

Rt Hon Grant Shapps MP  
Secretary of State for Transport  
Great Minster House  
33 Horseferry Road  
London SW1P 4DR

24 September 2019

### **Net-zero and the approach to international aviation and shipping emissions**

Dear Secretary of State,

The Government has legislated for the UK to reach net-zero greenhouse gas emissions by 2050. I am pleased the Government clarified to Parliament that the target must cover the whole economy, including international aviation and shipping (IAS) emissions. This letter responds to the Government's request on how to bring IAS emissions formally within the UK's net-zero target, setting out the rationale and the implications for the UK's climate strategy.

Our advice that 2050 is an appropriate date for net-zero is based on formal inclusion of IAS emissions within the target. Without this a more ambitious target is likely to be required.

#### *The rationale for inclusion of IAS emissions in the UK carbon targets*

The primary policy approach to reducing IAS emissions should be international. Through the efforts of your Department, the UK has played a key role in progress by both the International Civil Aviation Organisation (to agree a global offsetting scheme for aviation emissions to 2035) and the International Maritime Organisation (to agree to reduce shipping emissions by at least 50% by 2050 compared to 2008 levels and pursue efforts to phase emissions out entirely).

This international framing should not prevent the inclusion of IAS emissions in UK carbon targets, as is already the case for other sectors that are covered by international agreements and potentially exposed to competitiveness pressures (e.g. energy-intensive industry).

Addressing IAS emissions is strategically important. Formal inclusion of IAS emissions in the net-zero target would complement agreed international policies and should not be interpreted as a unilateral UK approach to reducing emissions in these sectors.

- Aviation is likely to be the largest emitting sector in the UK by 2050, even with strong progress on technology and limiting demand. Aviation also has climate warming effects beyond CO<sub>2</sub>, which it will be important to monitor and consider within future policies.
- Including IAS emissions in UK carbon targets increases confidence that the Government is appropriately prioritising their reduction. That should include pushing for suitably strong international levers, as well as using supplementary UK measures where these do not impact on the competitiveness of the IAS sectors.
- Inclusion of IAS emissions clarifies the requirements for policy development in other sectors (e.g. the scale of deployment needed for options to offset remaining emissions).
- There are no practical barriers to inclusion. Emissions are already estimated and reported to the UN and should be included in UK emissions targets on the same basis. The uncertainty attached to these estimates is no higher than for other sectors covered by carbon budgets.

- Inclusion can be managed through secondary legislation and without any additional costs for achieving net-zero beyond those already agreed by Parliament.

Formal inclusion of IAS emissions would help to guide long-term policy approaches and infrastructure investment decisions.

*Achieving net-zero IAS emissions in the UK*

**The planning assumption for IAS should be to achieve net-zero emissions by 2050.** This should be reflected in your forthcoming Aviation Strategy and as the Clean Maritime Plan is taken forward. It means reducing actual emissions in these sectors and is likely to require some use of greenhouse gas removals (GGRs) to offset remaining emissions:

- **Aviation.** Zero-carbon aviation is highly unlikely to be feasible by 2050.
  - Aviation emissions could be reduced by around 20% from today to 2050 through improvements to fuel efficiency, some use of sustainable biofuels, and by limiting demand growth to at most 25% above current levels. This is likely to be cost-saving. There is potential to reduce emissions further with lower levels of demand.
  - Novel fuels (e.g. synthetic carbon-neutral kerosene, algal biofuels) could allow greater reductions, but their development is highly speculative and should not be relied upon.
  - The Government should assess its airport capacity strategy in this context. Specifically, investments will need to be demonstrated to make economic sense in a net-zero world and the transition towards it.
- **Shipping.** Achieving zero-carbon or near zero-carbon shipping by 2050 is likely to be feasible and cost-effective through use of alternative fuels (e.g. zero-carbon hydrogen or ammonia). A transition to these fuels will need to be well underway globally before 2050, with refuelling infrastructure established and a substantial fraction of the fleet already switched, in order to meet the IMO's current 2050 objective.
- **Greenhouse gas removals (GGRs).** For aviation, and to the extent that shipping emissions cannot be eliminated, measures to remove CO<sub>2</sub> from the atmosphere will be required to offset remaining emissions. They cannot be a substitute for genuine emissions reductions.
  - In the long term offsets can only be based on verifiable emissions removal from the atmosphere. These would ideally be delivered through the international framework (e.g. CORSIA), but may need additional UK policies.
  - However, there will not be unlimited access to GGR offsets since their potential is constrained by global land and other resources. The focus should therefore be on highly scalable GGR options rather than those limited in scope (e.g. afforestation).

The Government can take steps towards enabling IAS to reach net-zero emissions in the UK and internationally by establishing a new market for GGRs. Such a strategy could create a significant new global export opportunity for the UK in GGR technology and expertise.

Further detail on the issues covered in this letter is set out in the accompanying annex.

Yours,



Lord Deben

Chairman, Committee on Climate Change

## Annex

# Net-zero and the approach to international aviation and shipping emissions

## Introduction

In June 2019 the Government legislated for the UK to reach net-zero emissions by 2050, but this formally excluded emissions from international aviation and shipping (IAS).

The Government clarified to Parliament that their plans for net-zero cover the whole economy, including IAS emissions, and that they await the Committee's advice on formal inclusion of these sectors within the target.<sup>1</sup>

Our advice is set out in the accompanying letter, which summarises the rationale for formal inclusion of IAS sectors within the net-zero target and sets out how this could be achieved. It reflects the advice in our net-zero report, which incorporated the UK's share of IAS emissions. If these emissions are not formally included then a more ambitious net-zero target is likely to be required.

This annex presents the evidence base underpinning our advice. It explains how and why IAS emissions should be brought formally within the net-zero target, and the implications for the UK's climate strategy.

We set out our assessment in the following four sections:

- (i) Recap of net-zero advice
- (ii) How to include IAS emissions within the net-zero target
- (iii) How to get to net-zero IAS emissions
- (iv) Implications for aviation and shipping policy

### (i) Recap of net-zero advice

The Paris Agreement set a long-term goal to hold the increase in global average temperature to well-below 2°C and to pursue efforts to limit the increase to 1.5°C (compared to pre-industrial levels). In order to achieve this long-term temperature goal it also aims to balance 'anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century' (which is widely interpreted as implying net-zero greenhouse gas (GHG) emissions globally).

Global emission pathways consistent with delivering this temperature goal require reducing global CO<sub>2</sub> emissions to net-zero by around 2050, and global GHG emissions to net-zero by around 2070 (Figure A1). This includes all sources of emissions globally, including those from aviation and shipping.

The Paris Agreement also requires that parties pursue their 'highest possible ambition'. At the UK level our analysis currently suggests that 2050 is the earliest credible date for reaching net-zero including IAS emissions, based on capability, equity, and responsibility to lead.

Reducing UK emissions to net-zero will require action across all sectors of the economy (Figure A2). Getting to very-low emissions (e.g. a few million tonnes of CO<sub>2</sub>-equivalent - CO<sub>2</sub>e) is feasible in most sectors. The greatest challenges are in reducing agriculture and aviation emissions, where there are limited zero-carbon options. These sectors are likely to be a significant source of emissions even in the long-term.

Getting to net-zero emissions overall will therefore require greenhouse gas removals (GGRs) (e.g. bioenergy with carbon capture and storage - BECCS, direct air capture of CO<sub>2</sub> with storage

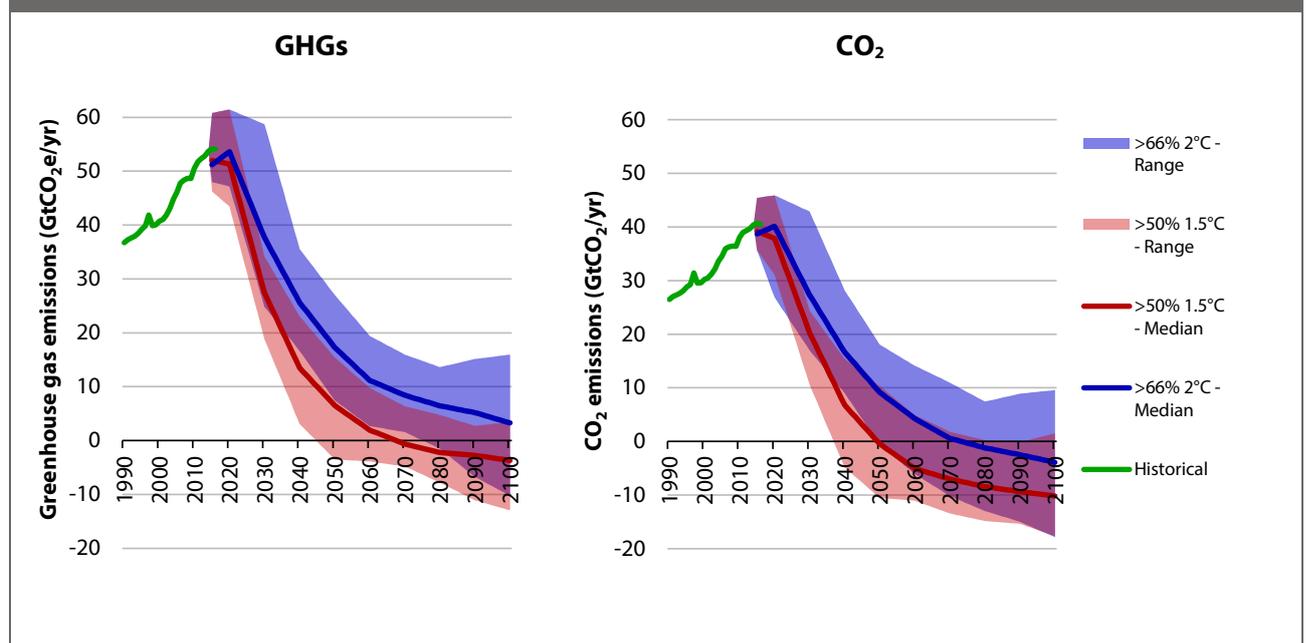
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<sup>1</sup> Hansard HC (12 June 2019) Volume 661 Column 682 *Net Zero Emissions Target*.

– DACCS) in order to offset remaining emissions. We identify sufficient potential for these to be delivered domestically to reach net-zero emissions for the economy as a whole, including IAS.

The net-zero target should therefore be met by reducing UK emissions as far as possible (i.e. not by offshoring them), and by using GGRs to offset the emissions that remain (Figure A3). Given potential to achieve this domestically, the aim should be to meet the target without relying on use of international offset credits. The Government confirmed to Parliament that this is its approach.<sup>2</sup>

**Figure A1.** Global emissions pathways for CO<sub>2</sub> and GHGs consistent with the Paris Agreement

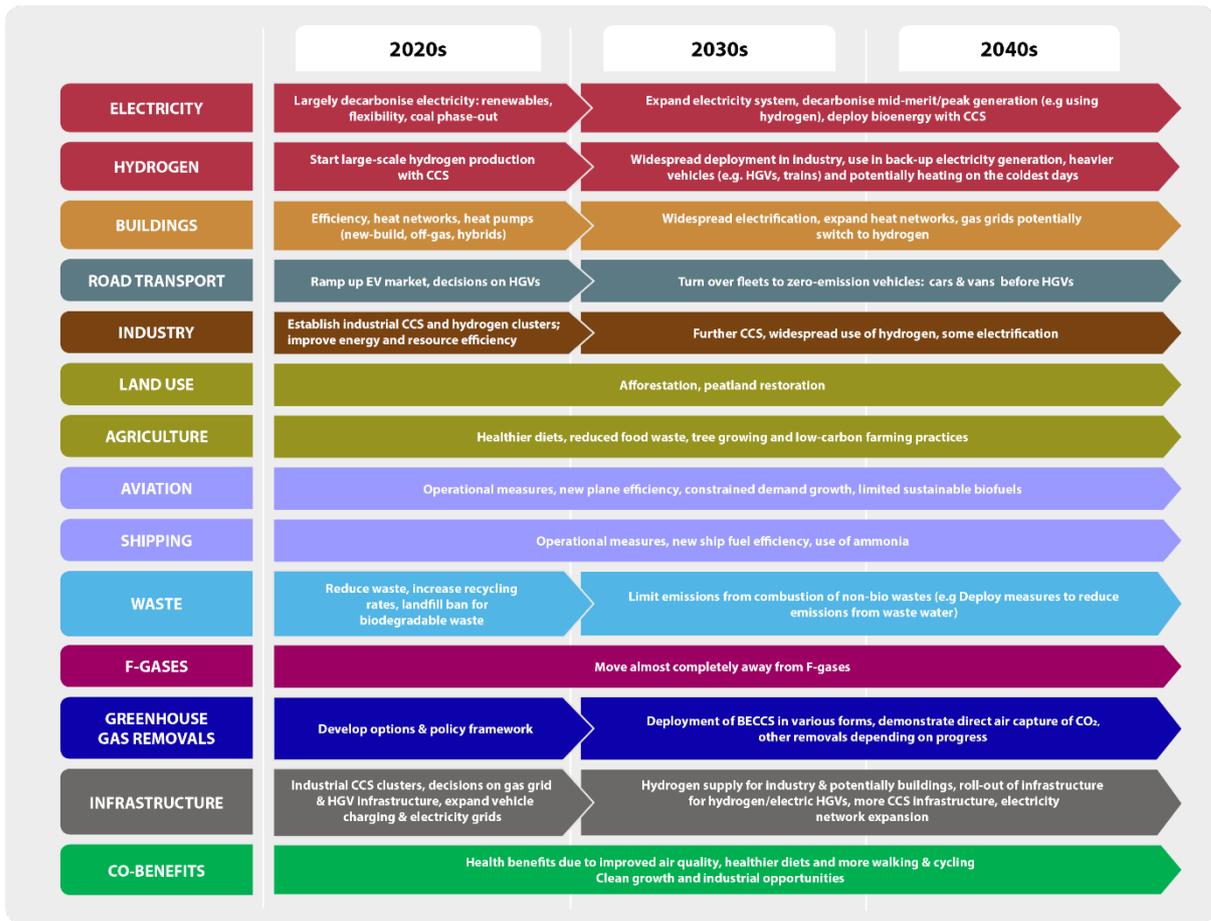


**Source:** Huppmann, D. et al. (2018) *A new scenario resource for integrated 1.5°C research*. *Nature Climate Change*, 8 (12), 1027.

**Notes:** Shading indicates maximum and minimum across the scenario grouping at any point in time. The solid coloured lines are the 'median' scenario (at each point in time) in each scenario group. GHG emissions in the bottom panel are aggregated across all GHGs using the GWP100 values from the IPCC 4th Assessment Report.

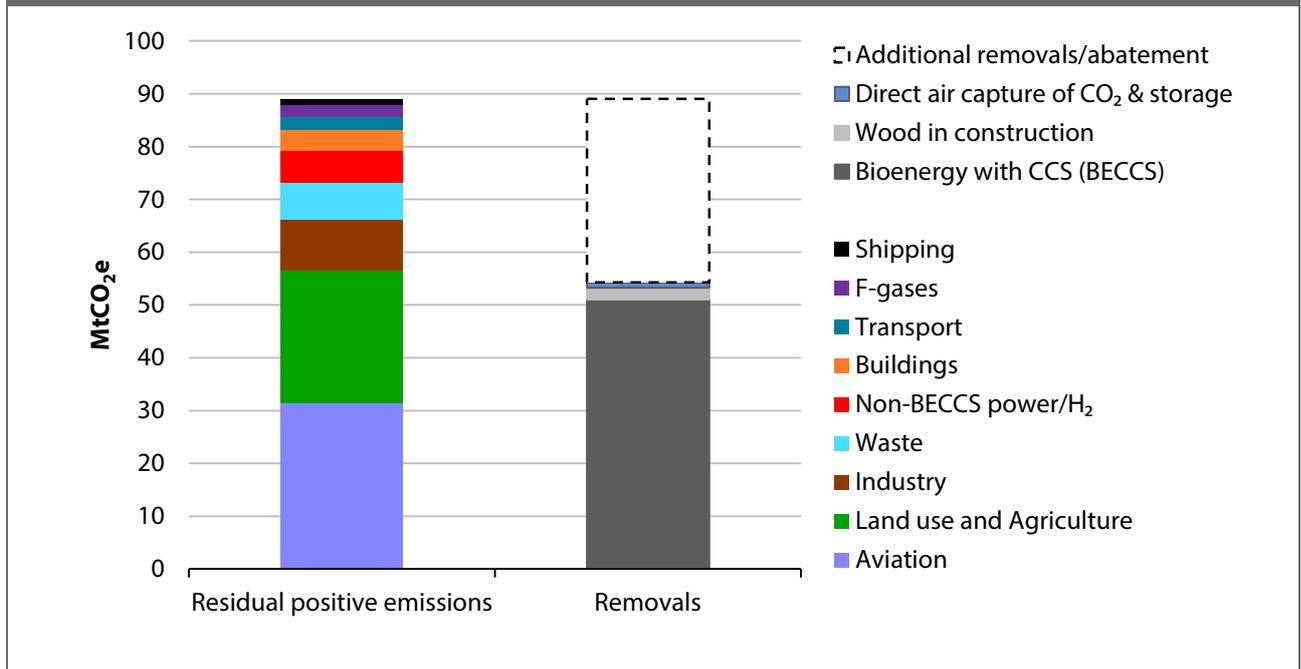
<sup>2</sup> Hansard HC (12 June 2019) Volume 661 Column 663 *Net Zero Emissions Target*.

**Figure A2.** Sectoral transitions required over the period to 2050 to reach net-zero



**Source:** CCC (2019) *Reducing UK emissions – 2019 Progress Report to Parliament.*

**Figure A3.** Greenhouse gas removals required to balance positive emissions in 2050



**Source:** CCC (2019) *Net zero – The UK's contribution to stopping global warming*.

**Notes:** Sectoral emissions and contributions from removals presented for the Further Ambition scenario in our net-zero report. The contribution from 'additional removals/abatement' refers to the options to go beyond the Further Ambition scenario and achieve net-zero emissions, which can be done with additional removals and/or further reductions of positive emissions.

## (ii) How to include IAS emissions within the net-zero target

The primary policy approach to reducing IAS emissions should be at the international level, given the global nature of these sectors and the risk of carbon leakage from a unilateral UK approach.

The UK has played a key role in progress by both the International Civil Aviation Organisation (ICAO) and International Maritime Organisation (IMO):

- **Global aviation policy.** The ICAO has agreed a global offsetting scheme for international aviation emissions (the Carbon Offsetting and Reduction Scheme for International Aviation - CORSIA). Airlines flying on routes between countries covered by the scheme are required to offset growth in emissions above 2020 levels. The scheme starts in 2021 and is mandatory from 2027. The policy currently stops in 2035.
- **Global shipping policy.** The IMO has agreed to peak GHG emissions from global international shipping as soon as possible, to reduce them by at least 50% below 2008 levels by 2050, and to pursue efforts to phase them out entirely.

Other voluntary industry initiatives have also been agreed:

- **Aviation.** The International Air Transport Association (IATA), which represents the global airline industry, has adopted a target to reduce net aviation CO<sub>2</sub> emissions by 50% below 2005 levels by 2050. The European airport industry has committed to net-zero CO<sub>2</sub> emissions by 2050 at the latest, covering emissions at airports but not from flights.

- **Shipping.** Maersk, the world's largest shipping company, has announced a goal to reach carbon neutrality by 2050.

At the UK level, addressing IAS emissions is strategically important for the robustness of the net-zero target:

- IAS emissions cause climate change and should therefore be included within the UK's targets and strategies.
- Aviation is likely to be the largest emitting sector in 2050, even after strong progress on technology and measures to limit demand.
- Aviation's true climate impact is likely to be understated, given the existence of short-term non-CO<sub>2</sub> effects (e.g. from contrails) which are not covered in the basket of gases reported to the UN or by the Climate Change Act.

An international framing should not prevent the inclusion of IAS emissions in UK carbon targets, as is already the case for other sectors that are covered by international agreements and potentially exposed to competitiveness pressures (e.g. energy-intensive industry).

Formal inclusion of IAS emissions in the net-zero target would complement agreed international policies and should not be interpreted as a unilateral UK approach to reducing emissions in these sectors:

- **Inclusion increases confidence that the Government is sufficiently prioritising reduction of IAS emissions.** That should include pushing for suitably strong international levers, as well as using supplementary UK measures where these do not impact on the competitiveness of the IAS sectors.
  - At the international level this includes the need for a long-term objective for the aviation sector in line with the Paris Agreement, and future CORSIA caps consistent with this that incentivise GGRs for all emissions, not just emissions growth above 2020 levels.
  - At the UK level, supplementary policies that have limited competitiveness risks include support for developing alternative fuels, managing growth in demand, and kick-starting a market for GGRs.
- **Inclusion clarifies the requirements for policy development in other sectors.** That includes the scale of deployment needed for GGR options, and the need for low-carbon fuel infrastructure to extend to ports.

There are no practical barriers to formal inclusion of IAS emissions. Emissions are already estimated and reported to the UN and should be included in UK emissions targets on the same basis. The uncertainty attached to these estimates is no higher than for other sectors covered by carbon budgets.

- The Climate Change Act requires that inclusion be on the basis of international carbon reporting practice. Bunker fuel sales are the currently agreed methodology by which countries report IAS emissions to the UN.
- While a range of alternative methodologies have been proposed, uncertainty in IAS emissions is no higher than for other sectors already covered by carbon budgets and the net-zero target (Figure A4).
  - Domestic aviation and shipping emissions are already formally included within the net-zero target on the basis of bunker fuel sales.
  - For international aviation, bunker fuel sales are an accurate reflection of aviation activity as airlines do not tend to carry more fuel than needed for a

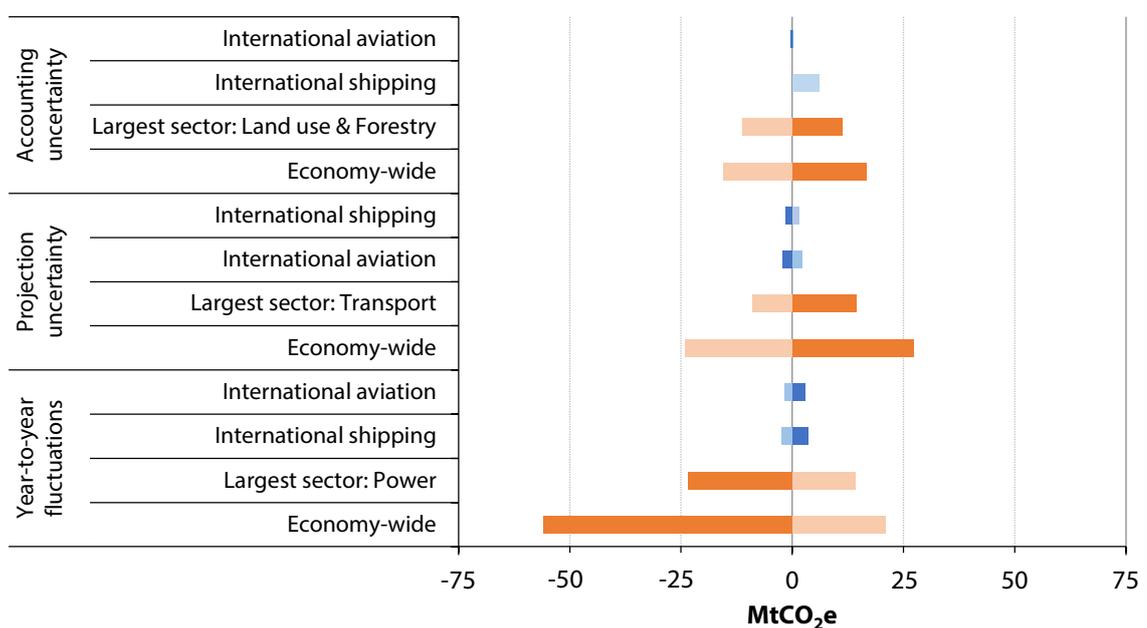
given flight (UK departing-flight emissions modelled by DfT are within 4% of the bunker fuel sales estimate).

- For international shipping, bunker fuels *may* not accurately reflect country-level shipping activity and emissions, given the potential for ships to refuel at multiple ports on routes. However, while imperfect, the difference between this approach and alternative methodologies is unlikely to be material.
- Were alternative methodologies for measuring IAS emissions to be developed and agreed internationally for annual reporting (e.g. by the ICAO, IMO, or UNFCCC) then this could be managed through adjustments to carbon budgets, as allowed under the Climate Change Act.
- Inclusion can be managed through secondary legislation under section 30 of the Climate Change Act, and without any additional costs for achieving net-zero beyond those already agreed by Parliament.

Other countries have already decided to include IAS emissions in their net-zero targets and/or strategies (e.g. in Scotland<sup>3</sup> on the basis of bunker fuel sales, and in France<sup>4</sup>).

In the context of international negotiations at ICAO and IMO, inclusion of IAS emissions in the net-zero target should not be interpreted as a rejection of multi-lateral approaches or as prejudicing discussions on burden sharing.

**Figure A4.** Uncertainty in IAS emissions compared to wider uncertainties in carbon budgets



**Source:** CCC calculations, BEIS (2019) *2017 UK Greenhouse Gas Emissions, Final Figures*, Lee et al (2005) *Study on the Allocation of Emissions from International Aviation to the UK inventory*, CCC (2011) *Review of UK Shipping Emissions*, CCC (2015) *Sectoral scenarios for the Fifth Carbon Budget – Technical report*, DfT (2017) *UK Aviation Forecasts*, BEIS (2019) *Updated energy and emissions projections 2018*.

**Notes:** Chart shows uncertainty across three main categories for IAS compared to other sectors already included in carbon budgets and for the economy as a whole. Projection uncertainty is for 2030. Year-to-year fluctuations show the largest annual increase and decrease since 1990.

<sup>3</sup> See [www.climate.scot](http://www.climate.scot)

<sup>4</sup> See [http://www.assemblee-nationale.fr/dyn/15/dossiers/energie\\_climat](http://www.assemblee-nationale.fr/dyn/15/dossiers/energie_climat)

Aviation and shipping both emit very small amounts of regulated non-CO<sub>2</sub> greenhouse gases (methane and nitrous oxide) but also have additional warming and cooling effects that are not included in the basket of gases covered by the Paris Agreement and the Climate Change Act (Figure A5):

- **Aviation** produces a range of different pollutants that affect the climate in different ways. The most significant effect is from creation of contrails and high clouds, although the impact of these are short-lived as these clouds are high in the atmosphere. Measuring these effects on an annual basis is challenging, given their short-term nature and dependence on localised conditions. Overall, non-CO<sub>2</sub> effects from aviation warm the climate and approximately double the historic warming effect of CO<sub>2</sub> alone.
- **Shipping** has non-CO<sub>2</sub> effects that come from the emission of sulphur dioxide, which has an overall cooling effect on the climate but causes local air pollution.

In both aviation and shipping these non-CO<sub>2</sub> effects are mainly short-lived, meaning that if they were stopped their effects on the climate would rapidly disappear.

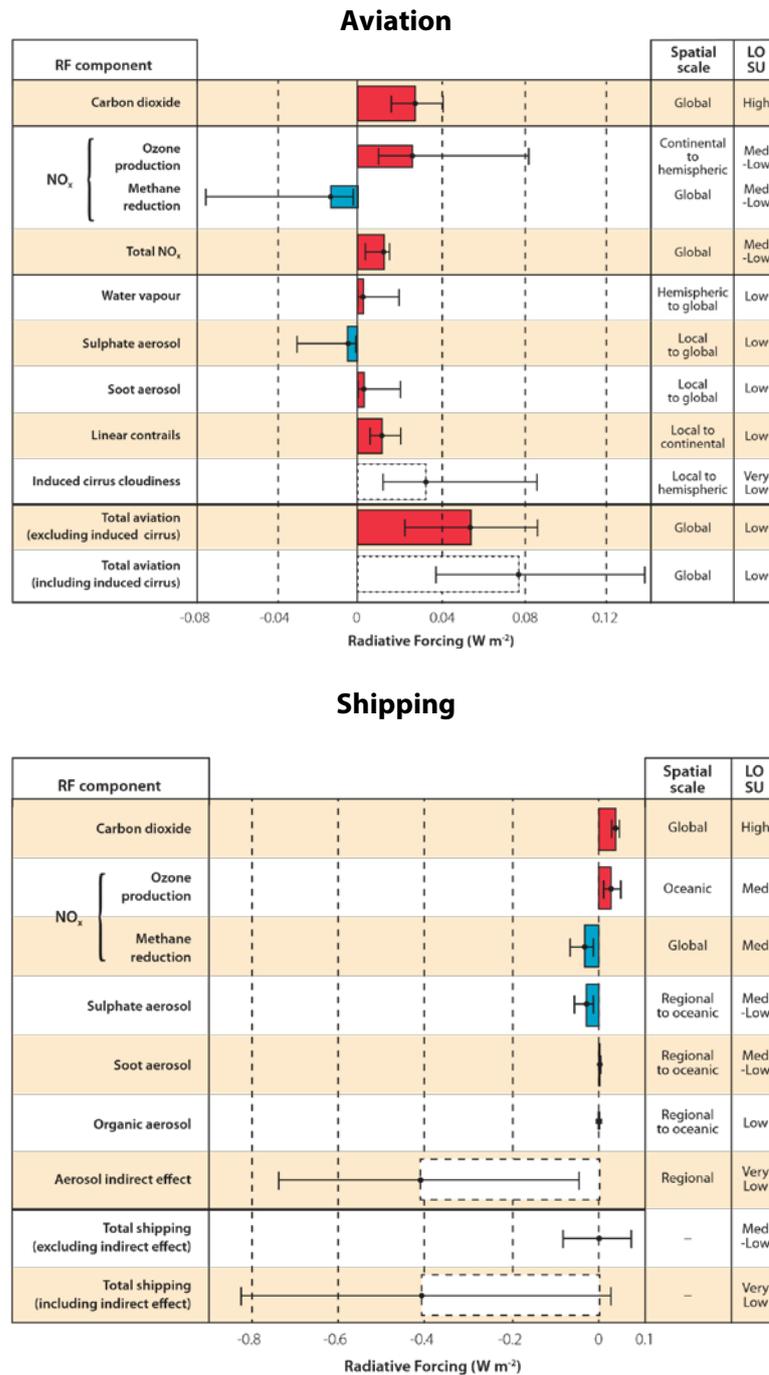
The appropriate approach to policy at this stage is not to include these effects within the net-zero target, but to improve scientific understanding (e.g. for annual reporting) and develop options to markedly reduce them over the coming decades that are not at the expense of GHG emissions.

In aviation, policies are already in place to limit some non-CO<sub>2</sub> effects due to their impact on air quality. In shipping, sulphate emissions are likely to be significantly reduced in future due to global regulations to reduce the sulphur content of shipping fuels. These are expected to come into force in 2020.

While addressing non-CO<sub>2</sub> effects is important, this does not change the need to reduce CO<sub>2</sub> emissions which are the dominant factor contributing to IAS' impact on the climate.

We will continue to monitor progress to reduce the non-CO<sub>2</sub> effects of IAS in our annual progress reports to Parliament and in our advice on setting carbon budgets.

**Figure A5. Non-CO<sub>2</sub> effects from aviation and shipping**



**Source:** Lee et al (2010) *Transport impacts on atmosphere and climate: aviation*, Atmospheric Environment; Eyring et al (2010) *Transport impacts on atmosphere and climate: shipping*, Atmospheric Environment.

**Notes:** Each component of aviation and shipping's effect on climate is shown in terms of radiative forcing, which measures the current atmospheric imbalance (in Watts per square metre, Wm<sup>-2</sup>) due to aviation and shipping activity up until now. Note that it does not give a measure of future effects from current activity - for instance, emitted CO<sub>2</sub> will reside in the atmosphere for many decades, whereas today's contrails and aerosols will only last up to a few hours or days. Whiskers denote 90% confidence intervals (aviation) and range of estimates in the literature (shipping). LOSU indicates the Level of Scientific Understanding regarding each effect. Induced cirrus and aerosol indirect effects are shown as a dotted bar due to high uncertainty.

### (iii) How to get to net-zero IAS emissions

The planning assumption for the IAS sectors should be to achieve net-zero emissions by 2050. This reflects the strategic importance of these sectors, and their international nature.

Getting to net-zero emissions will require reducing IAS emissions as far as possible and using scalable GGRs (e.g. BECCS or DACCS) to offset remaining emissions.

#### Reducing IAS emissions

Reducing aviation emissions will be more challenging than for shipping, given the lack of zero-carbon options in aviation (Figure A7):

- **Aviation.** Our scenarios from our net-zero advice suggest aviation emissions could be reduced from 36.5 MtCO<sub>2</sub> in 2017 to around 30 MtCO<sub>2</sub> in 2050 through a combination of fuel efficiency improvements, limited use of sustainable biofuels, and by managing demand growth. Major technological breakthroughs in commercial aviation are unlikely to make a significant difference to emissions by 2050 given long development and certification lead times, and slow turnover of the fleet.
  - **Fuel efficiency.** Our scenarios reflect a 1.4% annual improvement in fuel efficiency, which is in line with the historical average since 2000 for UK departing flights on a seat-km basis. This rate of improvement could be achieved through:
    - More efficient engines, including both advanced conventional jet designs, and some deployment of hybrid-electric aircraft in the 2040s (e.g. hybrids make up less than 10% of kilometres flown in 2050). There are no full-electric aircraft in the scenario which, particularly for long-haul flights, are unlikely to be feasible by 2050.
    - Improvements in aircraft design including through reductions in design speeds, and use of design elements such as high aspect ratio wings and composite materials.
    - Efficiency improvements in airlines' operations and in airspace management.
  - **Sustainable fuels.** Our scenario has a 10% uptake of sustainable fuels in 2050. It is not appropriate to plan for higher levels of uptake at this stage, given the range of competing potential uses for biomass across the economy (Figure A8) and uncertainty over which use will be most cost-effective. Our scenarios are based around supply of sustainable biomass with strong governance to ensure they reflect genuine emissions savings. We therefore assume high emissions saving from these biofuels. Emissions relating to cultivation, processing and transportation are relatively small and, where relevant, are included elsewhere in our economy-wide scenario.
  - **Demand.** In the absence of a true zero-carbon plane, demand cannot continue to grow unfettered over the long-term. Our scenario reflects a 25% growth in demand by 2050 compared to 2018 levels. This compares to current Government projections which are for up to a 49% increase in demand over the same period.<sup>5</sup>

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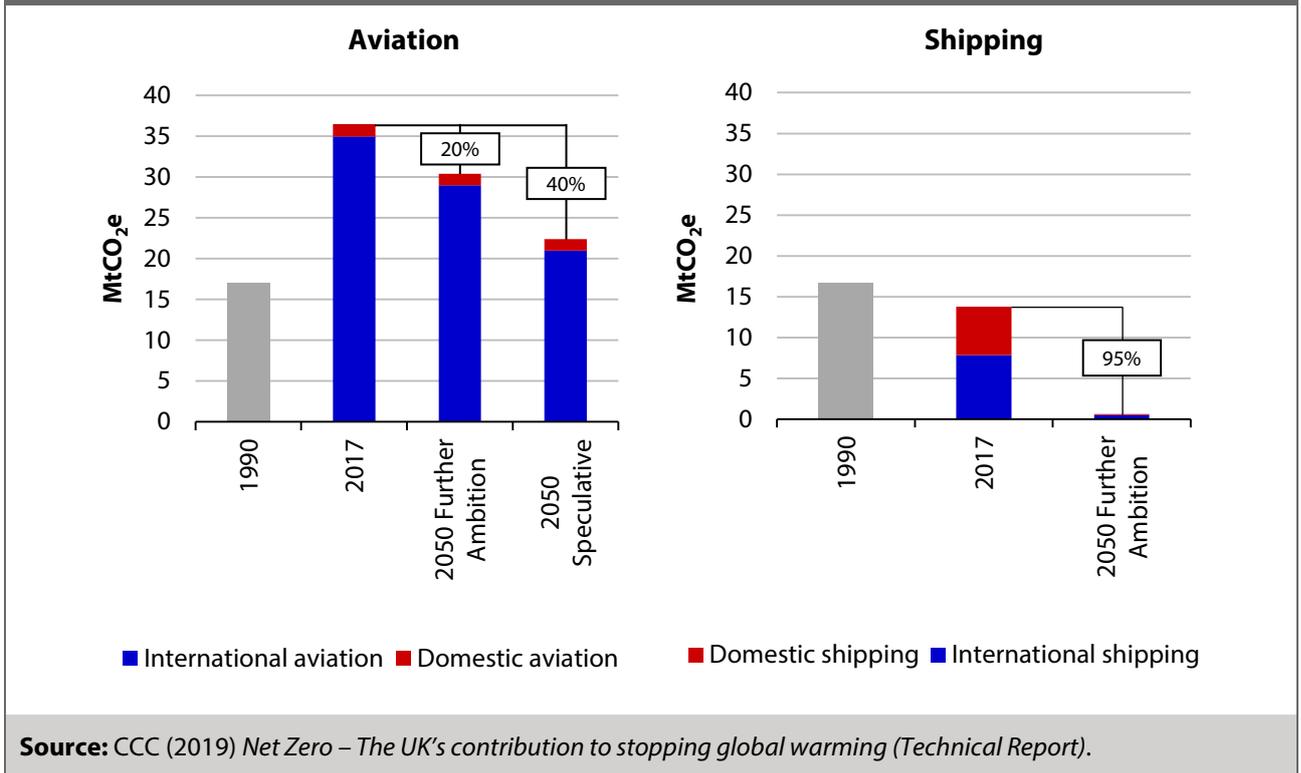
<sup>5</sup> DfT (2017) *UK Aviation Forecasts*.

- **Speculative aviation options.** We have identified ‘Speculative’ options in aviation on demand and alternative fuels which could reduce emissions below 30 MtCO<sub>2</sub> in 2050, though these have greater challenges:
  - **Further demand constraint** is possible in order to limit growth to less than 25% above current levels by 2050. We illustrate the potential emission savings from additional demand constraint through a scenario where demand is broadly at 2018 levels in 2050. This could save up to 8 MtCO<sub>2</sub>e in 2050, and could, for example, reflect future changes in consumer preferences and social norms, or more ambitious policy.
  - **Alternative fuels.** It is possible that synthetic carbon-neutral fuels (‘power-to-liquid’) could be used to reduce aviation emissions. Production of such fuels would entail recycling captured CO<sub>2</sub> (e.g. via direct air capture, DAC) in conjunction with zero-carbon hydrogen into a drop-in replacement for kerosene. However, costs for DAC are expected to be high (e.g. in our net-zero advice we estimated that it might be around £300/tCO<sub>2</sub> by 2050). On top of this, production of synthetic fuels is likely to have substantial further costs given low thermodynamic efficiency and multiple processing stages, even if the input electricity comes from low-cost renewables. CO<sub>2</sub> captured through DAC is therefore likely to provide emissions reductions at lower cost when combined with CCS rather than it being inefficiently recycled into a fuel:
    - Once CO<sub>2</sub> has been captured, sequestering it geologically can provide abatement at a further cost of up to £20 per tonne of CO<sub>2</sub>. By contrast, the cost of recycling it into a carbon-neutral fuel to displace fossil kerosene is estimated to have a further net cost of around £100 per tonne of CO<sub>2</sub> in 2050 (Figure A9).
    - Paying this premium to reduce aviation emissions to net-zero via synthetic fuels rather than sequestering the CO<sub>2</sub> would have an additional cost to the UK of £2-4 billion annually in 2050 under the level of aviation emissions in our net-zero scenario.
- **Shipping.** A range of options exist to reduce shipping emissions, some of which may allow shipping to get to near-zero GHG emissions. These include more fuel-efficient ship and engine designs, improved ship operations, and use of alternative fuels:
  - **Improvements to fuel efficiency** include measures to reduce water resistance (e.g. more efficient hull coatings), measures to improve energy efficiency (e.g. recovery of waste heat), and use of alternative sources of propulsion (e.g. kites, sails and Flettner rotors).
  - **Ship operations.** Reducing speeds at which ships travel can significantly reduce fuel use. Other operational measures include use of software to plan the most efficient routes and to optimise ballast and trim.
  - **Alternative fuels.** Use of hydrogen or ammonia could allow for zero-carbon shipping, but widespread use of biofuels or electrification is unlikely.
    - There is potential for fuel switching in shipping to hydrogen or ammonia, both of which would need to be produced in a low- or zero-carbon way (i.e. from zero-carbon electricity or with CCS). These options can be applied to new ships and retrofitted to existing ships. The potential development of an international market in hydrogen (e.g. as ammonia) shipped from countries with low costs of low-carbon hydrogen production, does raise

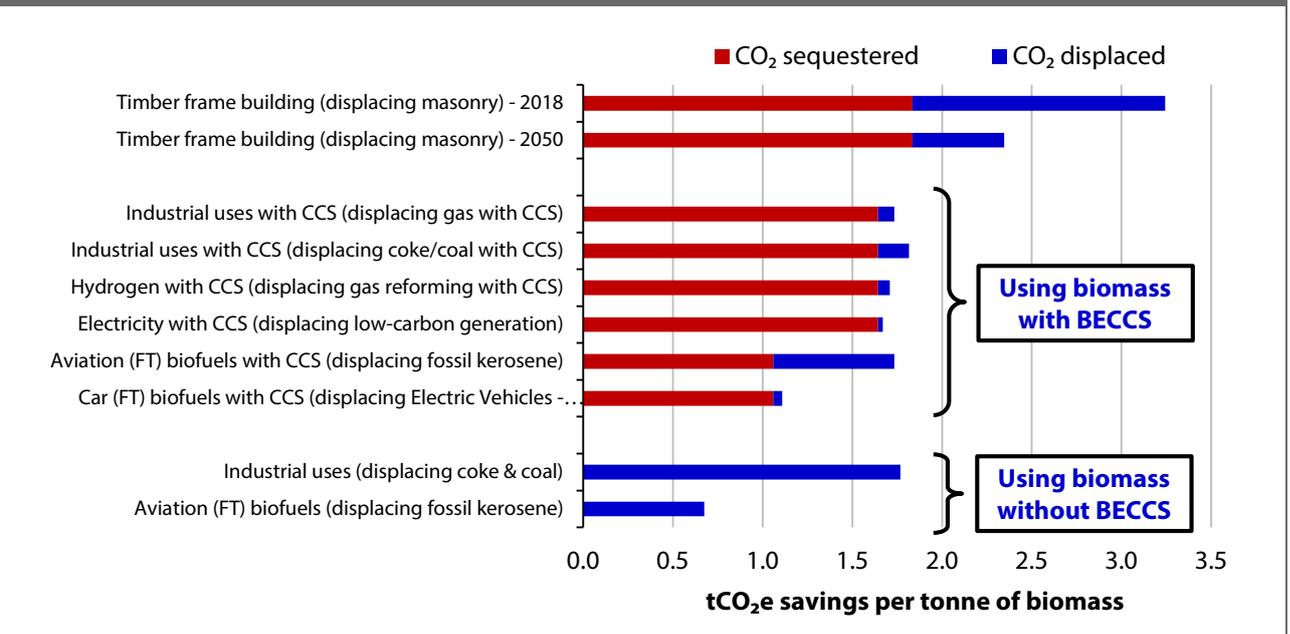
the possibility of this being the primary way of supplying low-carbon fuel for refuelling at ports.

- Biofuels are technically feasible in shipping but not likely to be a priority or cost-effective given other competing uses for this resource.
- Electrification is possible for ships, but is likely to be limited to relatively short routes given energy and therefore battery requirements.

**Figure A7.** Aviation and shipping emission scenarios to 2050



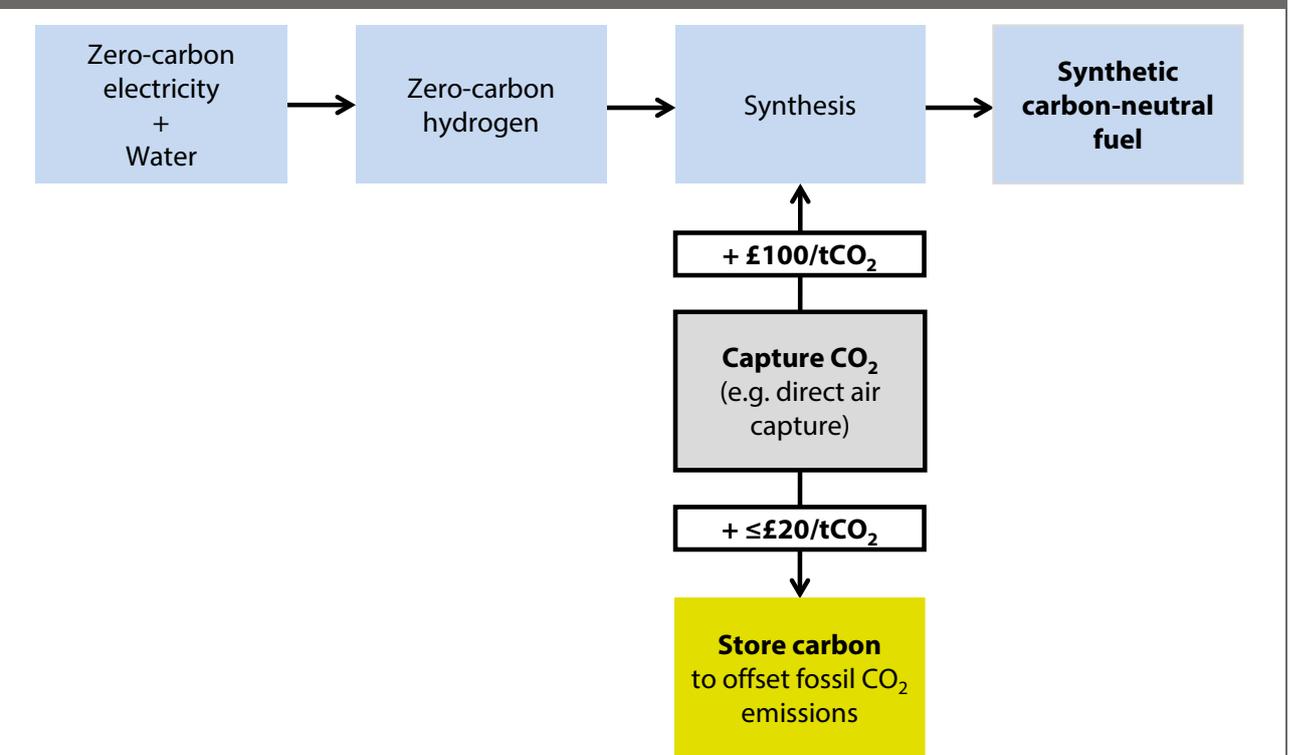
**Figure A8.** Estimated GHG abatement across different biomass applications



**Source:** CCC (2018) *Biomass in a low-carbon economy*.

**Notes:** Shows estimates of GHG abatement provided by an oven dried tonne of biomass used in various sectors, considering an appropriate counterfactual (i.e. what we would expect it to be displacing, long-term).

**Figure A9.** Cost of storing captured CO<sub>2</sub> compared to cost of using it to produce synthetic fuels



**Source:** CCC analysis based on Royal Society (2019) *Sustainable synthetic carbon based fuels for transport*.

### Getting IAS emissions to net-zero

Achieving net-zero IAS emissions will require limited use of scalable GGR offsets (e.g. BECCS or DACCS), given likely significant remaining IAS emissions in 2050 (primarily from aviation).

- GGR offsets could be funded through a requirement on IAS sectors to pay for removals, or Governments could generate revenues (e.g. through an emissions trading system or carbon tax) that can be used to pay for Government-procured removals.
- GGR offsets could in principle be delivered through international (e.g. CORSIA) or domestic policies, but must demonstrate genuinely additional removals within a robust governance framework. For CCS-based removals it would make sense for a substantial proportion of these to occur domestically, given the UK's advantages relating to availability of CO<sub>2</sub> storage capacity, offshore engineering expertise, and market regulation and design.
- There will not be unlimited access to GGR offsets. The potential for deploying these is limited by global constraints on land and resources. As some GGR options (e.g. afforestation) have relatively low costs but are limited in scope, it should be assumed that these opportunities will be taken in any case and will not provide additional scope to offset positive emissions elsewhere. The GGR options appropriate to offset 'hard to reduce' emissions will therefore generally be those that are highly scalable and towards the higher end of GGR costs (e.g. BECCS or DACCS).
- Offsets that do not offer potential for genuine GGR should not be pursued in the long term.

It may also be possible to deploy synthetic fuels to fully replace fossil fuel use, particularly in aviation. This could reduce emissions to gross (i.e. actual) zero. However, this is likely to be significantly more expensive than a GGR-based approach.

#### **(iv) Implications for aviation and shipping policy**

The approach to reducing IAS emissions should be through a combination of international and domestic policies. It will require a co-ordinated cross-government approach to join up the Government's clean growth, industrial strategy, and aviation and shipping objectives.

At the international level, global policies consistent with the ambition in the Paris Agreement are required to provide a level-playing field for airlines and shipping operators, and to guard against the risk of competitive distortions.

But international policies are unlikely to overcome all barriers to decarbonising the IAS sectors. Domestic policies should also be pursued where these can help overcome UK-specific market barriers, and where these do not lead to risk of carbon leakage.

Specific international and domestic policy approaches that should be considered for aviation, shipping, and GGRs include:

- **Aviation.** A package of international and domestic policy measures should be put in place that includes carbon pricing, support for research, innovation and deployment, and measures to manage growth in demand.
  - **A long-term goal for global international aviation emissions.** The ICAO's current carbon policy, CORSIA, has an end date of 2035 and will need to be based on robust rules that deliver genuine emission reductions. A new long-term goal for global international aviation emissions consistent with the Paris Agreement would provide a strong and early signal to incentivise the investment in new, cleaner, technologies that will be required for the sector to

play its role in meeting long-term targets. This is particularly important in aviation given the long lifetimes of assets. A similar approach has been agreed for global shipping emissions in the IMO, which has set a target for greenhouse gas emissions to be at least 50% below 2008 levels by 2050 (although this may need to be tightened further).

– **Support for research, innovation, and deployment in technology and alternative fuels.**

- **Technology.** Our analysis, and that of industry, suggests the largest contribution to reducing aviation emissions will come from new technologies and aircraft designs. Many of these developments are likely to be cost-effective, given their potential fuel savings. The Government should build on the approach set out in the Aerospace Sector Deal and Future Flight Challenge, and set out a clear strategy to ensure these technology solutions are developed and brought to market in a timely fashion.
- **Sustainable biofuels.** Some deployment of sustainable biofuels is likely to be appropriate in aviation (e.g. up to 10% of fuel use in 2050), but higher levels of uptake should be not planned for given competing alternative uses. Development of a UK market for aviation biofuels could be supported by achieving more of the 2030 Renewable Transport Fuel Obligation target through aviation fuels, subject to strong sustainability criteria being put in place. Aviation biofuels will need to be produced with CCS to be competitive against alternative uses of biomass.
- **Synthetic fuels.** Synthetic fuels should not be a priority for government policy, but if the aviation industry wants to pursue them it should focus on demonstrating that these fuels, used in aviation, would be genuinely low-carbon, and could become cost-competitive and scalable in a global market.

- **Managing demand.** Measures should be put in place to limit growth in demand to at most 25% above current levels by 2050. These could include carbon pricing, a frequent flyer levy, fiscal measures to ensure aviation is not undertaxed compared to other transport sectors (e.g. fuel duty, VAT), reforms to Air Passenger Duty, or management of airport capacity. Research commissioned by the Department for Transport concludes that UK demand management policies in aviation are unlikely to lead to carbon leakage in aggregate.<sup>6</sup>

- **Airport capacity.** The Government should assess its airport capacity strategy in the context of net zero. Specifically, investments will need to be demonstrated to make economic sense in a net-zero world and the transition towards it. Current planned additional airport capacity in London, including the third runway at Heathrow, is likely to leave at most very limited room for growth at non-London airports.

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<sup>6</sup> ATA and Clarity (2018) *The carbon leakage and competitiveness impacts of carbon abatement policy in aviation*.

- **Shipping.** The Government's Clean Maritime Plan<sup>7</sup> sets out many of the steps needed to decarbonise the shipping sector, and commits the UK to 'moving faster than other countries and faster than international standards'. A globally co-ordinated approach will be needed for the transition towards zero-carbon shipping, supported by domestic policies.
  - **Global policy to deliver the IMO 2050 target.** The IMO has agreed to reduce global international shipping emissions by at least 50% by 2050 compared to 2008 levels, and to pursue efforts to phase them out entirely. It must now put in a place a package of policies to deliver that target. That should include carbon pricing, support for research, innovation, and deployment, and a co-ordinated approach to provision of refuelling infrastructure for alternative fuels. Consideration should also be given to increasing the IMO's 2050 ambition, given the potential for much deeper reductions in global shipping emissions (e.g. to nearly zero through use of ammonia or other hydrogen-based fuels).
  - **Domestic policy to support the transition to zero-carbon shipping.** The main focus for domestic shipping policy should be on developing supply chains for zero-carbon fuels (e.g. hydrogen or ammonia), and the refuelling and other port infrastructure required to support this. That should include ensuring availability of key input technologies, including CCS, which will require a co-ordinated cross-government approach. It could also include support for developing and deploying these vessels (e.g. to demonstrate safety standards).
- **Greenhouse gas removal.** The Government can take steps towards enabling IAS to reach net-zero emissions in the UK and internationally by establishing a market for scalable GGR solutions (e.g. BECCS, DACCS). Such a strategy could create a significant new global export opportunity for the UK in GGR technology and expertise. This will require an effective cross-government approach across IAS and GGR policy. It highlights the importance of developing a UK CCS industry, which will be required for production of biofuels in aviation, and hydrogen and ammonia in shipping, as well as for GGRs.

These policy approaches should be reflected in the forthcoming Aviation Strategy and as the Clean Maritime Plan is taken forward.

The Committee will continue to monitor progress in decarbonising aviation and shipping as part of our annual reports to Parliament and as part of our advice on carbon budgets.

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<sup>7</sup> Department for Transport (2019) *Clean Maritime Plan*.