Chapter 7
Meeting the 2050 aviation target

This chapter brings together the analysis in Chapters 1 to 5 and sets out emissions scenarios under alternative assumptions about demand-side factors, improvement in fleet fuel efficiency, and use of sustainable biofuels.

The scenarios are built in the following way:

- **Demand assumptions:** We start with emissions projections reflecting different assumptions on the extent of demand response to carbon prices, modal shift from domestic/short-haul aviation to rail/high-speed rail and reduction in the need for travel through videoconferencing.
- **Fleet efficiency assumptions:** We then overlay alternative assumptions about improvement in fleet fuel efficiency from engine/airframe and Air Traffic Management (ATM) and operations; scenario assumptions on aircraft efficiency differ as regards the pace of innovation.
- **Biofuels assumptions:** We next consider emissions projections which overlay different levels of biofuels penetration onto scenarios for demand-side measures and improvement in fleet fuel efficiency. We model a range of scenarios from 10% to 30% penetration in 2050, on an assumption that lifecycle emissions reductions would be 50%.

We develop three sets of scenarios:

- **Likely scenario:** This reflects demand reductions and carbon intensity reductions likely to be achieved given current policies, investment levels and the pace of technological advance.
- **Optimistic scenario:** This would require both:
  - A significant shift from current policy (e.g. in respect to high-speed rail), and an increase in the level of investment in new aircraft technologies and/or in the pace of fleet renewal as well as improvements in ATM and operations so as to make a 1.0% per annum improvement in carbon efficiency attainable.
  - Progress of biofuel technologies which would make it reasonable to assume that a 20% penetration was compatible with sustainability.
- **Speculative scenario:** This would require both technological breakthroughs and a significant increase in the pace of aircraft fuel efficiency


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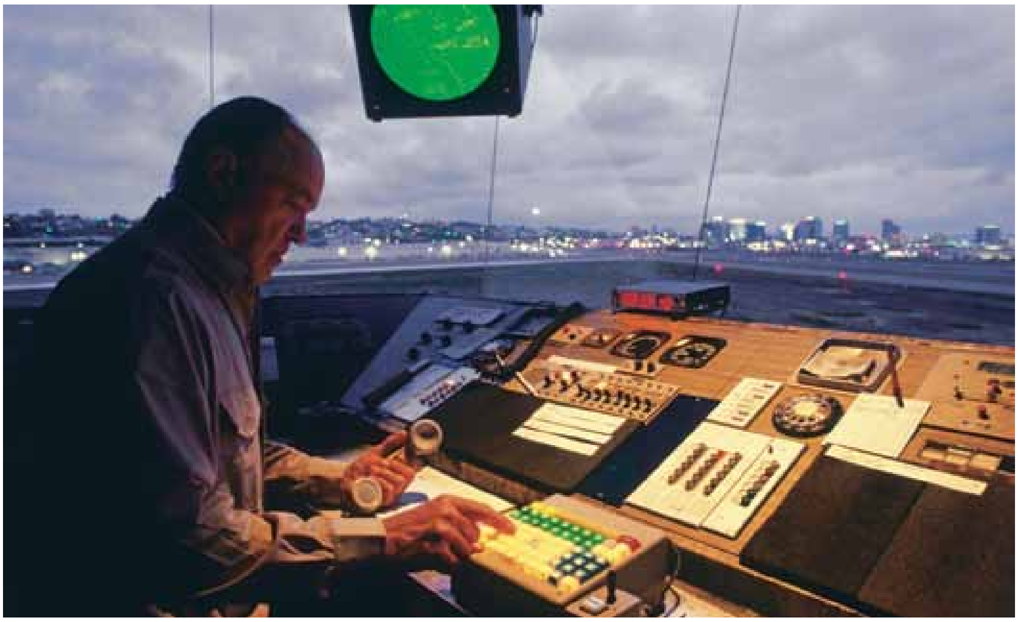
Baggage Claim
Ground Transport



improvements. In addition, it would require the development of sustainable biofuels which are currently speculative (e.g. biofuels from algae), or an evolution of global population, food demand and agricultural productivity which would make possible the sustainable and large scale use of current agricultural land and water to grow biofuel feedstocks. These developments are assessed today as very unlikely.

We reflect the full range of uncertainty by considering various combinations from these sets of scenarios. In particular, we overlay alternative assumptions about biofuels penetration across each of the scenarios for improvement in fleet fuel efficiency. We then define three core scenarios which combine Likely, Optimistic and Speculative assumptions across each of the options. We consider any gap between projected emissions under these scenarios and the 2050 target, and options for addressing this.

The key messages in this chapter are:

- In our Likely scenario, we assume fleet efficiency improvement of 0.8% annually and biofuels penetration of 10% in 2050. Together these would allow meeting the target with demand growth of around 60% in the period to 2050 (e.g. compared to unconstrained demand growth of over 200%). Demand growth based on planned capacity expansion, with demand response to the carbon price and opportunities for modal shift could be around 115%. Explicit constraints on demand growth in addition to the carbon price would therefore be required to meet the 2050 target.

- There are scenarios with a faster pace of fleet efficiency improvement and higher levels of biofuels penetration where the target is achieved without the need for explicit constraints on demand growth. However, unless and until new evidence is available that the pace of fleet fuel efficiency and the level of sustainable biofuels may be higher than currently envisaged, it is prudent to plan for a world where explicit constraints on demand growth are required to meet the target.

- There are no clear implications of our analysis for specific airports (e.g. Heathrow). The key implication for aviation expansion is that whatever the pattern of capacity development, this should be consistent with constraining demand growth in 2050 to around 60% on 2005 levels if the target is to be achieved.

We set out the analysis that underpins these messages in four sections:

1. Emissions projections including demand response to the carbon price, modal shift, and videoconferencing

2. The impact of improvement in fleet fuel efficiency on emissions

3. Emissions projections including biofuels

4. Options for meeting the 2050 target: planning for demand growth constraint

1. Emissions projections including demand response to the carbon price, modal shift, and videoconferencing

Unconstrained demand growth

We first consider demand response in a context where demand growth is not constrained by runway capacity and where therefore there are further additions to runway capacity beyond what is envisaged in the 2003 Air Transport White Paper (i.e. Heathrow, Stansted, Edinburgh) as required to meet a growing demand.

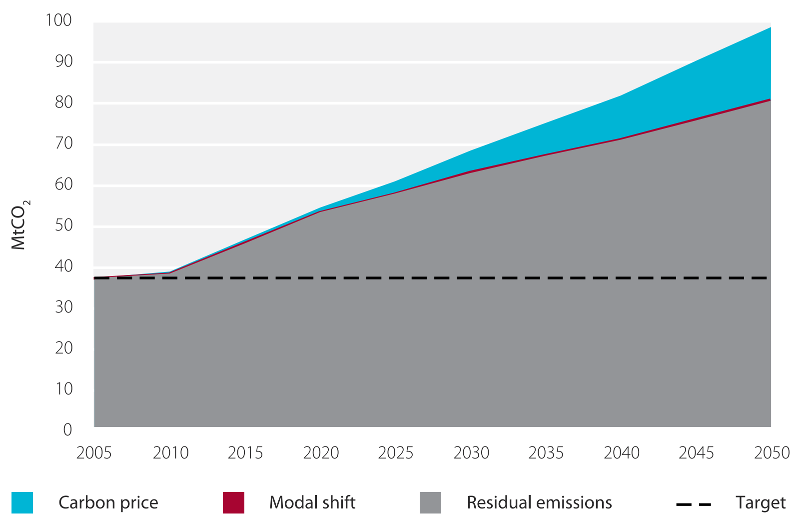
In Chapters 2 and 3 we set out three scenarios for demand response to the carbon price, modal shift and videoconferencing:

- Our **Likely** scenario assumptions result in modal shift equivalent to reducing air demand by 1% of passengers and 2% ATMs in 2050. We assume that videoconferencing has no net impact on aviation demand.
- Our **Optimistic** scenario modal shift and videoconferencing assumptions result in a reduction equivalent to reducing air demand by 7% of passengers and 10% of ATMs in 2050.
- Our **Speculative** scenario modal shift and videoconferencing assumptions result in a reduction equivalent to reducing air demand by 16% of passengers and 19% of ATMs in 2050.

We now overlay these scenarios for demand response to the reference emissions projection for unconstrained demand growth. Emissions projections net of demand response range from 74 $MtCO_2$ to 81 $MtCO_2$ in 2050:

- In the Likely scenario, the demand response due to the carbon price results in an emissions reduction of just under 18 $MtCO_2$ in 2050 from the reference case, with a small additional reduction due to modal shift (Figure 7.1).

Figure 7.1 Likely scenario: demand response with unconstrained runway capacity

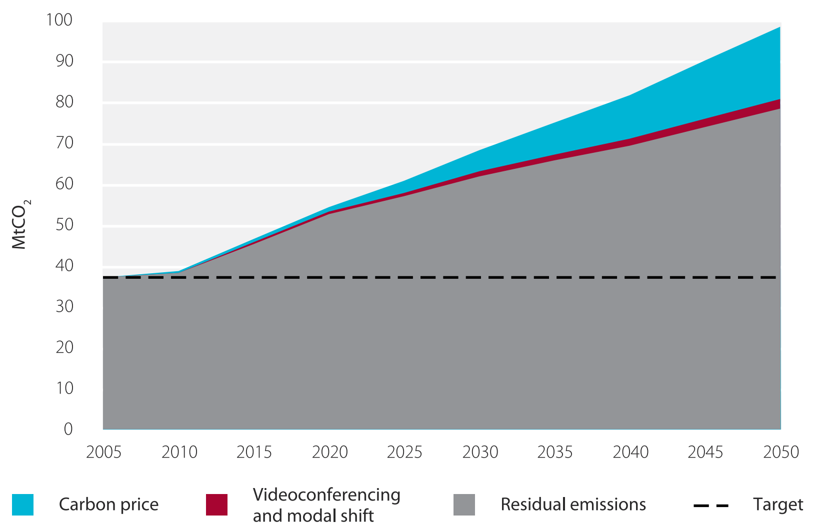


Source: CCC modelling.

- In the Optimistic scenario, modal shift and videoconferencing result in a further reduction of just over 2 $MtCO_2$ beyond the carbon price impact (Figure 7.2).
- In the Speculative scenario, modal shift and videoconferencing result in a further reduction of 7 $MtCO_2$ beyond the carbon price impact (Figure 7.3).

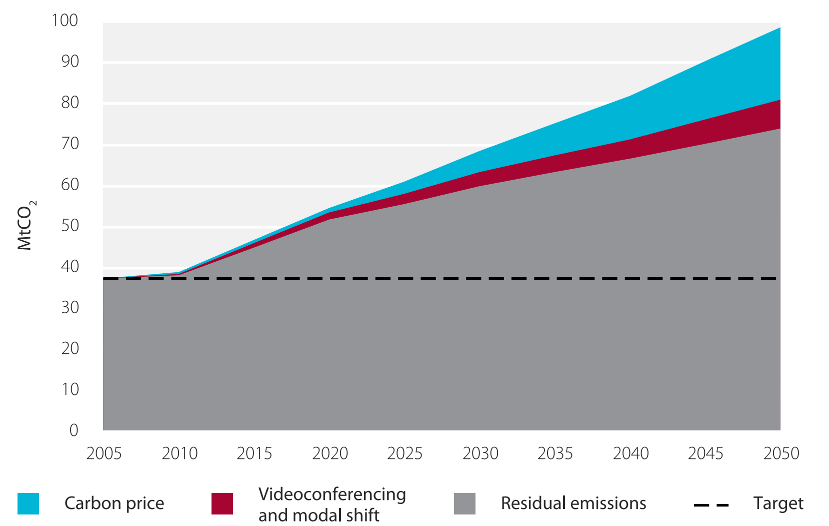
In none of the scenarios, therefore, does demand response alone result in achieving the 2050 target.

Figure 7.2 Optimistic scenario: demand response with unconstrained runway capacity



Source: CCC modelling.

Figure 7.3 Speculative scenario: demand response with unconstrained runway capacity



Source: CCC modelling.

Demand growth with planned capacity expansion

The DfT modelling approach assumes that no capacity is added beyond that envisaged in the 2003 Air Transport White Paper. There are two implications of this assumption for emissions projections:

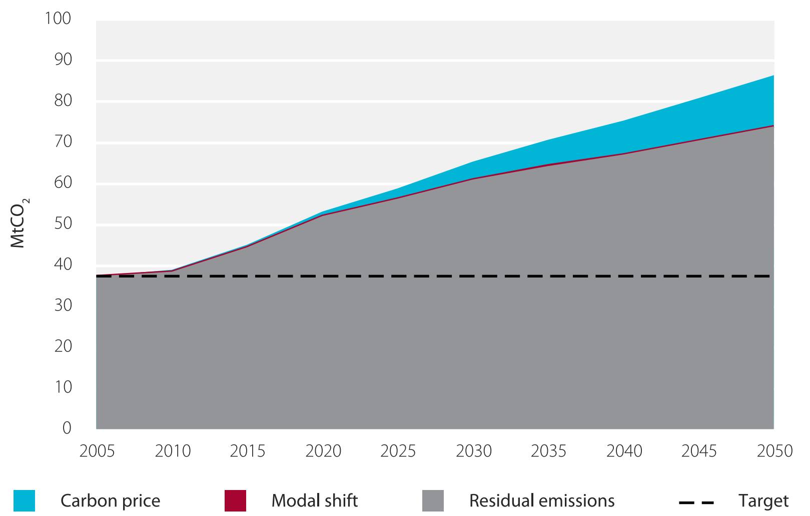
- The reference emissions projection is lower than in the case of unconstrained demand growth (e.g. by around 12 $MtCO_2$ in 2050).
- The emissions reductions due to modal shift and videoconferencing fall. The reason for this is that where the system operates at capacity, modal shift and videoconferencing free up slots which can therefore be used to meet suppressed demand.

When overlaying scenarios for demand responses to the carbon price, modal shift and videoconferencing, emissions projections in a scenario with only planned capacity additions range from 70 $MtCO_2$ to 74 $MtCO_2$ in 2050:

- In the Likely scenario, the demand response due to the carbon price results in an emissions reduction of 13 $MtCO_2$ in 2050 from the reference case, with a negligible further reduction due to modal shift (Figure 7.4).
- In the Optimistic scenario, modal shift and videoconferencing together result in a further reduction of 1 $MtCO_2$ beyond the carbon price impact.
- In the Speculative scenario, modal shift and videoconferencing together result in a further reduction of 4 $MtCO_2$ beyond the carbon price impact.

Demand response alone is therefore still not sufficient to achieve the 2050 target even in a system with capacity constraints; we follow DfT and model a system with planned capacity constraints as envisaged in the 2003 Air Transport White Paper in the remainder of this chapter.

Figure 7.4 Likely scenario: demand response with planned runway capacity



Source: CCC modelling.

2. The impact of improvement in fleet fuel efficiency on emissions

In Chapter 4 we set out three scenarios for improved fleet efficiency through engine and airframe innovation, air traffic management and operations:

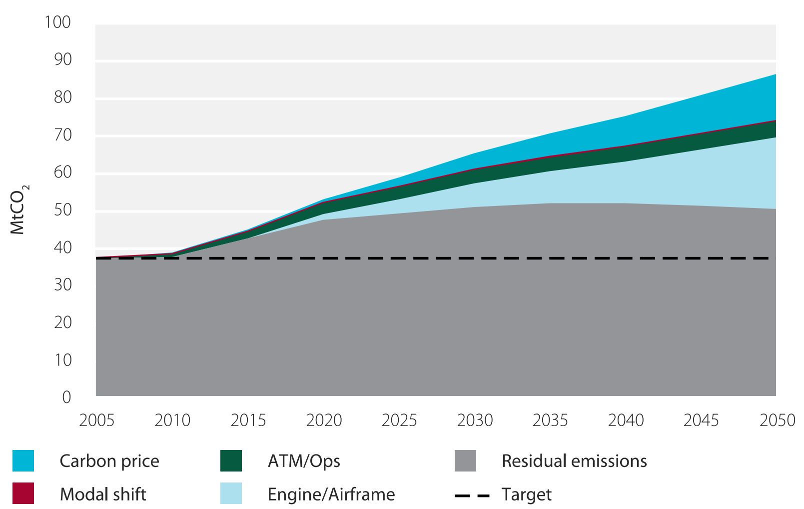
- Our **Likely** scenario reflects annual improvement in fleet average fuel efficiency between 2005 and 2050 of 0.8% per year on a seat-km basis.
- Our **Optimistic** scenario reflects annual improvement in fleet average fuel efficiency between 2005 and 2050 of 1.0% per year on a seat-km basis.
- Our **Speculative** scenario reflects annual improvement in fleet average fuel efficiency of 1.5% per year on a seat-km basis.

We now overlay emissions reductions corresponding to these scenarios onto the emissions projections including demand response to carbon prices/ modal shift/videoconferencing in Section 1 above:

- With Likely efficiency improvements and Likely demand response, emissions are above allowed aviation emissions in the period to 2050, and around 13 $MtCO_2$ above the 2050 target (Figure 7.5).
- With Optimistic efficiency improvement and Optimistic demand response, emissions are around 8 $MtCO_2$ above the 2050 target (Figure 7.6).
- With Speculative efficiency improvement and Speculative demand response, emissions are around 1 $MtCO_2$ below the 2050 target (Figure 7.7).

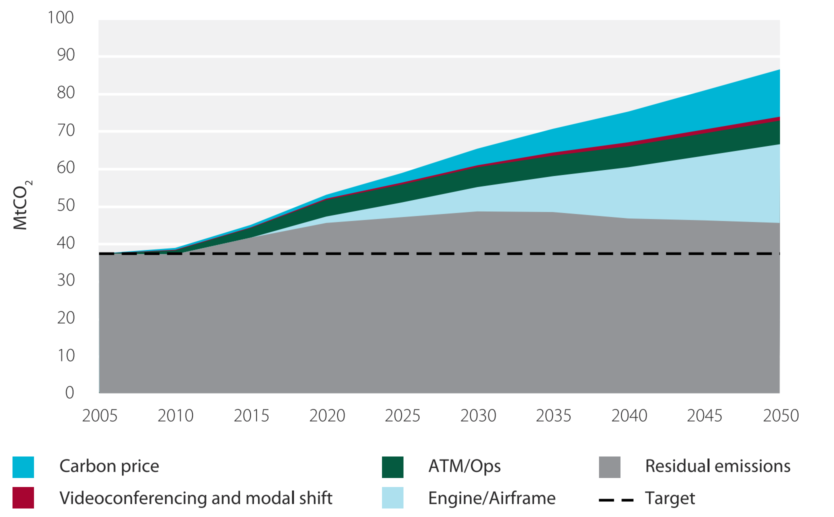
The 2050 target is therefore only achieved in the Speculative efficiency improvement scenario, and not in the Likely or Optimistic scenarios.

Figure 7.5 Likely scenario: impact of fuel efficiency improvements



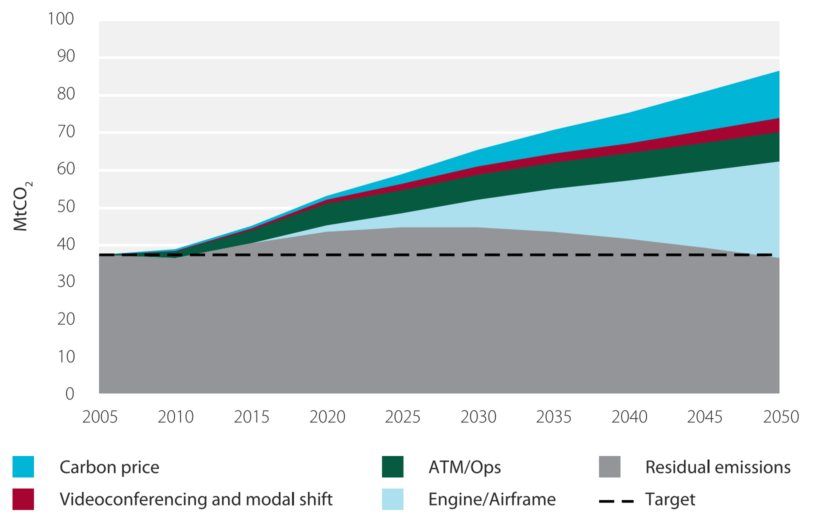
Source: CCC modelling.

Figure 7.6 Optimistic scenario: impact of fuel efficiency improvements



Source: CCC modelling.

Figure 7.7 Speculative scenario: impact of fuel efficiency improvements



Source: CCC modelling.

3. Emissions projections including biofuels

Scenario assumptions

The next step is to overlay scenarios for biofuels penetration across the scenarios in section 2 above. In Chapter 5, we set out three scenarios for increased biofuels penetration, in each of which we assume a 50% lifecycle emissions reduction:

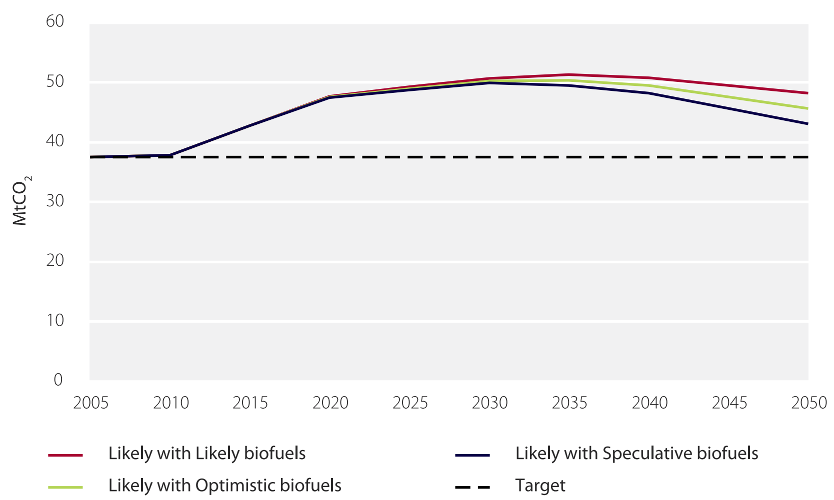
- Under our **Likely** scenario we assume that penetration of biofuels is below 2% in 2030 and reaches 10% by 2050.
- Under our **Optimistic** scenario we assume that penetration of biofuels reaches around 3% by 2030 and 20% by 2050.
- Under our **Speculative** scenario we assume that penetration of biofuels reaches 5% in 2030 and 30% by 2050.

Emissions projections including the impact of biofuels

Combining scenarios for biofuel penetration with the demand responses and fleet efficiency improvement scenarios presented above in Sections 1 and 2 gives the following results for the core set of scenarios:

- The Likely scenario (including Likely demand response, efficiency improvement and biofuels penetration) gives emissions that are 11 $MtCO_2$ above the 2050 target (Figure 7.8). Triggering the Optimistic and the Speculative scenarios for biofuels on top of Likely scenarios for the other wedges would leave a gap of 8 $MtCO_2$ and 6 $MtCO_2$ respectively.
- The Optimistic scenario (including Optimistic demand response, efficiency improvement and biofuels penetration) gives emissions that are around 4 $MtCO_2$ above the 2050 target (Figure 7.9). Triggering the Speculative scenarios for biofuels on top of Optimistic scenarios for the other wedges would still leave a small gap of 1 $MtCO_2$.

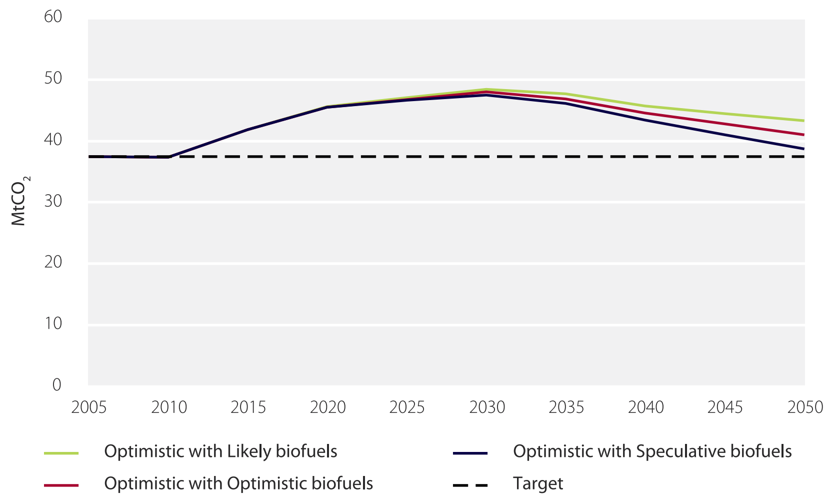
Figure 7.8 Likely scenario: impact of alternative biofuels assumptions



Source: CCC modelling.

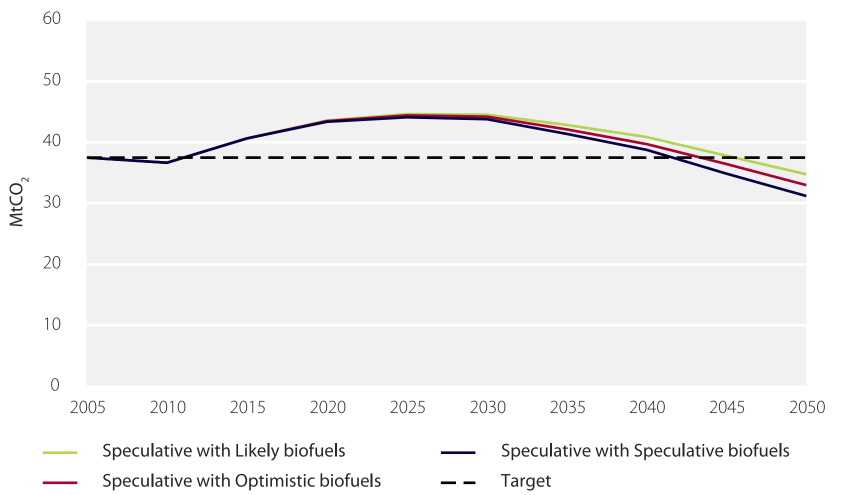
- The Speculative scenario (including Speculative demand response, efficiency improvement and biofuels penetration) gives emissions reductions that are around 6 $MtCO_2$ below the 2050 target (Figure 7.10). The target would still be exceeded by around 3 $MtCO_2$ when overlaying the Likely biofuels scenario on top of the Speculative wedges.

Figure 7.9 Optimistic scenario: impact of alternative biofuels assumptions



Source: CCC modelling.

Figure 7.10 Speculative scenario: impact of alternative biofuels assumptions



Source: CCC modelling.

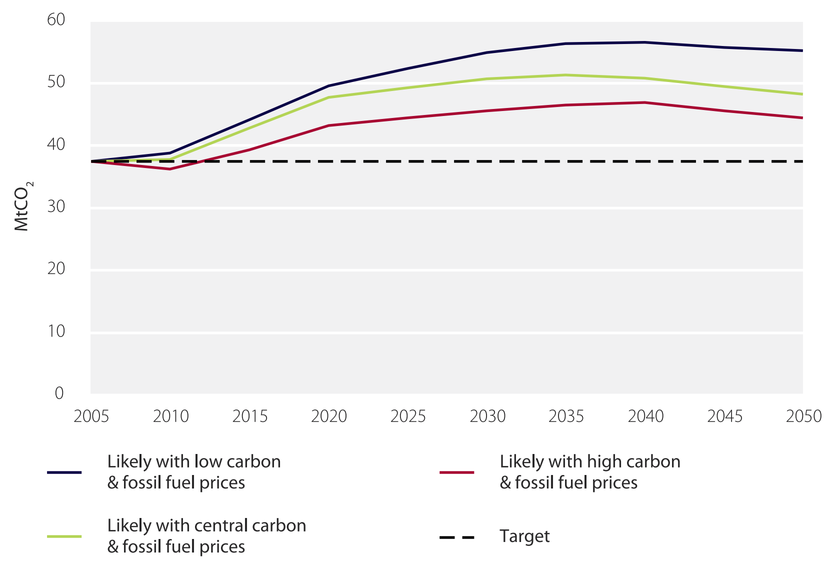
Demand sensitivities: alternative assumptions on fossil fuel and carbon prices

Having looked at sensitivity incorporating a range of biofuels assumptions across different scenarios we now look at the sensitivity of the full Likely scenario (i.e. with Likely biofuels assumptions) to carbon and fossil fuel prices. The Likely scenario with demand sensitivities for low fossil fuel prices and low carbon prices gives emissions that are 18 $MtCO_2$ above the target, and 7 $MtCO_2$ above the target with high fossil fuel prices and high carbon prices (Figure 7.11); demand reduction due to high fossil fuel and carbon prices is therefore not sufficiently high to achieve the target.

Summary of biofuels scenarios and sensitivities

The 2050 target is only achieved in those scenarios which combine significant demand-side responses and ambitious efficiency improvements with a significant level of biofuels penetration.

Figure 7.11 Likely scenario: sensitivity to low and high carbon and fossil fuel prices



Source: CCC modelling.

4. Options for meeting the 2050 target: planning for demand growth constraint

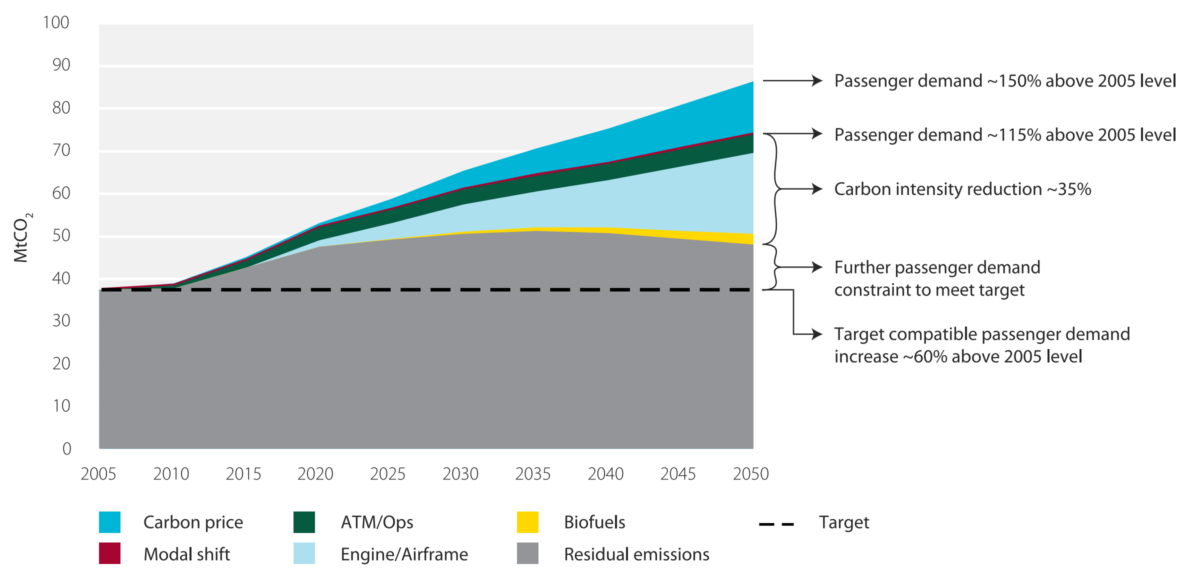
Meeting the target in the Likely scenario

In our Likely scenario we assume annual improvements in fleet fuel efficiency of 0.8% together with 10% biofuels penetration in 2050. This combination of improvement in fleet fuel efficiency and biofuels penetration implies a carbon intensity reduction of around 35% in 2050 relative to the reference projection (Figure ES.6). As a result, an increase in ATMs of around 55% relative to 2005 levels would be compatible with the target of ensuring that 2050 CO_2 emissions did not exceed the 2005 level of 37.5 $MtCO_2$. Given increasing load factors over time, an increase in passengers of around 60% on 2005 levels by 2050 would be possible, taking total annual passenger numbers from 230 million to around 370 million. This would be equivalent to taking total passenger trips (one departure plus one arrival) from 115 million in 2005 to around 185 million in 2050.

This target-compatible demand growth of around 60% compares with the growth of over 200% which might result in a world where there were no capacity constraints and no carbon price.

On the demand side, however, the Likely scenario incorporates the future capacity limits assumed by the 2003 Air Transport White Paper. It also allows for the impact of carbon price in line with our central projections (rising gradually to around £200/tCO_2 by 2050), and for some modal shift to conventional rail. These assumptions generate a demand growth of 115% relative to current levels by 2050.

Figure 7.12 Likely scenario (planned capacity)



Source: CCC modelling.

Meeting the 2050 target that CO_2 emissions are no higher than 37.5 $MtCO_2$ is therefore likely to require policy measures to restrain demand which go beyond our central projected carbon price. The policy instruments which could achieve this restraint include a carbon tax on top of the forecast carbon price, limits to further airport expansion, and restrictions on the allocation of take-off and landing slots even where airports have the theoretical capacity available.

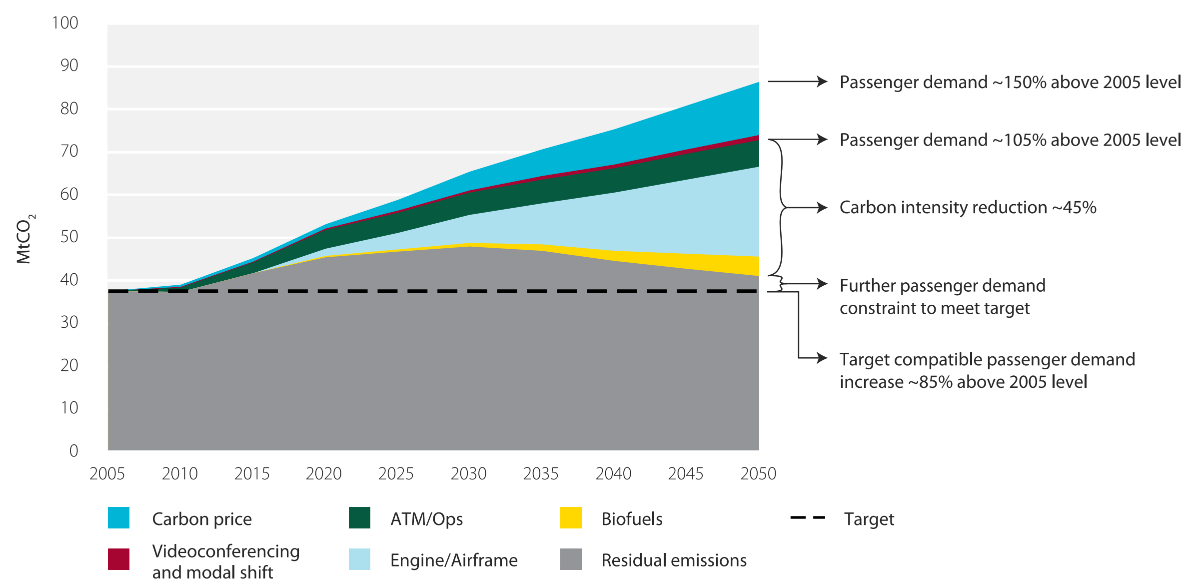
Meeting the target in other scenarios

In the *Optimistic* scenario, we assume 1.0% annual improvement in fleet fuel efficiency and 20% biofuels penetration in 2050. This combination of improvement in fleet fuel efficiency and biofuels penetration implies a carbon intensity reduction of around 45% in 2050. As a result, it would be possible to increase ATMs by around 80% and passenger numbers by around 85% and still meet the target that CO_2 emissions should not exceed 37.5 $MtCO_2$ in 2050 (Figure 7.13). Passenger trips (one departure plus one arrival) could increase from 115 million in 2005 to around 215 million in 2050.

Given demand growth under this scenario of 115%, meeting the target would still require additional policy measures to constrain demand beyond those implied by the 2003 Air Transport White Paper and the central carbon price projection. But these additional measures would not need to be as restrictive as in the Likely scenario.

In the *Speculative* scenario, we assume annual improvement in fleet fuel efficiency 1.5% and biofuels penetration of 30% in 2050. The implied carbon intensity reduction is around 55% by 2050. This would make an increase in ATMs of around 125% and of passengers of around 135% compatible with

Figure 7.13 Optimistic scenario (planned capacity)



Source: CCC modelling.

meeting the target. The combination of already planned capacity limits, the demand response to the projected carbon price and opportunities for modal shift and videoconferencing, would produce a demand increase below this 135%. No additional policy measures would therefore be required to meet the target (Figure 7.14).

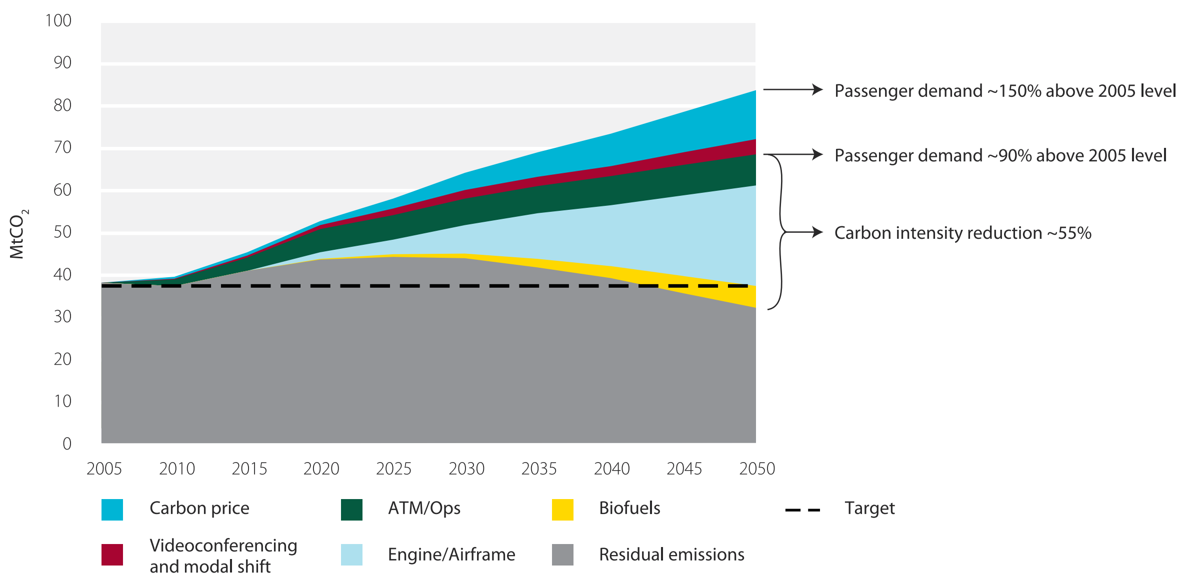
It should be noted however that even in this scenario the maximum demand increase compatible with the target (135% increase in passengers) is much lower than the increase which our projections suggest would occur in a world of no constraints (i.e. with no carbon price and unlimited airport expansion).

The high growth in aviation demand which would occur in an unconstrained environment illustrates the high value which people place on the opportunity to fly, in particular for leisure purposes. If the Optimistic or Speculative scenarios can be achieved, the number of flights compatible with meeting the 37.5 $MtCO_2$ target increases.

In considering the difference between scenarios, three aspects should be distinguished:

- Achieving greater modal shift to rail and greater use of videoconferencing does not increase the total target-compatible level of demand, but it makes it possible for more of that total to be devoted to other uses (e.g. long-haul leisure) where there are no alternatives to air travel. Investing in a new high-speed rail line and promoting full integration of UK and European high-speed networks can increase the potential for modal shift. Promotion of videoconferencing technologies could ensure higher levels of business travel substitution.

Figure 7.14 Speculative scenario (planned capacity)



Source: CCC modelling.

- Achieving more rapid fuel efficiency improvements directly increases target-compatible demand growth. It could be fostered through increasing investment in R&D, introducing regulatory limits on new aircraft CO_2 performance, exploring possible benefits from early scrappage of older aircrafts, and full implementation of SESAR and NATS initiatives on ATM efficiency improvement.
- The higher the percentage of biofuels use which can be considered sustainable the greater the target-compatible demand increase. Here however it is not clear that higher investment will necessarily drive more rapid improvement, since there is inherent uncertainty about what progress can be achieved, and about the implications of population growth and food demand for land use. We therefore need to observe through time the development of speculative technologies, and trends in agricultural productivity and land availability. Governments could however encourage investment in those technologies most likely to be sustainable. And expanded use of biofuels will need to be underpinned by a global policy framework to mitigate the risks of harmful land-use changes resulting from the growth of biofuel feedstocks.

Several of these developments which might make possible more rapid demand increases than in the Likely scenario are ones over which the UK acting alone has only small influence. EU or broader international action would be required to accelerate the pace of improvement of fleet fuel efficiency and international action would be required to develop a framework to mitigate against risks of indirect land use impacts from biofuels.

The prudent assumption on which to base policy today is therefore that reductions in the carbon intensity of air travel will be limited to the reduction of around 35% achieved in the Likely scenario, implying a maximum allowable increase in ATMs of around 55% and a maximum demand increase of around 60%. If faster technology progress is in fact achieved this can be reflected in adjustments in policy over time.

Implications for airport expansion and slot allocation

The 2003 Air Transport White Paper proposed that there could be airport runway capacity expansions at Edinburgh, Heathrow and Stansted, but at no other airports. In January 2009, the Government decided in favour of a third runway at Heathrow and in favour of increasing slot capacity there from 480,000 to 605,000. It decided however that any decisions on the allocation of further slot capacity (to the maximum theoretical potential of 702,000 with a third runway in place) should be subject to recommendations from the Committee on Climate Change in 2020 on whether further expansion then appears compatible with the target of restricting CO_2 emissions to a maximum 37.5 $MtCO_2$ in 2050. The Terms of Reference for this report in addition asked the Committee to consider "the implications [for meeting the 2050 target] of further aviation expansion in the 2020s".

The key implication from our analysis is that future airport policy should be designed to be in line with the assumption that total ATMs should not increase by more than about 55% between 2005 and 2050, i.e. from today's level of 2.2 million to no more than around 3.4 million in 2050. This constraint could be consistent with a range of policies as regards capacity expansion at specific airports.

Total current theoretical capacity at all airports in the UK is about 5.6 million ATMs which is already in excess both of today's actual ATMs and of maximum ATMs compatible with the 2050 target (Table 7.1a and b). But demand cannot be easily switched between different geographical locations, and there is a tendency for demand to concentrate at major hubs, given the advantages of inter-connection between different routes. As a result, capacity utilisation differs hugely between for instance 97% at Heathrow and well below 50% at some smaller airports outside the top ten.

If demand was allowed to grow in line with the demand assumptions of the Likely scenario, with passenger numbers growing 115% ATMs would reach about 4 million by 2050. Our modelling suggests that an allocation of demand at this level would entail Heathrow operating at its maximum 702,000 capacity (with a third runway) with several other airports highly utilised (Table 7.1b). Our analysis suggests however total ATMs need to be restricted to a maximum of about 3.4 million in 2050, about 0.6 million below the level modelled in the Likely scenario.

Table 7.1a: Actual runway capacity and utilisation in 2005

Airport	Maximum runway capacity (ATMs, '000s)	Actual use (ATMs, '000s)	Capacity utilisation	Spare capacity (ATMs, '000s)
Heathrow	480	466	97%	14
Gatwick	260	248	95%	12
Stansted	241	166	69%	75
London City	73	60	82%	13
Luton	100	72	72%	28
Bristol	188	58	31%	130
Birmingham	186	111	60%	75
Manchester	276	213	77%	63
Glasgow	188	93	50%	95
Edinburgh	186	106	57%	79
Other UK Airports	*3,400*	*568*	*17%*	*2,832*
Total	**5,577**	**2,160**	**39%**	**3,417**

Source: CCC modelling.

Table 7.1b: Projected runway capacity, utilisation and target compatible ATMs in 2050 (Likely scenario assumptions)[1,2]

Airport	Maximum runway capacity (ATMs, '000s)	Planned capacity, ATM distribution ('000s)	Capacity utilisation	Spare capacity (ATMs, '000s)
Heathrow	702	702	100%	0
Gatwick	260	260	100%	0
Stansted	480	317	66%	163
London City	120	120	100%	0
Luton	135	135	100%	0
Bristol	226	127	56%	98
Birmingham	206	206	100%	0
Manchester	500	449	90%	51
Glasgow	226	198	88%	27
Edinburgh	450	224	50%	226
Other UK Airports	*4,000*	*1,227*	*31%*	*2,773*
Total	**7,304**	**3,965**	**54%**	**3,339**
Target compatible ATMs		**3,418**		
Difference between the Likely scenario and target compatible ATMs		**547**		

Source: CCC modelling.

This restriction could be achieved through a range of different policies relating to taxes, capacity expansion or slot allocation at specific airports. Optimal decisions on specific airport capacity do not therefore mechanically follow from national aggregate demand, but need to reflect a wide range of other factors such as customer preference, alternatives to air travel, local environmental impact, competition between UK airports and continental hubs, and economic impacts both local and national. It is not the Committee's role to assess these factors.

The Committee's clear conclusion is, however, that the combination of future aviation policies (combining tax, capacity expansion and slot allocation decisions) should be designed to be compatible with a maximum increase in ATMs of about 55% between now and 2050, and that this should continue to be the policy approach until and unless technological developments suggest that any higher figure would be compatible with the emission target.

1 The ATM distribution is an indicative model output rather than a definitive view on the distribution in the Likely scenario.

2 Stansted utilisation and total demand may be higher in practice when suppressed demand is reallocated from other London airports.

Future work of the Committee on aviation

Further work on aviation emissions by the Committee over the next year will include:

- Assessing whether international aviation emissions should be included in carbon budgets given the final mechanisms agreed by the EU for allocating EU ETS allowances across Member States.
- Assessing the relative costs of emission reductions in different sectors of the economy (including aviation) within the context of the Committee's development of recommendations for the fourth budget period (2023-2027) which will be delivered in December 2010. This will entail consideration of the feasibility of reductions in other sectors sufficient to offset the fact that aviation emissions are likely to grow before falling back to the 37.5 $MtCO_2$ level.

Over the longer term the Committee will:

- Review any new evidence on improvement in fleet fuel efficiency, sustainable biofuels and aviation non-CO_2 effects and their implications for the maximum demand increase compatible with meeting the emissions target.
- In 2020 advise Government on whether release of the second tranche of slots from Heathrow capacity expansion (from 605,000 to 702,000) is then compatible with meeting the 2050 target.

The Committee's next annual report to Parliament in June 2010 will include an assessment of latest data on UK aviation emissions and will reflect any developments on international aviation policy resulting from the Copenhagen climate change summit.