TyndallManchester
Climate Change Research

Aviation Sector Emissions and the Manchester Climate Change Framework

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NB: All views contained with this report are attributable solely to the authors and do not necessarily reflect those of researchers within the wider Tyndall Centre.

This report considers the scale of aviation emissions associated with Manchester and Manchester Airport in the context of the Paris Agreement on climate change and the Manchester Zero Carbon Framework decarbonisation pathway. Whilst there are a number of greenhouse gases and warming effects associated with air travel, carbon dioxide is the primary driver of long term warming and is the main focus of Manchester City Council's climate change mitigation efforts. This report therefore considers carbon dioxide only with the phrase "carbon emissions" synonymous where used.

Summary

To be consistent with the 15 million tonne carbon budget for Manchester's direct CO_2 emissions, UK aviation emissions need to stay below 1,200 million tonnes CO_2 for the period 2020 to 2100 (Kuriakose et al 2017). This is 37% of the total Paris Agreement aligned UK carbon budget, a much larger allocation than for other sectors of the economy, recognising the more acute technical constraints limiting CO_2 mitigation in this sector. Manchester should work with national government and others to help ensure the UK stays within this budget.

Targets that are in line with this budget should be adopted for Manchester residents and Manchester organisations' business travel. The CAA passenger survey allows these figures to be estimated for all UK airports.

A limited carbon budget of 6.6 million tonnes for carbon emissions from residents' flights from all airports in the period 2020 to 2100 is proposed. Emissions are currently estimated to be 0.2 million tonnes CO_2 (2017 data) so the budget is equivalent to this remaining static between 2020 to 2030, then declining to zero by 2075. Further monitoring and reporting will be necessary to calculate CO_2 emissions from business flights taken by Manchester organisations. A budget and pathway should be set that is equivalent to that for residents.

Cooperation with national government and other stakeholders on a range of technical, operational, demand management and out-of-sector actions, such as sustainable aviation fuels and greenhouse gas removals, will be required.

1. Sources of emissions from Manchester Airport in relation to the Manchester Climate ChangeFramework

There are multiple sources of carbon emissions from air travel, attributable variously to passengers, airlines, airports and other service providers.

Airport emissions

Carbon emissions directly associated with an airport, typically termed Scope 1 and 2 under the World Resources Institute's Greenhouse Gas (GHG) Protocol, include fossil fuel and electricity consumption due to:

- Building services – so called "regulated energy consumption" of heating, lighting, and air conditioning
- Activities within buildings – energy consumed by appliances, office and security equipment
- Ground operations – tugs and other vehicles

Depending on ownership structures, other organisations active at the airport may be administratively responsible for some energy consumption, including for instance, businesses active within the terminal and air traffic control on site. All of these sources of carbon emissions are included within the scope of the Manchester City Climate Change Framework direct emissions budget, and BEIS sub-national data where the metering and reporting of emissions occurs within the local authority boundary.

Indirect sources of emissions that might typically be included in an airport's Scope 3 emissions inventory include passenger surface travel to the airport, staff commuting, staff business travel, procurement and waste disposal. Some of these sources, such as surface travel within the City of Manchester boundary will be included within the Manchester Climate Change Framework.

The above sources of emissions are not the focus of this report, however, both direct emissions and these indirect emissions should be considered by Manchester City Council and Manchester Airport Group when making development plans.

Flight emissions

Emissions from the fuel burned by aircraft in transit are the largest source of emissions from the aviation industry. Aircraft emissions can be broken up into Landing Take-off Cycle (LTO) which includes Landing (from 1000 m to ground), taxiing (movements on the ground) and take-off (from ground to 1000 m) and the cruise phase (the remainder above 1000 m). Nationally, aviation

emissions have recently returned to growth, following a decline during the global economic downturn starting in 2008, and traffic is increasing nationally and at Manchester Airport.

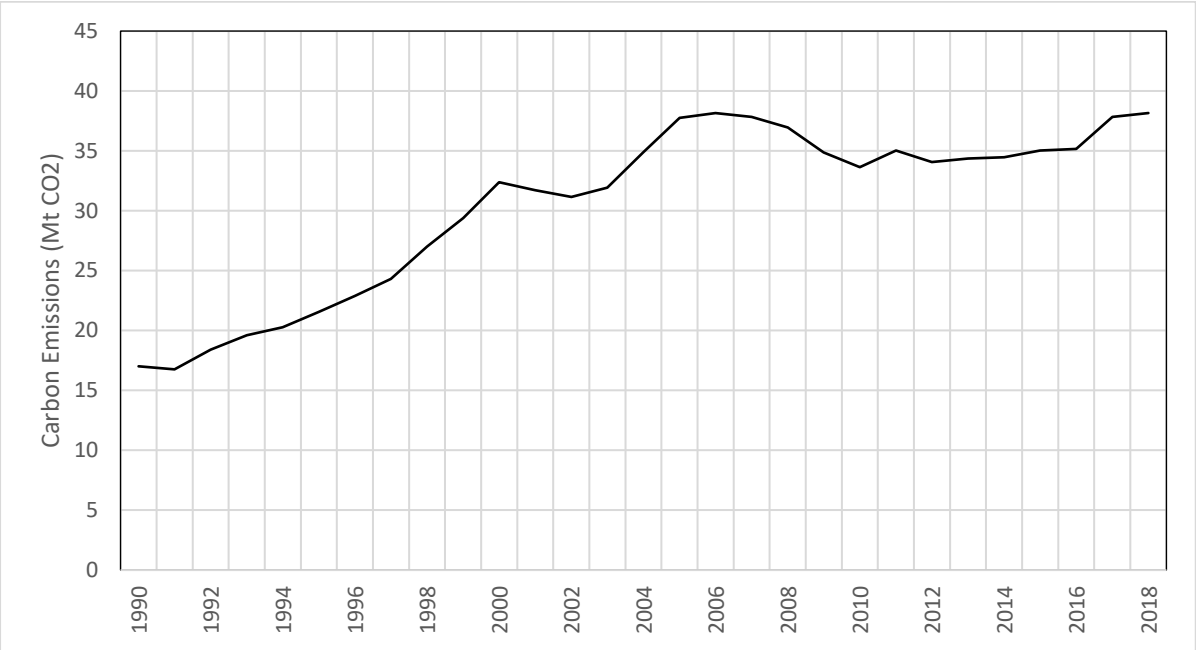

Figure 1 Historic carbon emissions for UK aviation sector (Source BEIS 2020)

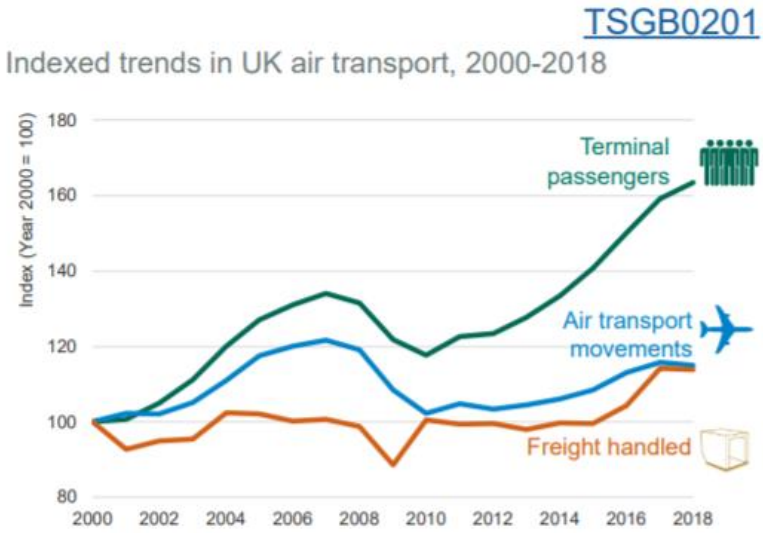

Figure 2 UK national trends in air traffic, indexed to 1992 levels (Source DfT 2019)

2. Rationale for an aviation emissions target

The primary rationale for Manchester Climate Change Framework adopting an aviation emissions target is consistency with the City of Manchester's overarching emissions budget approach. The UK emissions budget developed by the Tyndall Centre for the City of Manchester is comprehensive; all sources of carbon emissions are accounted for in some way (Kuriakose et al 2018). Emissions from the aviation sector have to date been considered at the national level, recognising that many of the policy levers to influence this sector are not primarily held at the local level. A 37% share of the UK budget has been allocated to the aviation sector, totalling 1200 $MtCO_2$ for the period 2020 to 2100.

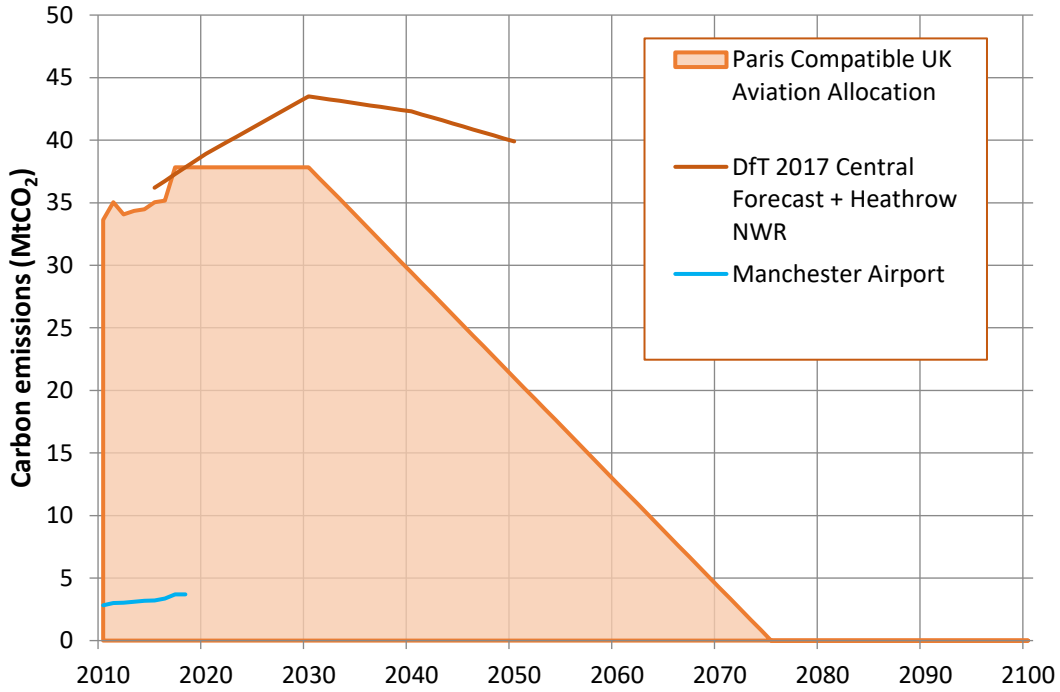

Figure 3 Aviation emissions i) at UK level historical to 2018, then a scenario to 2100 compatible with Manchester's carbon budget (light orange line and shaded area), ii) forecast to 2050 by DfT (upper dark orange line), iii) estimated from Manchester Airport activity to 2018 (lower light blue line). Emissions are allocated from bunker fuel sales to departing aircraft by convention.

UK aviation emissions need to remain within this assumed budget if the sub-national allocations, of carbon budgets for direct emissions, to Manchester and other cities are to remain at their present levels. It is therefore reasonable to establish local targets, monitoring and actions whilst residents of Manchester and Manchester based businesses participate in and benefit from air transport, the airport is in part owned by the City Council, and the airport's operations facilitate this travel.

A secondary rationale is that presently air transport emissions are not regulated to be compliant with the Paris Agreement. This is not unique to this sector, however, international aviation emissions are not included in existing UK carbon budgets, despite the recommendations of the Committee on Climate Change and the opportunity that was presented in passing the Net Zero Amendment to the Climate Change Act (2019). The shipping sector is similar in this respect, and likewise a national allocation was made before calculating the direct carbon budget for Manchester. However, international shipping is approximately five times smaller than aviation as a source of carbon

emissions, is not increasing at present, has an international target for absolute reductions of 50% by 2050, and does not have the same opportunity for local action to reduce consumption.

With aviation outside of absolute carbon emission regulations nationally and internationally there is potentially no limit on the growth in this source of emissions. A number of Market Based Measures (MBMs) have been introduced in the sector, whereby cuts are paid for in other sectors, but there are substantial weaknesses with the existing and proposed systems as discussed in Section 5. If Manchester wishes to show leadership on climate change, and maintain the integrity of its science based direct carbon budget, then aviation is an area where it can take action in advance of national and international regulation.

3. Emissions associated with Manchester and Manchester Airport

Carbon emissions from all aircraft using Manchester Airport can be estimated by scaling the national sum of carbon emissions (BEIS data, domestic aviation + international bunker fuel) by the proportion of passengers served. Use by local residents can be attributed to the city and airport level using the Civil Aviation Authority (CAA) passenger survey dataset. In doing so, it is assumed that Manchester residents fly to destinations similar to the national average passenger, and the range of destinations

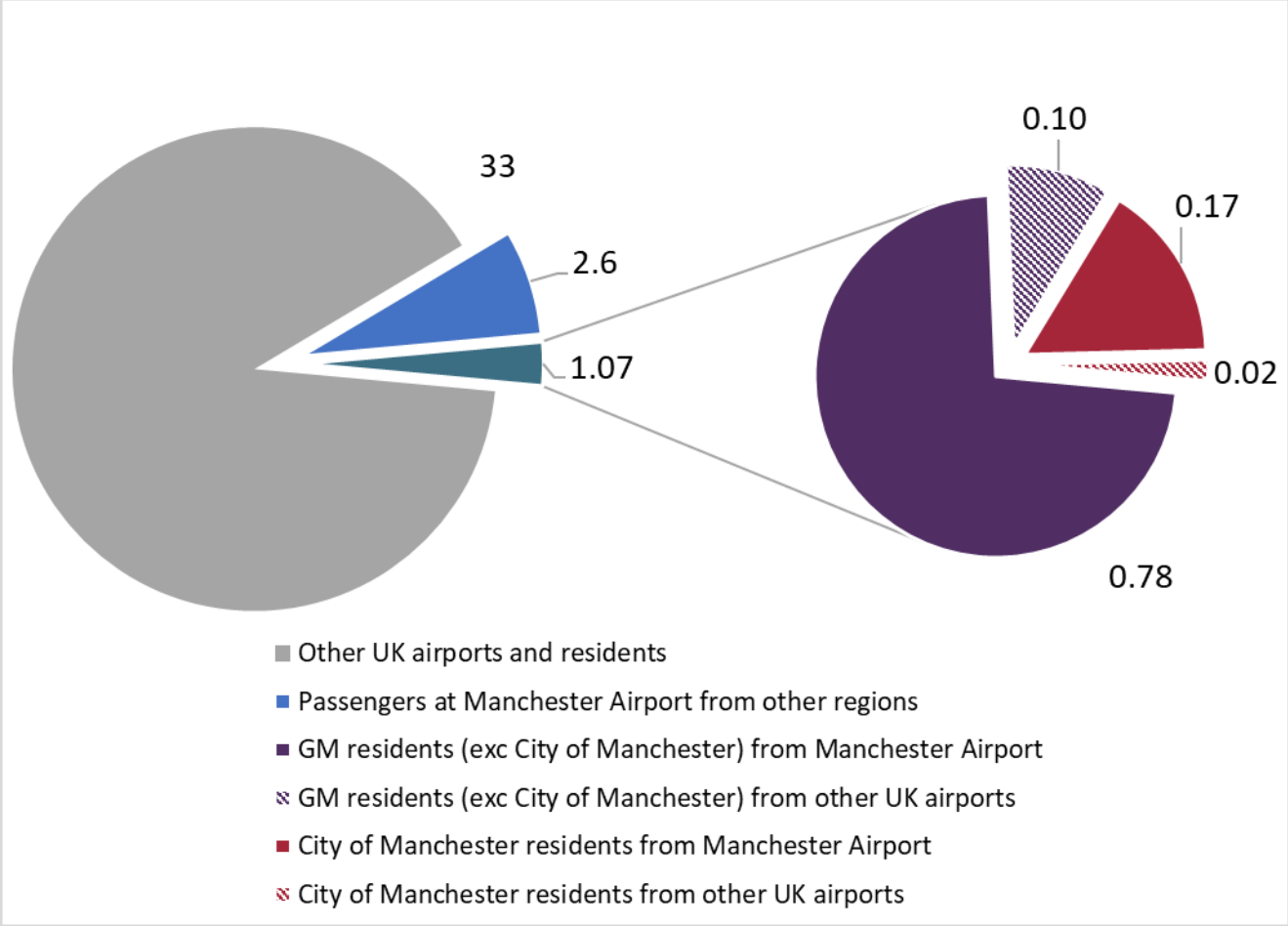

Figure 4 UK National aviation emissions shared out by airport (MAN is the IATA code for Manchester Airport) and consumer according to their place of residence reported in the CAA passenger survey, 2017 data (Sources BEIS, CAA). Values are given in millions of tonnes of carbon dioxide (MtCO2).

served by Manchester Airport suggest that this is the case (CAA 2017 Data Table 12). This approach was first presented by Manchester Airport Group at the Mayors' Green Summit in March 2018.

Figure 4 shows the breakdown of carbon emissions by this method for 2017. The total estimate of carbon emissions from aircraft serving Manchester Airport is 3.6 $MtCO_2$ per annum with approximately 0.2 $MtCO_2$ associated with residents of the City of Manchester. It does not directly measure the fuel consumption of the particular aircraft using each airport; fuel sales are reported to the national government and this provides the basis of the national carbon emissions calculation. This approach is acceptable for the purposes of monitoring emissions at the city scale as it recognises sectoral progress on technical and operational improvements given that there is limited direct local influence on these aspects. It is also a known underestimate of emissions attributable to Manchester residents flying from airports other than Manchester Airport. The CAA passenger survey is not conducted at all UK airports annually and in the 2017 dataset above, airports representing approximately 20% of UK passenger movements are absent. However, it is not likely that Manchester residents use all of these, for instance Aberdeen, Belfast International and Belfast City. The maximum discrepancy is therefore assessed to be less than 1% of the total emissions attributed to Manchester residents.

Alternative calculation method

Emissions could be calculated from air traffic data at each airport and the known fuel consumption of reported aircraft types. A "bottom up" inventory created in this way would enable a more accurate allocation of emissions to Manchester's residents and better reflect any changes in the destinations served by Manchester Airport and the performance of aircraft on these routes. The capability to do this exists within the Manchester universities. However, it would be a time consuming and data intensive task and to be most useful would have to be repeated for all major UK airports.

4. Options for a Manchester aviation carbon reduction path

There is no single ideal target for Manchester to adopt in relation to aviation at Manchester Airport. There are multiple options that reflect different aspects of the city's relationship to this source of emissions.

1 Manchester's use of aviation calculated from CAA passenger survey data

A calculation based on the CAA passenger survey, makes it possible to monitor consumption of air transport at a city level. As such, a target or pathway can be set against which the city's progress can be monitored. This path would act as an indicator of progress to identify whether the city is collectively acting to meet its objective to align with the Paris Agreement. It would reflect patterns of consumption of residents' air transport wherever it occurs, not only at Manchester Airport. Similarly, it would reflect national progress on low and zero carbon aviation fuels, air traffic control and improved aircraft performance but would not reflect specific actions taken at Manchester Airport.

The share of the national budget for Manchester's future aviation emissions pathway could be determined in a number of ways:

a) National allocation grandfathered from present levels of residents' use

The total pathway emissions would be based on the national aviation allocation assumption in the 2018 Manchester carbon budget report (Kuriakose et al 2018). In this path, emissions remain constant to 2030 and reduce to zero by 2075. For Manchester, this present level is approximately 0.2 $MtCO_2$, and corresponds to a total budget share of 6.6 $MtCO_2$ for the 2018 to 2100 budget period.

b) Per capita allocation

There is an uneven distribution of per capita emissions from aviation nationally, with Manchester's consumption somewhere between the North East of England at the lowest end and London at the highest (Wood 2011). A pathway taking a share of the national aviation allocation on a per capita basis corresponds to a total budget of 10 $MtCO_2$. If emissions remain at 2017's constant level this would be equivalent to 50 years without reduction and would require that other regions and cities take stronger action on this source of emissions than Manchester.

c) Including business travel

In either case a) or b), air travel by Manchester based businesses would only be included if their staff are also resident within the city boundary due to the current data collection method. It would therefore be prudent to establish a system of reporting for businesses, whilst recognising the potential for double counting. Further work would be required to establish an appropriate process. The national grandfathered pathway, option a), has significant advantages in this regard. Because the overall shape and total budget implied by the pathway is parallel with the national assumption, new businesses could be added each year and targets updated on a pro-rata basis. It would be challenging to retain consistency were option b) (per capita share) to be adopted.

2 Combined Carbon Budgets

An alternative approach would be to incorporate a proportion of the national allocation for aviation within the Manchester emissions budget of 15 $MtCO_2$. However, data quality and the calculation method for aviation are not as robust as for other sectors at the city level and so this is not recommended. The two budgets should not be regarded as equivalent and exchangeable as the relative quantities and lower data quality for aviation could potentially create distortions. Despite the two budgets being separate they should nonetheless be seen as mutually dependent. Exceeding the aviation budget or the city-level budget will necessitate a reconsideration of the emissions space afforded in the other, or indeed elsewhere within the global emissions budget.

3 Ownership Share of Manchester Airport

Manchester could adopt a share of the national emissions allocation on the basis of the total aircraft activity at Manchester Airport reflecting the City Council's part ownership (35%) of the airport and the contribution of the airport to the economic and cultural life of the city. Based on the 2017 share of terminal passengers, Manchester Airport's grandfathered share of a national aviation budget would be approximately 120 $MtCO_2$ in the period 2020-2100. This measure could be reduced pro-rata according to proportion of ownership but similarly so would the corresponding share of the national emissions allocation.

Alone, an airport ownership share option would not reflect the choices made by residents and businesses, nor their use of other airports. This measure also includes emissions from use of the airport by non-Manchester residents, which are the large majority of passengers. It is likely that a

target set in this way would need to be reviewed according to national policy on airport development. For instance, the proposed expansion of Heathrow would suggest a reduced share of activity for regional airports if it is to act as a national hub. Manchester Airport Group also owns London Stansted and East Midlands Airports offering a greater opportunity to influence national policy to maintain carbon budget consistency. Actions at a national scale to achieve the 1200 $MtCO_2$ national budget will be valuable in achieving the overall goals of the Manchester Climate Change Framework.

4 Possible actions to maintain consistency with the national aviation allocation

There are a range of possible actions that could be taken by Manchester City Council (MCC), Manchester Airport Group, Manchester's organisations and residents to help to maintain aviation emissions within the national pathway required by the city's direct carbon budget. A non-exhaustive, non-exclusive, list of possibilities for further investigation is presented below:

- Work with national government, other airport operators and stakeholders to establish an aviation policy consistent with the Paris Agreement in its scope, climate impact, and delivery mechanisms through a national sectoral carbon budget of 1200 $MtCO_2$ to 2100.
- Consider emissions projections from all sources (buildings, surface access and aircraft) when developing airport Master Plans. National aircraft emissions should remain in line with the city's direct carbon budget assumption and pathway.
- Work with Manchester Airport to establish a local departure fee to fund low carbon activity within the city. A charge of £10 per departure, accompanied by an annual first flight waiver for residents, may raise the order of £100m per annum in total, £35m accruing to MCC.
- Identify opportunities for innovation to reduce emissions in Landing and Take-Off cycle. Establish monitoring of this source of emissions for comparison the national pathway.

Recommendation

Adopting a target for residents' total use of air transport (option 1a) whilst developing mechanisms to include business travel (option 1c) would reflect local and national actions and allow consistency with the national aviation carbon budget assumption to be assessed. The pathway and budget outlined do not necessitate immediate emissions reduction, however, if emissions increase in the near term there is a substantial risk that the total budget may not be achieved given the known technical limitations and slow rate of change in the aviation sector. Actions to achieve the national carbon budget of 1200 $MtCO_2$ to 2100 should be pursued through the City Council's part ownership of Manchester Airport Group in parallel with the local targets.

5. Market Based Measures (MBMs), Greenhouse Gas Removal (GGR) and Sustainable Aviation Fuels (SAF) in relation to carbon budgets

MBMs and GGR share the common intention to reduce the climate change impact of the aviation sector by paying for a reduction elsewhere in the economy, rather than by reducing the amount of carbon emissions directly from aircraft, an approach often termed "offsetting". Similarly, SAF offers the prospect of reduced emissions from a point earlier in the aviation supply chain rather than directly at the aircraft. These concepts require some additional explanation, unpacking and consideration in relation to the scope of the Manchester targets and actions proposed in this report.

Market Based Measure (MBM) are financial systems that connect different sectors and can take a number of forms. The largest such scheme is the EU Emissions Trading System (EU ETS), a cap-and-trade system incorporating the largest point sources of greenhouse gas emissions, predominantly power sector and industrial facilities, in the European Economic Area (EEA) – the EU Member States, plus Iceland, Liechtenstein and Norway. Flights where both the take-off and landing airports are within the EEA are regulated in this way. However, the system has a mixed reputation for emissions reductions because of an excess of emissions permits due to down-turns in heavy industry, following the 2008 global financial crisis, and the recent uptake of renewable power and efficient appliances. Permits traded at prices well below €10 per tonne from 2012 until early 2018, finally settling at €25 through 2019 after remedial measures were introduced. In addition to the EU ETS, the UK government introduced a Carbon Price Floor in early 2013 to drive greater emissions reductions, predominantly through the closure of coal power stations. The level of the future EU ETS cap is not set to achieve the temperature objectives of the Paris Agreement and will reduce by only 2.2% per annum from 2021 to 2030. As such, aviation offsets where these permits are bought and cancelled are not equivalent to keeping direct emissions within a Paris Agreement aligned carbon budget.

The International Civil Aviation Organisation (ICAO) has introduced a scheme known as CORSIA to require airlines to offset emissions greater than their 2020 level, every year to 2035. This system has established general eligibility criteria to define the credits that will fulfil this commitment (ICAO 2019). These carbon credits are created by funding specific projects that the sellers claim have reduced GHG emissions against their "business as usual" activities. For instance, the project developer may distribute efficient cook-stoves that reduce fuel consumption or part finance wind energy projects. Auditors are then employed to inspect the project plans and verify implementation, for instance that the stoves have been distributed and the wind turbines constructed. However, these auditors cannot observe that there is less CO_2 in the atmosphere as a consequence. The reduction, which justifies the offset carbon credit, is defined against a baseline, for instance of ongoing use of existing stoves and power stations, determined by the overarching offsetting scheme. This leaves the systems vulnerable to misrepresentation of the carbon benefit of purchasing the credit. For instance, recent research identified that the projects responsible for 82% of future credits from the UN's Clean Development Mechanism will likely continue whether anyone buys the offset credits or not (Warnecke et al 2019). Indeed, many of these projects have discontinued applying to generate credits for sale. Credits like these are eligible within the general criteria outlined for CORSIA, and would substantially undermine the emissions reduction claims of the system, if finally approved.

Other offset projects do require continued financial support and so have more convincing claims of "additionality" but concerns about permanence (whether the carbon ever re-enters the atmosphere) and quantification of reductions (whether the offset scheme has captured all of the significant sources of emissions following the project) persist and will never be entirely resolved. For forest projects, the concerns about permanence are particularly acute given that fire, pests and intentional deforestation are risks in the multi-century lifetime of the carbon emissions that are being offset.

Further, in a net-zero world no country, business or individual will have "business as usual" emissions to reduce and sell as credits. Ultimately, all offset credits need to move to a model of funding greenhouse gas removals (GGR) from the atmosphere, for instance by chemically extracting CO_2 and burying it underground. This mode of offsetting gives much greater confidence in its effectiveness and is not limited by land use constraints like standing-forestry based offsets. The UK Committee on Climate Change (CCC) has advised that although removals cannot be a substitute for

genuine emissions reductions, where there are unavoidable emissions from aviation the focus should be on these scalable technologies as a remedy (CCC 2019).

Sustainable Aviation Fuels (SAF) are generated either from plant based sources, crops or wastes of some type, or by removing CO_2 from the atmosphere to incorporate it in a synthetic fuel. When they are burned in aircraft they should not add substantially to the total quantity of CO_2 in the atmosphere as they have absorbed an equivalent quantity when the plants grew or the fuel was synthesised. The emissions reduction compared to fossil fuel is not 100% as some emission are associated with the production and distribution of the SAF. Reductions of greater than 70% are possible although in some cases this can be lower than 30% (EASA 2019 Table 3.4) so careful accounting and auditing is required to verify the benefit of switching fuels.

Recommendation

For compatibility with Manchester's carbon budgets established for direct emissions, emissions reductions from offsetting with MBMs should not be included in monitoring of Manchester's targets unless the trade is with another entity with an emissions budget set with the same Paris aligned carbon budget approach. An exception may be considered in two cases; i) realised greenhouse gas removals, and ii) sustainable aviation fuels. Reduced emissions could be recognised in Manchester's account where it can be verified to international regulatory standards that either carbon dioxide has been removed from the atmosphere to a permanent physical store or that SAF has lower effective life cycle emissions than fossil fuels. Policy and plans should not be set on the expectation of these greenhouse gas removals being delivered. However, it is reasonable to account for them post-hoc, i.e. after the removal has been realised or fuel produced, and procured by a Manchester based organisation or individual.

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