ºC"* and advice presented by the Committee on Climate Change on the role of aviation in the UK's emission reduction pathway (CCC, 2009).

Encourage immediate inclusion of airports in existing carbon schemes
Achieving cuts in emissions may, in part, be driven by rising oil prices and the inclusions of aviation within the EU ETS. Yet for reductions to be in line with the 2ºC goal (and even a reasonable probability of avoiding 4ºC), additional schemes and regulations will be necessary. Following the lead of Manchester airport, all airports should be encouraged and supported in joining the Airport Carbon Accreditation Scheme's Optimisation stage to achieve emission reductions from the LTO cycle.

Become an exemplar region in supporting step-change mitigation
For the aviation industry to make their fair contribution to the UK's emission reduction aspirations, support from all tiers of government is required. In this regard, the RDA is in a position to stimulate the North West's established and vibrant aviation sector to bring about step-changes in both technology and air traffic management. Increasing the focus on this 'difficult to tackle' sector provides an opportunity for the North West region and its airports to become an exemplar in this area.

Adopt short-term mitigation measures with urgency
With the majority of technological change likely to bear fruit over the longer-term, opportunities for short-term operational emission reductions must be exploited urgently. Examples of short-term measures include the use of the 'continuous climb' and the 'continuous descent' approaches, reducing ground congestion, encouraging airlines to taxi using only one engine and refrain from using auxiliary power units. Further short-term operational changes include the use of alternative business models that consolidate flights to increase occupancies and reduce aircraft deadweight (for example, enabling passengers to collect duty free shopping at their home airport rather than buying or carrying it on the flight). These and similar measures will partially offset the emissions implications of short-term growth in demand and could increase the attractiveness to airlines purchasing permits from the EU ETS for airports facilitating low emissions operations.

Promote local tourism & encourage high-tech video conferencing
Understanding the region's aviation users – both work and leisure flyers – facilitates the RDA in identifying areas with known high emissions but uncertain economic benefit. Local tourism is actively promoted to inbound tourists; additional work is required to examine the impacts of inbound tourism and to further encourage North

West residents to use local tourism services. For those flying on work-related purposes measures to promote ICT would be beneficial. The need for aviation services is not sector specific and organisations require different levels of service at different stages of the business life cycle; ICT should be targeted to provide bespoke support across these stages. There may be a role for the NWDA in conjunction with the Carbon Trust and Energy Savings Trust in delivering this support.

Encourage widespread use of carbon accounting systems

Evidence suggests that organisations with carbon reduction strategies that take a more systems-based approach, incorporating both work-related travel and ICT, benefit in terms of emission reductions and economic growth. Such systems allow management, monitoring and reporting of carbon reductions for staff members to distinguish ‘necessary’ from ‘unnecessary’ high-carbon activity.

Make ICT training and development core for public sector staff

The patchy use of ICT within public and private sector organisations undermines opportunities for decarbonising travel. Despite high levels of interest by many employees, support and training for alternative modes of communication varies widely within organisations, with a subsequent low uptake of ICT and little substitution for significant air travel.

Categorise economically-essential organisations by their function

Given that the economic category of an organisation is not closely linked to flying habits, a comprehensive assessment of how organisations use aviation within the region is necessary for the RDA to develop policies for supporting the region’s economy whilst making a transition to a low-carbon future.

Make fair comparisons between aviation and other sectors and collate comprehensive North West economic indicators

For a fair comparison to be made between aviation and other sectors of the economy, comparable indicators based on consistent data must be used for assessing both the negative impacts of emissions and the subsequent socio-economic benefits. Arguments supporting a positive or negative contribution of aviation must take into account both its environmental impacts, and the potential negative economic effects on all the other sectors as a result of the additional efforts required from them to counteract the environmental burden imposed by aviation when complying with emissions budgets. Finally, other influences such as the opportunity cost of investment in growth in aviation, negating the same investment elsewhere, and the negligible effect of reducing the outputs of the sector in the long term should also be considered.

The limitations of the use of economic indicators (e.g. GVA) are highlighted in the latest assessment of the economic value of aviation by Oxera (2009). A detailed critical review of the economic indicators commonly used to inform policy decisions at the regional level – and specifically in the North West – has been carried out by Randles *et al* (2006). The work proposes an exhaustive list of indicators more suitable for regional policy-making that should be considered for adoption in the North West.

Through the use of a set of indicators with *systemic*, *comparative*, and *process-based* dimensions (Randles *et al*, 2006) and by considering negative economic impacts across **all** regional economic sectors, the region can more confidently make policy decisions to balance the demands of climate change with those of economic sustainability.

Use of a more appropriate methodology for the estimation of catalytic economic effects

To assess aviation's true contribution to the North West, any economic evaluation must include, in addition to the direct and indirect economic effects, the catalytic or wider economic effects of the industry. These effects are likely to represent the principal economic benefit of aviation. However, currently there is no consensus on the size of these benefits, despite the existence of a significant body of literature devoted to their quantification. The quantification of these effects typically relies on general equilibrium models with input output ratios; however such an approach is unable to capture the dynamics and complexity of catalytic effects (Oxera, 2009)[15].

Dynamic input-output analysis and accounting for feedback loops, inter-sectoral dependencies (such as system dynamics computational simulation models) and a facility for incorporating economic structural changes should be central to any modelling approach if the quantification of the catalytic effects of aviation are to be considered.

Take early action to build a resilient local economy

Future climate change mitigation polices are set to become more stringent across all sectors, with climate levies, rising oil prices and potential changes in perceptions towards flying all likely to add constraints to the aviation sector. To ensure the North West has a competitive advantage over other regions, low-carbon innovation that may bring dividends to the region in the medium term must be incentivised as a matter of urgency to avoid reliance on carbon-intensive industries for future growth.

Mitigate for 2ºC whilst adapting for 4ºC

It is essential all tiers of government understand the implications for adaptation of exceeding the 2ºC threshold. Even the budgets of the UK's Committee on Climate Change, underpinning this report, are based on a high probability of exceeding 2ºC (30-78 per cent). In light of this and the possibility of insufficient action to seriously mitigate emissions, it is essential the RDA consider seriously regional adaptation to at least 4°C by as early as 2060/70.

Further Research Requirements

In order for the aviation industry to support local economic development, the relationship between aviation services and the North West's business and organisational users needs to be better understood. Additional research is required in order to examine the current requirements for aviation of the North West's corporate airport users and their future development plans.

[15] Indeed, this work, which is the latest assessment of the economic contribution of aviation, does not attempt a quantification of its wider effects.

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