Zero Emissions English Airports Target Further Analysis

DfT TAV14102 Final Report

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This report originates from a 2023 commission from the Department for Transport to Mott MacDonald to further assess the commercial feasibility of airport operations achieving zero emission status by 2040.

It builds on a previous study by Mott MacDonald and Connected Places Catapult published in May 2022. The policy and analytical work undertaken was commissioned under the previous government. Therefore, the report refers to policies and evidence from this period.

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Background and scope

This report aims to provide a high-level assessment of the commercial feasibility of achieving zero emissions at English airports by 2040.

The work undertaken builds on a previous report prepared for the Department for Transport (DfT) and commissioned by Connected Places Catapult.[1] This concluded that, despite uncertainties, the technology challenges associated with the reduction of airport emissions are likely to be overcome by 2040. However, the principal challenge lies in the commercial financing of the required changes to services, operations and infrastructure.

The report did not seek to quantify the operational and investment costs associated with those changes. It did, however, recognise that because of the significant variations in the type and scale of English airports, along with their differing asset bases and age profiles, there is considerable uncertainty regarding the precise quantification of emissions reduction and elimination costs and that these would be site-specific.

Accepting this, the project team made an effort to provide illustrations of, and high-level guidance on, the commercial issues, costs and priorities associated with the 2040 zero emission policy proposal. It was understood at project outset that given the commercial sensitivities and the limited availability of reliable published data, this work needed to be undertaken on an 'arm's length' basis. The report is by nature, therefore, illustrative and does not represent actual financial positions or investment intentions.

Four representative airport 'archetypes' – large, medium, small and business/general aviation – were identified, reflective of the broad range of English airports. The primary focus for the work was on scope 1 and scope 2 (ie airport) emissions, with addition of airside ground operations (such as airside vehicles and aircraft ground power) where the zero-emissions target is dependent on a collaborative effort across organisational boundaries at an airport level.

In terms of the scale of airport related emissions, this report, therefore, considers a comparatively minor proportion of total emissions, with the following exclusions:

- Aircraft operation
- Landside surface access
- Investment costs of infrastructure for sustainable aviation fuels (SAF) and deployment of hydrogen at a scale, which are both airport specific and still subject to considerable cost uncertainty.

Based on the analysis undertaken, this report consists of three principal components and outputs including:

- A high-level abatement model in the form of a marginal abatement cost curve (MACC) which has been built as an analytical tool to support the analysis, identifying the economic costs and priorities of abatement, based on the volume of air traffic movements (ATMs).
- A granular emissions reduction pathway involving organisational, policy and specific technology implementation at a corporate or airport level, which is complementary to the roadmap set out in the Jet Zero strategy. This focuses on actions and mitigations which are not dependent on technology maturity, are immediately available and can be regarded as the

[1] Mott MacDonald for Connected Places Catapult and Department for Transport, *Feasibility of Zero Emissions Airport Operations in England by 2040* (April 2022), https://cp.catapult.org.uk/report/feasibility-of-zero-emissions-airport-operations-in-england-by-2040, accessed 7 November 2023

foundation requirements or precursors to large-scale technology enabled investment in mitigation.

- A set of high-level policy recommendations that need to be addressed by government and the English airports as part of any proposals to develop a 2040 zero emissions target.

Summary outcomes and conclusions

From the work undertaken, the team arrived at the following conclusions. Further information is contained in the main body of this report.

1. Due to the need to use publicly available information, the team encountered some challenges in accessing detailed cost and emissions data at an airport level to inform the archetype-based analysis.
2. The application of the MACC approach has highlighted potential deficiencies in the current collection and analysis of emissions cost/investment data at an airport level. While considerable effort is clearly expended in assessing and reporting the quantum of greenhouse gas emissions for scope reporting, this is not necessarily undertaken on a consistent basis. The extent to which carbon pricing is considered as part of investment decisions at an airport or system level is not clear.
3. While the broad conclusions from the MACC modelling must be considered indicative or illustrative of the approach due to data limitations, they suggest the following: the costs of emissions mitigation will reduce over time; emissions abatement costs for the main on-ground airport activities and infrastructure are low compared with the current UK Emissions Trading Scheme (UK ETS)[2] carbon price (£83.03/tCO_2e); and more than half of the potential zero emissions target could be done at close to zero cost, meaning the investments would pay for themselves without any carbon credit. However, almost half of the emissions would require some carbon credit (subsidy) to be viable. This subsidy would fall over time, with the analysis here showing that all the emissions could, in principle, be implemented at less than £9/tCO_2e in 2040, compared with £15/tCO_2 in 2019. In practice, there is likely to be a small tail of difficult-to-decarbonise activities, where the marginal abatement costs may even exceed the UK ETS price.
4. While the marginal abatement costs of carbon are low, it is worth noting that almost all these costs will only be accessed as part of a huge asset replacement programme (of vehicles, mobile plant and equipment, and buildings and infrastructure) which will require expenditures in the hundreds of millions.
5. The work undertaken points to electrification as being the most immediate route to emissions reduction. This is based on the transfer to zero carbon energy supply from the national grid and investment in solar arrays, with some airports investing to become independent energy hubs.
6. While the MACC analysis addresses the emissions reduction impacts, it is not by itself the sole investment criteria. This is due to the fact that a low MACC for a specific investment can be economically rational. In practice, airport owners, operators and investors face a broader set of commercial imperatives – from statutory compliance and the management of capacity to operational efficiency and passenger experience – all competing for scarce capital.
7. The complementary pathway that the team produced points to the immediate availability of policy, organisational and technology mitigations at a corporate or airport level. This does not depend on uncertain technology maturity and forms part of foundational steps in emissions mitigation, paralleling the stepped approach embodied in the Airports Council International (ACI) Airport Carbon Accreditation programme.
8. Five policy recommendations have been identified relating to:

[2] Department for Business, Energy & Industrial Strategy/Department for Energy Security & Net Zero, 'UK ETS: Carbon Prices for Use in Civil Penalties, 2023' (updated 29 November 2022), https://www.gov.uk/government/publications/determinations-of-the-uk-ets-carbon-price/uk-ets-carbon-prices-for-use-in-civil-penalties-2023, accessed 7 November 2023

- Consistent emissions information and integrated (whole airport) emissions reporting
- Clarity on the zero emissions label and residual emissions
- Maintaining a level playing field and avoidance of market distortion
- Incentivisation of system-wide emissions mitigation
- Avoidance of additional complexity and administrative burden in emissions monitoring, validation and accreditation

1 Introduction

1.1 Background

In 2019, the UK became the first major economy in the world to legislate for a binding target to reach net zero emissions by 2050. The development of the Jet Zero strategy highlighted that there needed to be further evidence for the feasibility of a zero emissions target for English airport operations. This would include identifying the systems and infrastructure contributing to airport emissions and providing a high-level assessment of technology readiness.

Mott MacDonald was commissioned to undertake initial evidence gathering on feasibility, delivering a report in April 2022.[3] This concluded that, while uncertainties remained about the development and application of some specific technologies, on the basis of current progress it was reasonable to assume that by 2040 most technological obstacles would be overcome.

The report concluded that the most significant obstacle to achieving a 2040 zero emissions target would be the commercial financing. For many airports, the costs of the zero emissions target may not be justified or financeable within a 2040 timescale without supportive policy interventions, potentially involving both positive and negative incentives.

1.2 Focus and scope of this report

This report builds on the previous infrastructure and technology readiness assessment undertaken in 2022 and seeks to:

- Assess the commercial feasibility of reaching zero emissions from English airports by 2040 by establishing order-of-magnitude costs for a range of airports of different sizes and types.
- Develop a high-level financial model that will allow airports in England to assess their own order-of-magnitude costs.
- Develop a roadmap of technology implementation to 2040 as a guide to the timing of investment.
- Provide recommendations to incentivise, support and accelerate investment in initiatives for reducing and eliminating emissions on the path to achieving the target.

Given the different operational settings of English airports, each with different investment priorities, this report is based on four representative airport archetypes defined by size or by operational nature. They include a large, medium and small airport, alongside a general/business aviation airfield. These archetype labels provide a simplified basis for structuring the feasibility assessment and modelling.

The analysis carried out is focused on an airport's own operations and related airside ground operations, including scope 1 and 2 emissions. It includes airside vehicles and ground power provisions, regardless of the operator, as they can fall into the scope 1 or scope 3 categories depending on the operating model at a specific airport. It excludes activities that are related to the flying of aircraft.

The terminal building is considered in its entirety, regardless of the 'airside' scope and the inner airside terminal dividing line. Surface access is excluded from this analysis as the locational setting of individual airports and the transport systems supporting them vary widely and, therefore, cannot be reduced to an archetype.

In considering the split between scope 1 and scope 3 for airside operations, it is necessary to understand the roles of the different parties, for example:

[3] Mott MacDonald, *Feasibility of Zero Emissions Airport Operations in England by 2040* (April 2022)

- Ground handling operations (for example, baggage and cargo handling, and aircraft ground servicing) are mostly undertaken by third party handling agents, contracted by the airlines. In some instances, airlines undertake some or all of the operations in house – particularly at airports where an individual airline has a significant share of overall traffic. In other cases (usually smaller airports), the ground handling services may be provided by the airports themselves. Multiple business models may exist within an individual airport resulting in differences in scope boundaries between operators and airports. The 2022 study by PA Consulting[4] for the DfT provides further detail of the current ground handling market.
- Vehicles and equipment for ground handling are typically owned/leased by the individual ground handler, although there may be potential for pooled equipment. Energy supplies for ground handling (power/fuel) are often provided by the airport on a commercial basis.
- Energy for aircraft while parked on the ground may be provided either by the aircraft Auxiliary Ground Power Unit (APU) or from equipment provided on the ground. This could include both electrical ground power (400Hz) and pre-conditioned air (PCA). Electrical ground power and pre-conditioned air could be provided either from fixed infrastructure owned by the airport or mobile plant.

This division of roles has an impact both in the measurement and reporting of current emissions and in the introduction of measures to decarbonise, for example:

- The capital investment needed to achieve emissions reduction is not necessarily provided by the party that directly realises the economic and carbon benefits (for example, installation of electrical ground power by airport operator resulting in reduced fuel burn by aircraft operator).
- The airports are not wholly in control of the operations undertaken within and around their sites (for example, in timing/choice of equipment replacement for ground handling).

Many of the interventions to achieve the net zero objective may, therefore, require joint action across the ecosystem – for example, in agreeing charging models to recoup capital investment.

The sections which follow address:

- **Technology costs and abatement potential**

  The technologies examined here are a subset of those referred to in a previous Mott MacDonald report on the initial evidence gathering on feasibility in April 2022.[5] It focused primarily on airside vehicles and some building systems and infrastructure costs. The scope of the study specifically excluded emissions related to the operation of aircraft and landside surface access. Hence, costs of the infrastructure to support sustainable aviation fuels and hydrogen are not addressed.

- **The MACC model – overview and findings**

  This describes the application of the marginal abatement cost curve (MACC) approach that has been used to provide an illustrative assessment of the financial cost of offsetting or reducing a tonne of CO_2e. This includes a high-level explanation of the MACC approach, assumptions and the practical limitations which were encountered in securing sufficient detailed investment costs and quantified emissions mitigation data.

- **A complementary foundational pathway or roadmap**

  This sets out a number of policy, organisational and technology initiatives or investments. These, in comparison to the Jet Zero roadmap, are more granular in nature and rely less on technology maturity, making them quick wins.

[4] *Department for Transport, Support Study for the Department for Transport's Review of UK Ground Handling*

[5] Mott MacDonald, *Feasibility of Zero Emissions Airport Operations in England by 2040* (April 2022), pp9-10 (table 1.2: Technology status summary), pp16-17 (table 3.3: Emissions sources included)

The actions included are regarded as precursors to the higher-level initiatives found in the Jet Zero roadmap and are the foundations of any detailed emissions mitigations plan at an airport level. This includes reference to the stepped approach in the Airports Council International (ACI) carbon accreditation programme, which is currently accepted internationally as the most comprehensive and validated stepped pathway for decarbonisation and emissions mitigation.

- **Conclusions and recommendations**

  This summarises the conclusions arising from the work undertaken, the MACC modelling and the development of the complementary pathway and presents five policy and industry engagement recommendations.

Additional supporting information

The following supporting information is contained in six appendices:

1. Carbon terminology – key terms and acronyms
2. Emissions scope and reporting
3. Air traffic data and forecasts
4. ACI carbon accreditation and the status of English airports
5. Airport reported emissions data
6. Relevant literature references

1.3 Status of this report

Mott MacDonald has prepared this report on behalf of the UK Department for Transport (DfT). It forms part of the evidence base that will facilitate the discussions around a 2040 zero emissions policy for English airports. The report findings and conclusions are those of Mott MacDonald and do not represent the views of DfT or prejudge the outcome of any forthcoming consultation process.

It is important to understand the limitations of this work in terms of approach and access to reliable, publicly available data. Mott MacDonald has not had access to the detailed commercial information of individual airports; figures and analysis contained in this report are, therefore, illustrative and do not represent their actual financial position or investment intentions.

This reflects that most English airports are currently in the stage of identifying and reporting emissions. They are gathering emissions data for environmental reporting while grappling with the uncertainties of present and future technologies for mitigation. Financial costs and the specific technology mix to be implemented remain uncertain, affecting the confidence that can be placed on the MACC outputs.

Some investments are obvious and are being made with investment commitment, such as replacing diesel fuelled airside vehicles with electric alternatives and developing large-scale solar photovoltaic arrays. However, these are the exceptions, and few airports are at a stage where they have, or can quantify with reasonable certainty, the full expected costs of transitioning to zero emissions.

This is compounded by questions surrounding exogenous factors outside an airport's boundary. The most obvious being the production, supply and delivery of sustainable fuel, the feedstock that will be used to produce it and the increase in national grid capacity that would be required to meet significant increases in electrical demand arising from the rapid-charging requirements of new generations of electrical and hybrid aircrafts.

The above limitations all point to the need for the work undertaken here to be replicated at an airport level, with access to detailed information on costs and investment intentions or scenarios and the resulting emissions abatement outcomes.

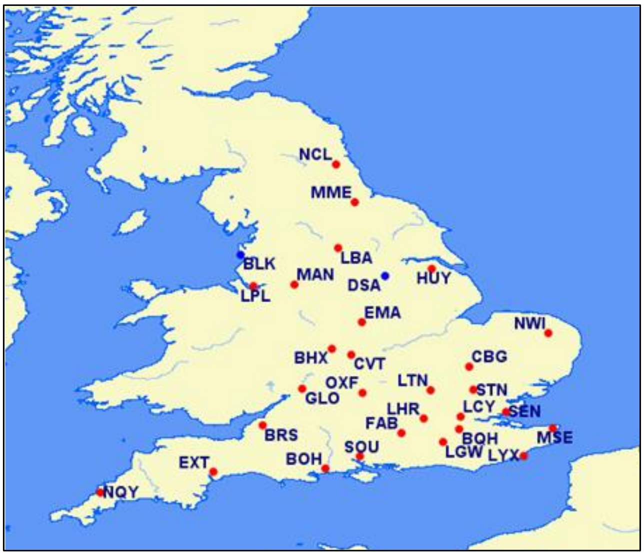
2 The English airport system and archetype groupings

This section describes the current system of principal airports in England and the four representative airport archetypes, based on historical and expected traffic volumes in the period to 2040, in addition to Air Traffic Movements (ATMs). These archetypes are then used in the cost and emissions modelling set out in sections 3 and 4 of this report.

2.1 The English airport network

The map below shows the location of the principal UK airports reporting volume and performance statistics to the UK Civil Aviation Authority.

Figure 2-1: English reporting airports



Note: Includes airports that recently closed for scheduled passenger services, such as Blackpool and Doncaster

For the purposes of this study, the English the team grouped the airports into four archetypes. The first three are defined by the scale of scheduled commercial passenger operations and the fourth captures general and business aviation operations on freestanding airfields.

Large: airports handling 25M passengers or more during 2019 (pre-pandemic).

Medium: airports handling between 5M and 25M passengers during 2019 (pre-pandemic).

Small: airports handling fewer than 5M passengers during 2019 (pre-pandemic).

General/business aviation: freestanding airfields handing regular volumes of business aviation and general aviation operations.

These archetypes are broadly representative of the following airports:

Large: London Heathrow, London Gatwick, Manchester

Medium: Birmingham, Bristol, London Luton

Small: East Midlands, Exeter, Teesside

General/business aviation: Biggin Hill

It is important that the term 'representative' is understood. They are representative in terms of a single dimension – overall ATM traffic volumes. This has been done for analytical management, due to the arm's length archetype requirement in the commissioning of this report. Additionally, the team did not have access to detailed internal costs, emissions or investment criteria data for individual airports.

As summarised below, there is a considerable range of volumes based on air traffic movements (ATMs) from 2019 (the year chosen as a pre-Covid baseline). For example, within the 'large' archetype, there is considerable range (based on CAA Annual Airport Data):

London Heathrow [478k], London Gatwick [285k], Manchester [203k]

The same holds true for 2019 commercial passenger volumes per annum which exhibit an even greater degree of spread:

London Heathrow [80.8M], London Gatwick [46.6M], Manchester [29.4M]

The same ranging holds true for the other archetype groupings.

Forecast ATM and passenger volumes

Since the report focuses on achieving the 2040 zero emissions target, the team used updated annual passenger traffic and ATM numbers provided by DfT for modelling purposes. These are based on pre-Covid volumes, which have been partially updated as part of the development of the Jet Zero strategy. This update was undertaken at a national level to generate UK totals rather than as specific allocations among airports.

There are, however, limitations in the use of any forecast. The updated numbers are unconstrained and do not incorporate any assumed demand reduction measures or limitation on the capacity at individual airports. As a result, the forecast volumes for specific airports will not necessarily match the forecasts prepared by individual airports. They do, however, provide a better reference point than DfT's pre-pandemic 2017 forecast.

A summary of the traffic context and forecast volumes used in the MACC modelling is included in the appendices.

3 MACC modelling approach and key assumptions

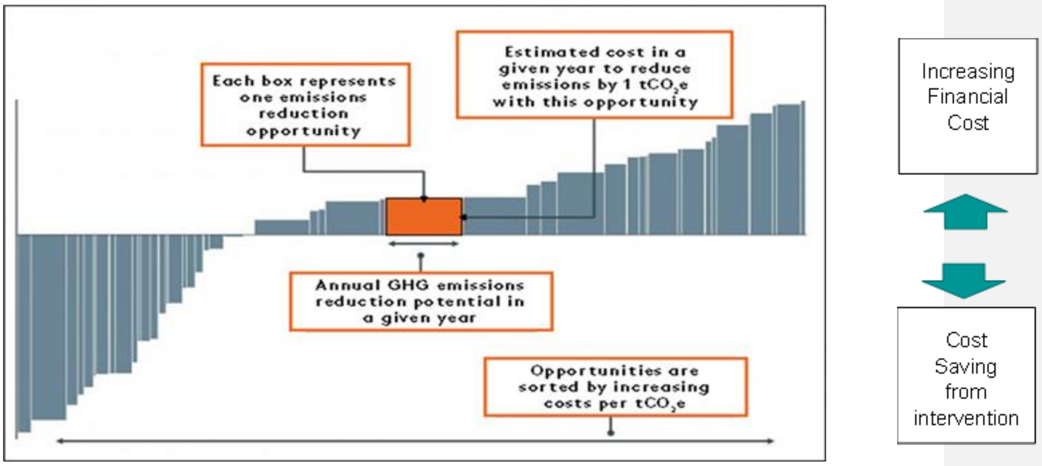
This section describes the modelling approach and key assumptions in assessing the carbon abatement costs and potential in the airports sector. Given its nature as an arm's length exercise, precise financial, operational, asset and accounting data were unavailable. This was either due to commercial confidentiality or because most airports have yet to quantify in sufficient detail their current CO_2 emissions or the interventions needed to achieve the 2040 zero emissions target in a sharable format.

As a result, the team created a high-level model that provides a formal framework to estimate the tonnage of carbon saving from pursuing different measures and the associated costs. These costs are expressed as levelised costs, in what is called a marginal abatement cost curve (MACC). The model generates MACCs for the four airport archetypes for five different snapshot years from 2019 to 2040. The results are discussed in the next chapter.

3.1 Marginal abatement cost curves

MACCs are an accepted technique used to illustrate carbon abatement costs, providing guidance on the costs and benefits of operational and investment interventions to reduce greenhouse gas emissions. These are typically represented as the cost per tonne of carbon dioxide equivalent (£/tCO_2e). They usually appear in the following form, shown in Figure 3-1 below, at different levels of granularity, where the x-axis shows the cumulative abated volumes of CO_2 and the y-axis the cost per tonne of abated carbon. Bars above the horizontal line indicate that there is a cost to that action in financial terms – the higher the bar, the higher the cost. Those below the line indicate a saving from that action – the lower the bar, the greater the saving. Traditionally, the width of a bar indicates the emissions saving.

Figure 3-1: Generic illustration of MACC outputs



Source: Climate Works Centre, Australia[6]

Provided the conceptual limitations are understood, MACCs remain a useful approach to identifying the cost, scale and prioritisation of emissions reduction interventions.

3.2 Key assumptions used in the MACC modelling

In developing the model, the team had to work within the following limitations, using a number of high-level assumptions based on experience, reasonableness and, where possible, information drawn from public sources. These include, but are not limited to:

1. **Forecast demand** – Mott MacDonald was not commissioned to develop an independent forecast of future passenger and ATM demand for the English airports. For consistency, the team relied on datasets taken from the partially updated post-Covid forecast assessments prepared by the DfT and published as part of the July 2022 Jet Zero strategy development process. These are partial updates, which recognise changes in economic activity (GDP) but have not updated the full range of variables included in DfT's sophisticated aviation demand model. In particular, the DfT update was focused on deriving UK volume totals for the strategy development process and did not address the allocation of those totals among specific airports to the same level of detail and assurance involved in a full update of the DfT traffic model. Recognising this limitation, the team judged it was better to use the partially updated DfT forecast figures rather than rely on a 2017 forecast that took no account of the severe aviation market disruption associated with the Covid pandemic.
2. **No deliberate demand suppression** – the volume drivers of the model do not take account of any potential future government policies or mandated compliance that would limit future passenger and ATM growth to 2040.
3. **Operational capacity constraints** – potentially, a subset of demand suppression. To examine the full effect on emissions costs, the model is unconstrained by capacity and assumes that, where demanded, airport capacity will be provided.
4. **Four airport archetypes** – as required by Mott MacDonald's commission, the model is based on four airport archetypes – large, medium and small airports serving scheduled commercial passenger operations and freestanding general/business aviation airfields.
5. **Volume ranges** – the volume ranges of each archetype (in terms of passengers and ATMs) are significant. The team used published traffic data from the English airports to notionally allocate airports to the archetypes. This allowed the team to derive high, low and average figures for each archetype for modelling purposes.
6. **Key volume drivers** – the team used traditional volume drivers of commercial passenger volumes and ATMs, along with high-level assumptions relating to variables such as airside vehicle requirements and use.
7. **Basic vehicles versus buildings and infrastructure split** – in common with the split found in much airport emissions reporting, the model considers the two main emissions contributors: vehicles; and buildings and infrastructure. However, in this analysis, the team also included emissions from fossil fuel fired auxiliary power generation for aircraft when on the ground.
8. **Scope exclusions** – the scope covers airside airport operations of the airport operator and third parties (airlines and aircraft operators). This includes all vehicles and equipment that service aircraft in their normal operations, but it excludes more major maintenance and repair operations (MROs) carried out in hangars. Emissions from fossil fuel fired auxiliary power generation for aircraft when on the ground are also included.

[6] Diagram taken from Climate Works Centre, Melbourne, Australia and amended; *https://www.climateworkscentre.org/resource/how-to-read-a-marginal-abatement-cost-curve*

9. **An economics approach** – as this work looks at archetypes (without access to detailed financial and accounting information), the team has adopted an economics approach. For example, it has not attempted to model the unexpended and undepreciated life and value of existing long-life assets. In economic and investment terms, these have been assumed to be sunk costs and not relevant to future investment costs.
10. **Fuel conversions and emission factors** – these have been taken from official government sources as far as possible.
11. **Five-year outputs** – the high-level nature of the exercise does not support the reporting of annual data, so modelling outputs are given at five-year intervals to 2040.
12. **Pathway to 2040** – while recognising the uncertainties surrounding the introduction of emissions mitigation technology, the team assumes that the currently published pathway to zero emissions for English airports by 2040 remains a reasonable set of specific objectives, milestones and realisable ambition.

3.3 The model building blocks

Given the limitations of data availability, the team applied a simplified MACC approach based on a set of 25 interventions. These target reducing emissions from vehicles, mobile equipment, buildings and infrastructure, as well as from auxiliary power generation for aircraft while on the ground. All interventions are assumed to be non-duplicative. This means that the team has selected the best (least cost) abatement option for each activity, for instance either electric or hydrogen fuel vehicles depending on the use case.

Key inputs on the cost side are capital costs, operational costs and energy costs. The team used a simple annuitised cost calculation to convert capital expenditure (capex) into an annualised capital charge which is incurred over the asset lifetime.

In a few cases, the team had to add on the ongoing fixed operational cost (opex) of a new option, although this was not considered when the fixed operational costs of the new and displaced options are broadly the same. For instance, the repair and maintenance costs of diesel and electric vehicles are similar, so these costs effectively netted off.

However, the team has included the energy costs of running the new options. Summing the capital charge, the energy costs and any fixed operational costs provides a total levelised cost of the intervention. Dividing this by the CO_2 emissions saved provides the levelised costs per tonne of CO_2e saved.

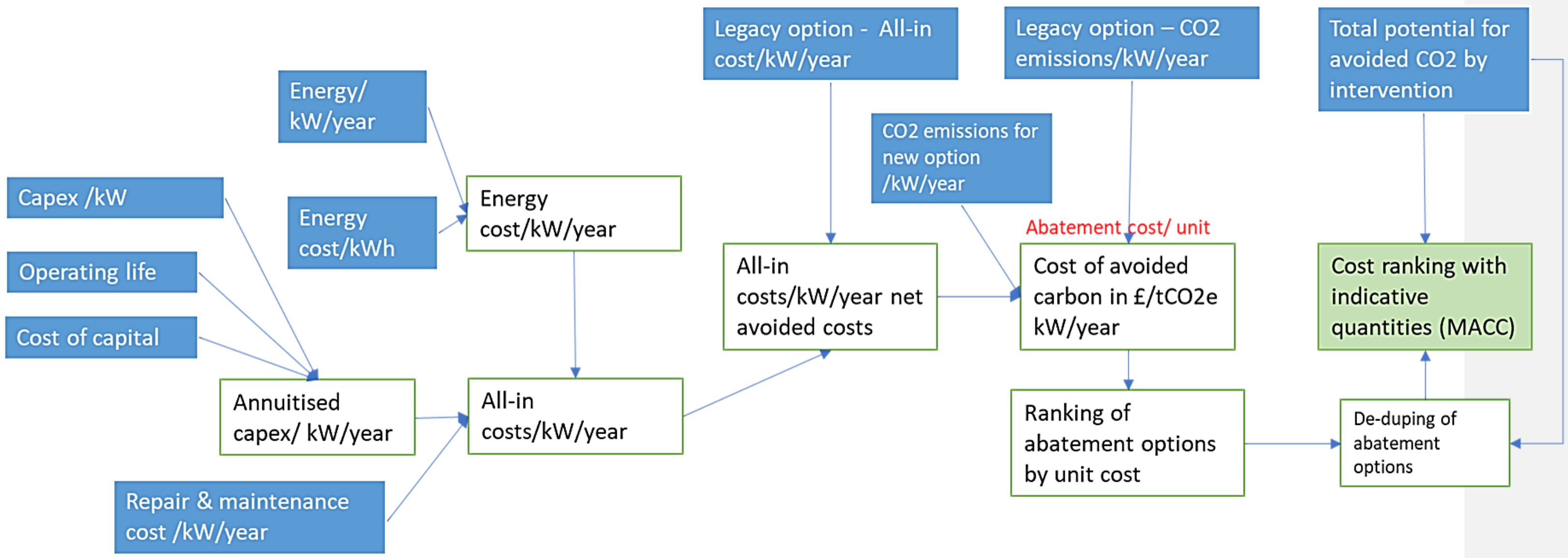
The team then factored in the avoided fuel or energy costs from the displaced option savings to provide a net all-in cost per tCO_2e. The levelised cost estimates do not include any residual value benefits (or costs) for non-life expired displaced assets (for instance, diesel HGVs).

Arranging the levelised costs from low to high provides a cost hierarchy of interventions which, when combined with the appropriate cumulative tonnage of emissions avoided, produces the MACC for carbon.

The model provides the option to include carbon prices, which are applied to the avoided carbon quantities. It has been assumed that the electricity used for the interventions is zero carbon, which implies that the airports will be buying renewable electricity or using their own onsite or nearsite renewable generation. Note that from the early 2030s the carbon intensity of the GB grid will be very low, and potentially zero from 2035.

Figure 3-2 provides an overview of the MACC model logic showing how the key inputs feed through to build up the MACC, with Figure 3-3 summarising the main inputs and outputs in the model.

Figure 3-2: MACC model logic



Source: Mott MacDonald

Figure 3-3: Main model inputs and outputs

Inputs	Outputs
Abatement options	
Specific capex in £/vehicle or kW for each of 25 options	Total annuitised cost per emission abatement activity for each option: £k
Life of asset (years)	Net costs of emissions abatement activity once differential in opex and fuel is considered: £k
Fixed opex (operations, repair and maintenance): £/kW (or vehicle)/yr (or % of initial capex)	Net abatement cost per tonne for each abatement option: £/tCO2e
Variable opex (non-energy): £/kW/yr	Annual emissions abated for each abatement option applied: ktCO2e
Energy use per year/kW (or vehicle) Energy price (delivered): £/MWh	MACC generated from two prior outputs
CO2 emissions per MWh (normally zero)	
Carbon producing activities	
Total level of emissions by activity: kt/yr Fixed opex: £/kW (or vehicle)/yr Energy use per year/kW (or vehicle)	
Energy price (delivered): £/MWh	
CO2 emissions per MWh (Emission factors) General	
General	
Cost reduction through time by key activities differentiated by option type (vehicles, buildings and infrastructure and auxiliary power)	
Cost reduction through time by key activities	
Discount rate (real and pre-tax), used to annuitise capex	
Carbon price: £/tCO2e	

Source: Mott MacDonald

Data constraints

The lack of data on baseline CO_2 emissions by category for each airport has meant that the team has not been able to differentiate between the airport types, except through applying a scale based on airport traffic. This points to the need for airports individually or collectively to develop additional refinements making use of detailed, airport-specific data.

3.4 Base level of emissions

As it has not been possible to get a consistent set of data on existing CO_2 emissions by activity across different airport sizes, the modelling has used a snapshot of publicly available information for 2019 for Heathrow Airport as a baseline, since this was the most quantified breakdown available.

For the purpose of this exercise, the data for Heathrow has been scaled for smaller airports based on air traffic volumes. This approach has been adopted to provide an indicative or order of magnitude assessment of the baseline emissions for each airport category with a high-level three-way split between vehicles, buildings and infrastructure and auxiliary power. It is not intended to provide a quantitative assessment of the specific emissions reductions that could be achieved or the economic case for possible interventions at individual airports.

The limitations of this simple scaling approach are understood – recognising that:

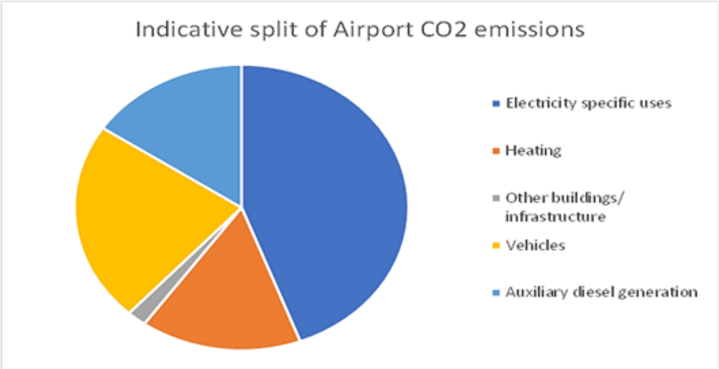
- While many elements of energy demand and carbon emissions will be proportional to traffic volume, others will be more closely correlated to other airport parameters (eg number of runways, number of terminals, traffic mix)
- The split of scope 1/2/3 emissions will vary between airports dependent on the operating model, as noted previously
- There will also be variability in current emissions between airports associated with the age and condition of existing assets, reflecting stage of capital cycle, which is not necessarily representative of the long term position

The Heathrow emissions were split between vehicles, at just over 36ktCO_2e, and buildings and infrastructure at 99ktCO_2e. A quarter of the buildings and infrastructure emissions were from gas heating, with almost all the balance accounted for by electricity use. Other sources (including fluorine-based gases used as refrigerants – often called F gases) accounted for just 3ktCO_2.

No number was available for emissions from auxiliary power generation to serve aircraft on the ground, so the team used a ratio between emissions from auxiliary diesel generation and airport vehicles (42%) for a US airport, to estimate emissions for auxiliary diesel power generation (from ITW GSE's 'Go Green on Ground – A Better Environment at Your Airport'[7]). This gives a figure for Heathrow of 25ktCO_2 for auxiliary power generation. Figure 3-4 shows the breakdown of emissions, including this number. The main features to note are that electric-specific uses account for over 40% of total emissions, with heating, vehicles and auxiliary power generation accounting for roughly equal slices of around 20% each.

[7] ITW GSE, 'Go Green on Ground – A Better Environment at Your Airport', https://itwgse.com/go-green-on-ground/, accessed 10 November 2023

Figure 3-4: Indicative split of airports' ground-based CO_2 emissions in 2019



Source: Mott MacDonald estimate

3.5 Defining the abatement interventions

The MACC model allows for 25 interventions: 18 in the vehicles and mobile equipment category; six for buildings and infrastructure; and one for auxiliary power supplies for aircraft on the ground. These interventions map very closely to those identified in the previous technology feasibility study carried out by Mott MacDonald.[8] The main vehicle and mobile equipment items relate to airside vehicles as shown in Figure 3-5 to Figure 3-9. Note: the pictures show diesel or gasoline fired equipment rather than the electric or hydrogen fuel cell equivalent.

[8] Mott MacDonald, *Feasibility of Zero Emissions Airport Operations in England by 2040* (April 2022), pp16-17 (table 5.3)

Figure 3-5: Small general airside vehicles (4x4s)

Includes airfield operations vehicles, transit vans that may be used airside (for example, for transporting cabin crew to or from their aircraft), security airside vehicles

Source: Mott MacDonald

Figure 3-6: Small specialised airside vehicles

Includes baggage tugs, portable power units, bag loaders (for loose bags), snow tractors

Source: Mott MacDonald

Figure 3-7: Medium specialised airside vehicles

Includes fire trucks, catering trucks, hydrant fuel dispenser trucks, unit load devices (ULDs), aircraft towbar trucks

Source: Mott MacDonald

Figure 3-8: Large specialised airside vehicles

Includes passenger buses, de-icing rigs, snow ploughs, cargo loaders

Source: Mott MacDonald

Figure 3-9: Heavy airside vehicles

Includes refuelling tankers, aircraft recovery vehicles

Source: Mott MacDonald

In addition, in agreement with DfT, the team has added auxiliary power generation for aircraft while on the ground, which is used for air conditioning and plug power. This is often referred to as a pre-conditioned air (PCA) unit.

All of the interventions, bar two, are electrified options. The two exceptions are hydrogen fuel cell vehicles (HFCV) for heavy lifting or hauling applications.

In summary, the interventions included are:

- The introduction of electric vehicles, ranging from airline service cars and emergency vehicles to aircraft tugs and mobile stairs to specialised airside vehicles, examples of which appear in figure 3-5. These are split into light vehicles and heavy vehicles, most of which are likely to be electrified, although the heaviest duty vehicles are assumed to use hydrogen fuel cell drives.
- For buildings and infrastructure dominated by space heating, the study assumes the application of various electric heat pump options, with the legacy system assumed to be gas fired central heating.
- Elsewhere in the buildings and infrastructure category, the applications are new electrical equipment and control systems, which include:
    - Systems for moving people and baggage (escalators, lifts, belts and conveyors)
    - Lighting, communications, electronics and security
    - Retail, hotels and catering
    - Miscellaneous
- With regard to diesel generators providing auxiliary power for aircraft on the ground, it has been assumed that this will transition to electrification delivered by mobile battery packs or cabled power supply via passenger boarding bridges, where they exist.

In developing the MACC, the team has assumed that there are no constraints on the deployment of the interventions and no associated costs with upgrading infrastructure. Most of the interventions involve electrification of prior fossil fuel uses which would substantially increase electricity demand at the airport and, accordingly, its electrical connection capacity. This could be partially offset by onsite or nearsite (over-the-fence) generation which, in turn, would typically require some works in the airport's electrical network.

Notwithstanding such onsite development, the electrification of on-ground vehicles and heating would typically add substantially to the airport's peak electrical load. Accommodating increased peak demand is not always straightforward and may be subject to consent issues which can result in delays and also often significant additional connection charges.

3.6 Costs of interventions

Table 3-1: Indicative capital costs and emissions abatement intervention options in 2019 summarises the initial capital cost estimates for all 25 interventions considered in the model, starting with vehicles and then considering buildings and infrastructure and, lastly, auxiliary power. The capital costs are expressed in £k per unit, where the unit is vehicle or MW of electrical capacity. The prices are delivered (or installed) prices.

This shows very considerable variation in specific capex between vehicle type and also within the buildings and infrastructure items. The team also included the annual emissions abatement in tonnes of CO_2 per year per vehicle or MW of rated capacity, depending on the intervention type. While there is, again, significant variation between buildings and infrastructure options, there is practically none within the vehicle sector. The latter may reflect the lack of granularity on the emissions and fuel data for vehicles.

Table 3-1: Indicative capital costs and emissions abatement intervention options in 2019

Asset/intervention	Category	£k	Unit	Emissions abatement: tCO_2e/yr
Baggage tugs	Electric vehicle	199	per vehicle	6.58
Baggage loaders	Electric vehicle	305	per vehicle	6.58
Cargo handling	Electric vehicle	305	per vehicle	6.58
Catering trucks	Electric vehicle	288	per vehicle	6.58
Refuelling trucks	Electric vehicle	492	per vehicle	6.58
Aircraft tugs	Electric vehicle	149	per vehicle	6.58
Aircraft service (bowser, water, cleaning staff, materials/waste)	Electric vehicle	288	per vehicle	6.58
Aircraft de-icing	Electric vehicle	492	per vehicle	6.58
Mobile stairs	Electric vehicle	288	per vehicle	6.58
Buses	Electric vehicle	776	per vehicle	6.58
Crew transport	Electric vehicle	78	per vehicle	6.58
Operational cars	Electric vehicle	45	per vehicle	6.31
Other third party vehicles (logistics, maintenance, construction)	Electric vehicle	78	per vehicle	6.58
Fire tenders	Electric vehicle	776	per vehicle	6.58
Airport de-icing/snow	Electric vehicle	288	per vehicle	6.58
Cars (ops/company)	Electric vehicle	45	per vehicle	6.31
Cargo handling HFCV	Hydrogen fuel cell vehicle	308	per vehicle	6.58
Aircraft de-icing HFCV	Hydrogen fuel cell vehicle	308	per vehicle	6.58
Electric heat pumps	Buildings/infrastructure	2000	per MW capacity	1660
Cooling and ventilation	Buildings/infrastructure	150	per MW capacity	300
Baggage/people movement	Buildings/infrastructure	250	per MW capacity	530
Lighting, comms, electronics and security	Buildings/infrastructure	500	per MW capacity	530
Retail, hotels and catering	Buildings/infrastructure	1000	per MW capacity	530
Miscellaneous	Buildings/infrastructure	500	per MW capacity	530
Battery auxiliary power for aircraft	Auxiliary power for aircraft on ground	4100	per MW capacity	1190

Source: Mott MacDonald estimates

Below are some comments on costs for the main intervention groups.

Vehicles and mobile equipment

For most diesel and gasoline fuelled airport vehicles, there is now an electric or hydrogen fuelled equivalent available or expected to be available in the next five years. Capital costs are much higher than for the diesel or gasoline vehicles, reflecting the current high cost of battery packs and fuel cells. The cost estimates shown are based on discussion with supply chain providers for light vehicles and HGVs. These are current supply costs, and the expectation is that costs would fall significantly over the next decade as battery and fuel cell costs fall, as such technologies are more widely deployed.

Heating

Electric heat pumps of some kind (air source, ground source or augmented with district heating systems) are the most likely decarbonisation option for space and water heating. Other potential options, such as biomass or hydrogen boilers or nuclear, geothermal or active solar derived distributed heat, have been ruled out on grounds of cost, air quality issues or lack of technology maturity. While electric heat pumps are the obvious candidate, there remains considerable uncertainty about heat pump costs and performance. However, the team has assumed a capex of £2000/kW (input energy) and a coefficient of performance (COP) of 3.0 as a central/conservative case. Any additional costs for thermal upgrades of the buildings have not been included.

It is assumed the fixed opex for repair and maintenance is slightly higher for heat pumps than for gas central heating, and this is represented by applying an incremental opex equal to 1% of initial capex.

Other electric-specific building infrastructure interventions

The team has not found data for the various electric-specific interventions in the public domain, so estimates have been made on the basis that investments in control equipment and incremental costs of more efficient equipment made on normal replacement cycles are small in comparison to major investments such as heat pumps. However, the carbon savings will also be small and reduce over time as the CO_2 intensity of electricity declines.

Auxiliary power for on-ground aircraft

It is assumed that auxiliary power provided by on-ground auxiliary diesel generators or on-aircraft generators using diesel (or kerosene) is replaced by auxiliary mobile battery packs. The team took data from leading battery pack vendor, ITW GSE, using a 90kVa system (7400e GPU). The key assumptions are that it is rated at 90kW, runs for 5.5 hours a day and capex is £4100/kW, working back from a US$45,000 annual leasing fee for the 90kW unit and a conservative assumption of dollar/pound parity. The displaced fuel has been calculated on the ratio of the efficiency of the battery-based system and a diesel generator (90% and 45%).

3.7 Energy use assumptions

The energy consumption of electric and hydrogen vehicles has been calculated by scaling average fuel consumption. Since data on average fuel consumption by airport vehicles was not available, the team has calculated fuel use based on CO_2 emissions for Heathrow in 2019 and on Department for Energy Security & Net Zero (DESNZ) emission factors. These numbers were then divided by vehicle numbers to get fuel use (and emissions) per vehicle.

The team was able to differentiate between light and heavy vehicles because Heathrow provides a split in vehicle numbers between light and heavy and it also separates emissions by different vehicle categories. Using this data, the team estimated an average fuel use for light and heavy vehicles.

Interestingly, there is not a lot of difference between the average annual fuel use between heavy and light vehicles, which reflects the much higher mileage for the light vehicles offsetting the low mileage range per unit of input energy. There is a similar pattern for electric vehicles.

An illustration of the model relating to vehicles is given in Figure 3-10, showing the calculation of energy consumption by vehicle type.

Similar calculations were used to derive energy use per kW for the buildings and infrastructure interventions and the displaced assets, if readily available benchmarks were unavailable. The key numbers are shown in table 3-2.

Figure 3-10: Calculation of energy consumption by vehicle type – extract from MACC model

Diesel vehicle energy consumption

	% split of vehicles	Vehicle no.	ktCO2e/yr	t CO2e/ vehicle/yr	Emission factor: kgCO2/litre diesel	kilolitres/ vehicle/yr1	mpg	km/litre2	km/ vehicle/ yr	GJ3	MWh /vehicle/yr
Total		6300									
Cars/vans	60%	3780	22.2	5.9	2.68	2.6	35	12.4	32,034	98.1	27.2
Heavy	40%	2520	14.1	5.6	2.68	2.5	7	2.5	6,086	93.2	25.8

EV energy consumption

	km/vehicle/ yr	km range	Charges/ yr	kWh/ charge	kWh/yr	MWh/yr
Cars/vans	32,034	427	75	85	6,377	6.38
Heavy	6,086	277	22	324	7,123	7.12

Notes:
1 - assumes 0.85kg a litre
2 - assumes 2.82 km/litre to 1 mpg
3 - assumes 38 GJ in litre of diesel

Source: Mott MacDonald MACC calculations

Table 3-2: Energy use and displacement assumptions in the buildings and infrastructure interventions

Intervention	Annual utilisation factor: %	Energy use: MWh/yr per kW capacity	Efficiency scalar: intervention to legacy*	Energy displaced: MWh/yr
Heating (electric heat pumps)	30	2.63	3.5	9.20
Cooling and ventilation	17	1.50	2	3.00
Baggage/people movement	50	4.38	1.2	5.26
Lighting, comms, electronics and security	50	4.38	1.2	5.26
Retail, hotels and catering	50	4.38	1.2	5.26
Miscellaneous	50	4.38	1.2	5.26
Aircraft auxiliary power (when on ground)	25	2.20	2	4.40

*** For instance, 3.5 for heating is ratio of HP efficiency (300%) to gas boiler (85%)**

Source: Mott MacDonald estimates

3.8 Other assumptions

Emission factors

CO_2 emission factors for fossil fuels (diesel, gasoline and natural gas) assumed in this analysis are aligned with those from DESNZ. These are based on a global warming potential (GWP) of 100 years.

For electricity, it is assumed that the electricity used for the interventions is zero carbon, which implies that the airports will be buying renewable electricity or using their own onsite or nearsite renewable generation. Note: from the early 2030s, the carbon intensity of the GB grid will be very low and potentially zero from 2035.

Energy and fuel costs

Energy and fuel costs are assumed to be constant once the investment has been made. A central medium-term outlook has been taken for diesel, natural gas and electricity prices. An electricity price of £200/MWh, a gas price of £100/MWh and a diesel price of £168/MWh (£1.60/l) has been assumed. Low-carbon hydrogen is priced at £250/MWh.

Annuitisation of capex

Annuitised capital charges have been calculated using 5% real pre-tax cost of capital and an asset life of 10 years (except for heat pumps and air conditioning, where 15 years has been used).

Forward projections

To generate the MACCs for future dates, the team kept the same emissions breakdown split between activities and simply scaled by the projected growth in airport ATMs. The ATM projections differ by airport size category, with the cumulative growth between 2019 and 2040 ranging from 15% to 26% between small and large airports respectively, with the very large airport (Heathrow) seeing 55% growth.

The other main influencer is likely to be the capital costs of interventions, which will almost certainly see substantial reductions as technology improves and the supply chains mature. Here, it is assumed that capex costs across all the interventions will fall by 40% by 2040 in a broadly linear profile.

The same energy prices have been kept, as a mid-term price (post-energy crisis price) had already been assumed. All these variables can be flexed in the MACC model.

Carbon prices

The model has the facility to include carbon prices. However, for the base run it is assumed this is zero, since airports are not subject to the UK carbon prices for ground-based emissions, as none of them have combustion plant which exceeds the large combustion plant threshold.

The impact of adding a carbon price is simply to shift the MACC vertically downwards by the assumed carbon price. Given the low MACC values (see next chapter), it does not take a high carbon price to shift the MACC into negative values.

Some companies have adopted internal carbon prices in order to accelerate their decarbonisation efforts, but these tend to be less than the price in the UK ETS which, in early August 2023, was about £40/tCO_2e.

If HM Treasury's Green Book guidelines were applied, then this would include the social cost of carbon, which tends to be higher than the UK emissions allowance price. That would shift the MACC values into heavily negative territory.

4 The model results – the cost curves

This chapter presents the main findings of the MACC analysis. As previously noted, due to data limitations, the findings must be considered indicative, rather than values that translate into an ordered list of well-defined costs and benefits of abatement measures and their associated tonnages.

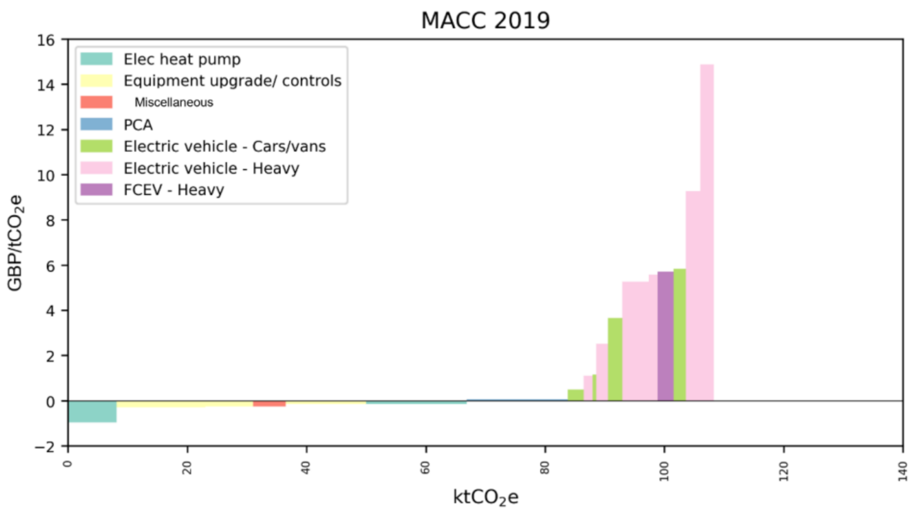
Figure 4-1 and Figure 4-2 show the MACCs for 2019 and 2040 for an average large airport. These show that all the emissions could, in principle, be implemented at less than £15/tCO_2 in 2019 and £9/tCO_2e in 2040. The curves are drawn with the same axis values so that the extent of shift through time is made clear.

These costs compare with the current UK carbon price (£40/tCO_2e) although, at present, this carbon price does not apply to the airports sector. In both cases, the charts show that more than two-thirds of the potential abatement volume could be done at close to zero cost, meaning that the investments would pay for themselves without any carbon credit.

Interventions in the buildings and infrastructure sector show the least cost, while electrification of vehicles shows a higher cost, with heavy vehicles tending to have a higher cost than light vehicles. Electrification of auxiliary power supplies for aircraft on the ground is also a low-cost option, which is consistent with the vendors of such equipment arguing that their technology provides a payback in just three years.

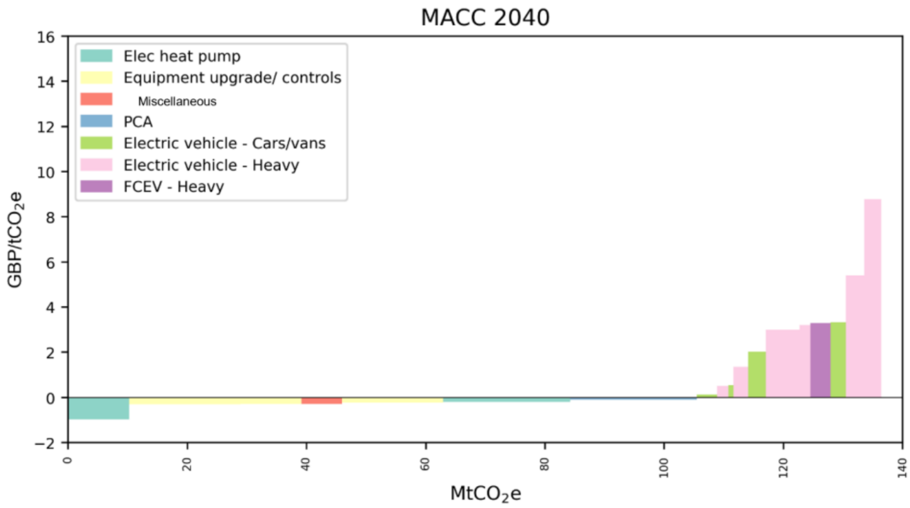
Going forward in time, despite the projected increase in ATMs, the MACC shifts downwards as a result of the projected decrease in specific capex for electrification and hydrogen options (40% between 2019 and 2040).

Figure 4-1: Indicative MACC for an average large airport in 2019



Source: Mott MacDonald calculations

Figure 4-2: Indicative MACC for an average large airport in 2040



Source: Mott MacDonald calculations

Table 4-1 provides the detailed values for the net abatement costs and tranche volumes underlying the 2019 MACC above. If the emissions saved numbers are multiplied by the cost per tonne figures, the result is a total annual cost for the 108ktCO_2e saved of £116,000 a year for the average large airport. This is equivalent to an average annual net cost of £1.07 per tonne of CO_2e abated.

Table 4-1: Marginal abatement costs for average large airport in 2019

Activity	Intervention	Use	Displaced emission s source	Emissions saved: kt/yr	£/t of CO_2
Cooling and ventilation	Electric heat pump	BNI	Electricity	8.1	-0.95
Baggage/people movement	Equipment upgrade/ controls	BNI	Electricity	14.9	-0.29
Lighting, comms, electronics and security	Equipment upgrade/ controls	BNI	Electricity	8.1	-0.24
Miscellaneous	Miscellaneous	BNI	Electricity	5.4	-0.24
Retail, hotels and catering	Equipment upgrade/ controls	BNI	Electricity	13.5	-0.14
Heating	Electric heat pump	BNI	Natural gas	16.9	-0.14
Aircraft auxiliary power (when on ground)	Battery power supply	Aircraft	Diesel	16.9	0.08
Ops cars	Electric vehicles	Cars/vans	Diesel	1.4	0.50
Cars (ops/company)	Electric vehicles	Cars/vans	Diesel	1.4	0.50

Other third party vehicles (logistics, maintenance, construction)	Electric vehicles	HGV	Diesel	1.5	1.12
Crew transport	Electric vehicles	Cars/vans	Diesel	0.7	1.17
Aircraft tugs	Electric vehicles	HGV	Diesel	2.0	2.52
Baggage tugs	Electric vehicles	Cars/vans	Diesel	2.4	3.67
Catering trucks	Electric vehicles	HGV	Diesel	1.0	5.26
Aircraft service (bowser, water, cleaning staff, materials/waste)	Electric vehicles	HGV	Diesel	1.7	5.26
Mobile stairs	Electric vehicles	HGV	Diesel	0.7	5.26
Airport de-icing/snow	Electric vehicles	HGV	Diesel	1.1	5.26
Cargo handling	Electric vehicles	HGV	Diesel	1.5	5.59
Cargo handling	Hydrogen fuel cell vehicles	HGV	Diesel	1.4	5.71
Aircraft de-icing	Hydrogen fuel cell vehicles	HGV	Diesel	1.4	5.71
Baggage loaders	Electric vehicles	Cars/vans	Diesel	2.0	5.84
Refuelling trucks	Electric vehicles	HGV	Diesel	1.4	9.28
Aircraft de-icing	Electric vehicles	HGV	Diesel	1.0	9.28
Buses	Electric vehicles	HGV	Diesel	1.4	14.87
Fire tenders	Electric vehicles	HGV	Diesel	0.9	14.87
			Total	**108.2**	

These low MACCs are consistent with findings elsewhere, which show that electrification of vehicles and heating, along with better controls on electrical equipment and systems, can be done at low cost. While the curve here shows a significant uptick in the costs as cumulative volumes increase, there is no high-cost tail with costs in excess of £50/tCO_2 as is often observed in other studies. This probably reflects the low granularity of this study, which may miss some difficult-to-decarbonise activities. These could include problematic F gases, which cannot readily be substituted, or process energy applications requiring natural gas firing, which cannot be electrified or easily replaced with hydrogen.

The MACC model can generate curves for each airport type and snapshot year, which makes 20 curves for each set of input assumptions. In this analysis, due to the data limitations, the MACCs for all the airport types are effectively the same – as the emissions volumes are simply scaled by ATM numbers, which stretches the curves along the x-axis. The curves are a similar shape in each year (2019, 2030 and 2040), except that the marginal costs of abatement are forecast to fall, compressing the y-axis, as the assumed cost reductions bring down the costs of each intervention through time. Given this outcome, it has been decided not to present all 20 of the curves.

Figure 4-3: MACCs for the four airport archetypes, 2019 compares the MACCs for the four airport types for 2019, while figures 4-4 to 4-7 show the evolution of the MACCs through time for different sizes of airports. In all of these charts, the MACCs are shown as a line, rather than as blocks as presented in figures 4-1 and 4-2. This is to make it easier to see the evolution of the shape of the MACCs through time.

Putting bespoke input data, including emissions baseline data, into the model for each airport type would lead to differentiated curves, as would making the intervention costs specific to individual airports. This should be the next stage of this analysis, once data is available.

It is important to remember that these MACCs are hypothetical constructs and that, in practice, the costs and benefits of implementing carbon abatement measures may be significantly different from depicted.

As mentioned previously, the MACCs are not constrained by connection constraints, which may exist in practice for some locations, in the near to medium-term, particularly to electrical connection capacity. Such constraints could become challenging, especially where electricity is also required for charging EVs of passengers and workers or to drive hydrogen supply infrastructure for aircraft (liquified H_2).

It is also worth noting that a low MACC (even a zero cost) for an option does not necessarily mean that it would be economically rational to pursue such a measure. In practice, owners face a broader set of commercial drivers with many competing investment options – including those required for compliance or to support core activity – as well as capital and management resource constraints on what they can pursue. This explains the persistence of short payback energy saving measures in the competitive industrial sector; a lesson that may be applicable to the airports sector.

Figure 4-3: MACCs for the four airport archetypes, 2019

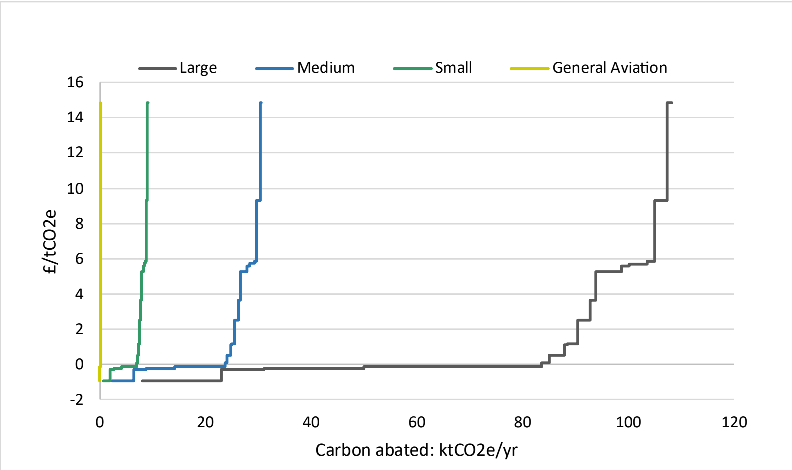
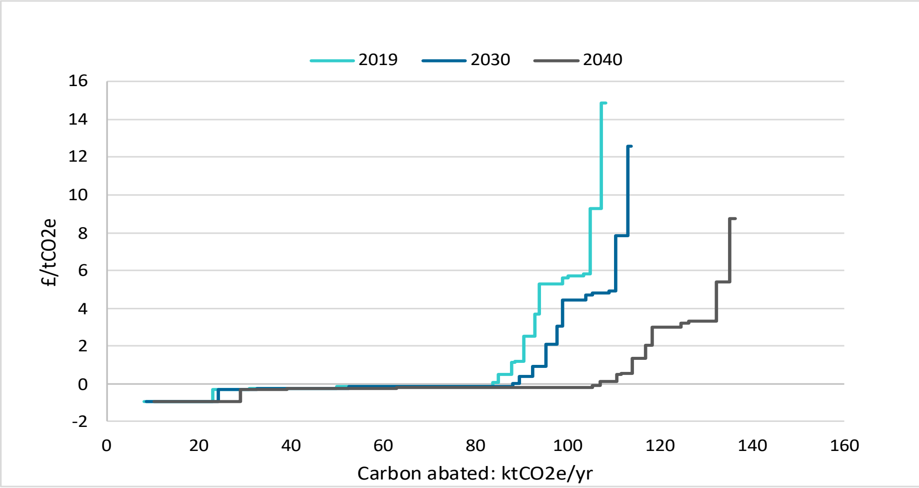
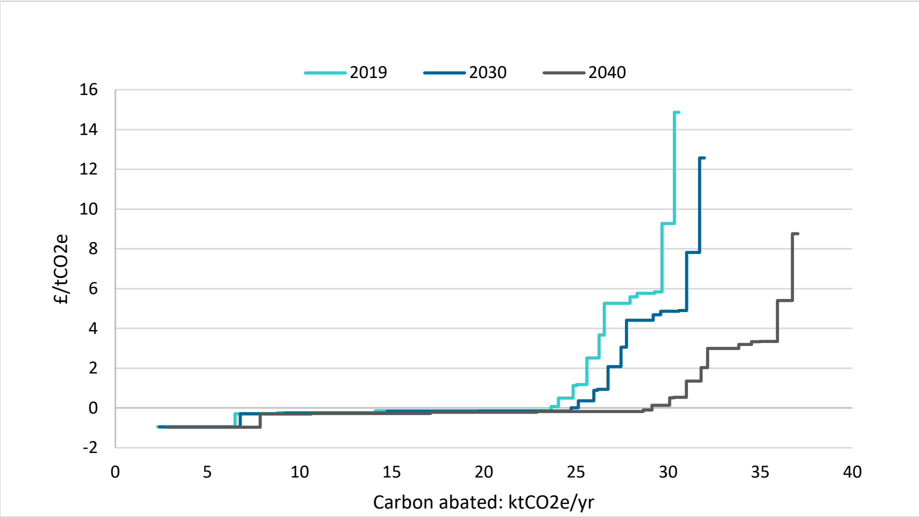


Figure 4-4: MACC large airport archetype (2019, 2030 and 2040)



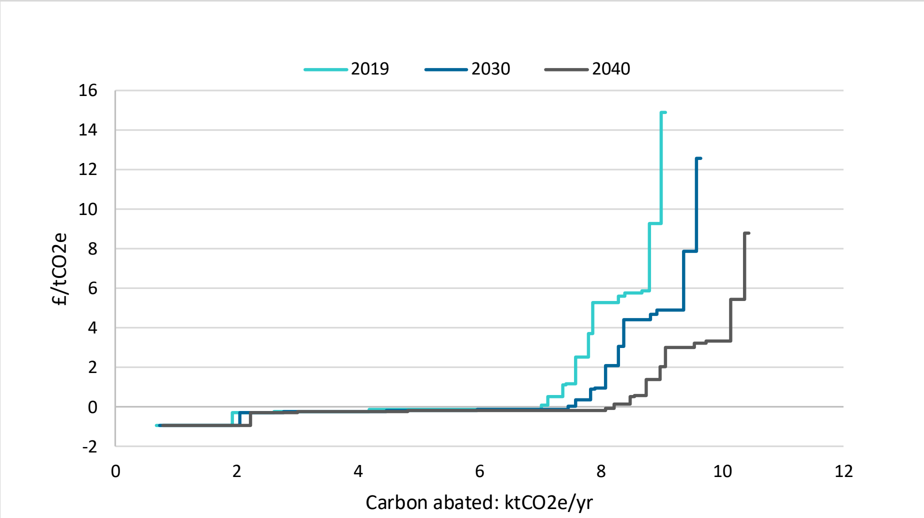
Source: Mott MacDonald

Figure 4-5: MACC medium airport archetype (2019, 2030 and 2040)



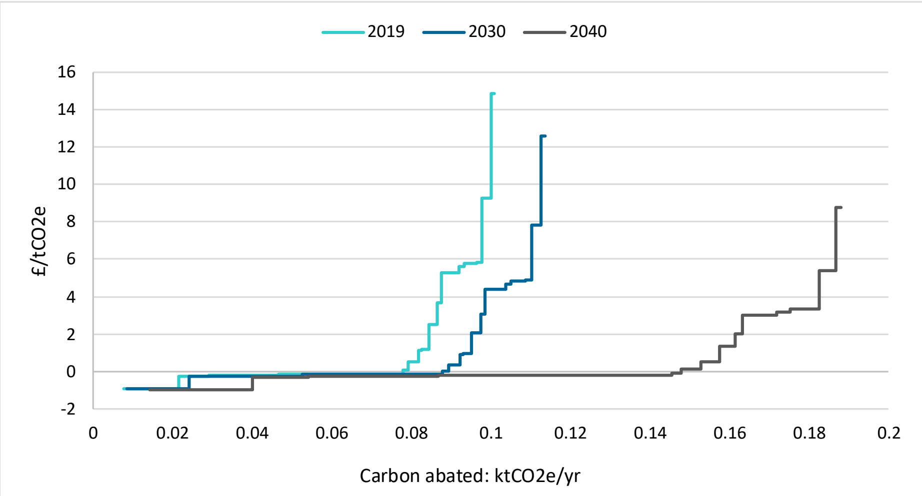
Source: Mott MacDonald

Figure 4-6: MACC small airport archetype (2019, 2030 and 2040)



Source: Mott MacDonald

Figure 4-7: MACC general/business aviation airport (2019, 2030 and 2040)



Source: Mott MacDonald

The principal conclusions arising from the analysis are:

1. The costs of abating carbon in the airports sector are low compared with the prices ruling in the traded carbon market and the social cost of carbon. Indeed, a substantial share of the volume of abatement is likely to be achievable at close to zero cost.
2. Most of the abatement measures are based on application of electrification using low-carbon electricity. The primary measures comprise electrification of heating using heat pumps (replacing fossil fuel heating), replacement of diesel and gasoline fuelled vehicle fleets by battery electric vehicles and replacement of auxiliary diesel generators (or on-board kerosene) providing power to aircraft on the ground by auxiliary battery packs (or direct connection to the airport's power supply).
3. Considered in isolation, the contribution of hydrogen may be limited in the short term, as the technology is less mature and higher cost than the electric options, except in a few heavy haul/high utilisation vehicle applications. The case for use of hydrogen may change dependent on wider adoption of hydrogen in the airport environment (for example, as fuel for heating or for zero emission flight) when funding of the required infrastructure is provided (wholly or in part) by other initiatives.
4. The application of electric measures will clearly increase the electrical load at airports, which is likely to require upgrades to electrical infrastructure (connection capacity and onsite distribution networks). This may entail significant additional investment but also considerable efforts in permitting and planning, which constrain the pace of the electrification rollout. Those factors are not considered in these MACCs.
5. The results show that the MACCs are projected to shift rightwards (in other words, cost falling for a given level of abatement), which reflects the assumed cost reductions of electric vehicles, heating and battery power packs as well as hydrogen vehicles. These cost reductions are expected to more than offset any increase in the air traffic movements.
6. Data limitations mean that the team has not been able to differentiate between different airport types, except for a scaling of abatement volumes. In practice, abatement cost will differ by airport. The key differences will be the costs and benefits of switching to electric heating (which will depend on the existing heating system and the characteristics of the buildings) and the options for auxiliary electrical power (where direct electrical connections are lower in cost than battery-based systems). Electrification of vehicle fleets is likely to be less of a differentiator.
7. The MACCs shown here do not include a high-cost tail, which probably reflects the absence of granularity in the measures considered. In practice, there will be some difficult-to-decarbonise activities, where the abatement costs could be a multiple of the current highest cost. However, the associated tonnages are likely to be small, which means the uplift in total abatement costs would not be material.

While these cost estimates are clearly indicative, it is possible to conclude that the net costs of carbon abatement for on-ground airport operations are very low. Our estimate for the average large airport is that undertaking the abatements measures in 2019 would have provided a net cost of £116,000 a year to achieve a 108ktCO_2e saving. On this basis the total net costs for abating the CO_2 emissions from all England's airports would be about £650,000 a year (assuming annual emissions of about 600kt). Clearly, these net costs are contingent on a huge capital programme of asset replacement across vehicles, heating and auxiliary power provision that integrates carbon saving. This expenditure could be in the order of £700M to £1bn, or £50M to £80M annually. That said, the message from this analysis is that incremental investments in low-carbon assets largely pay for themselves.

5 A complementary roadmap and pathway

This section reviews and comments on the current DfT trajectory or roadmap to 2040 zero emissions contained in the UK Jet Zero strategy,[9] which sets out the UK government's strategy framework and five key policy commitments to deliver net zero aviation by 2050. The more stringent 2040 zero emissions target for English airports is one of the key policy commitments and stepping stones along that roadmap but is described at a high level of abstraction.

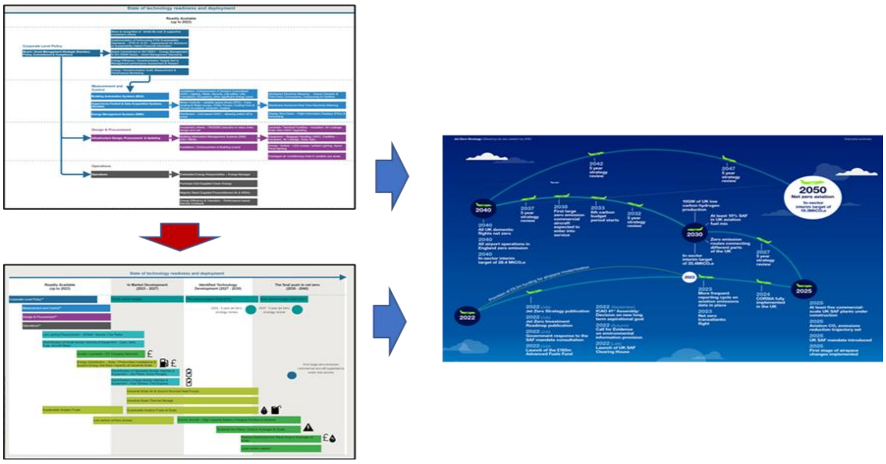
The complementary pathway described here does not replace it but provides a more granular and specific front end, including actions that can be seen as the foundations or precursors to the larger technology dependencies contained in the Jet Zero roadmap.

5.1 Foundations, precursors and immediate actions

Numerous energy transition and emissions reduction initiatives are built on existing proven technology and organisational structures. These are, in many ways, the foundations on which future-orientated technological investment rests.

The foundational pathway illustrated below, therefore, consists of two elements: the first is a series of immediately available initiatives that are not reliant on further technological developments; the second is a series of more technology dependent developments that align with the findings in the previous Mott MacDonald feasibility study.

Figure 5-1: Foundational pathway to Jet Zero and 2040 zero emissions



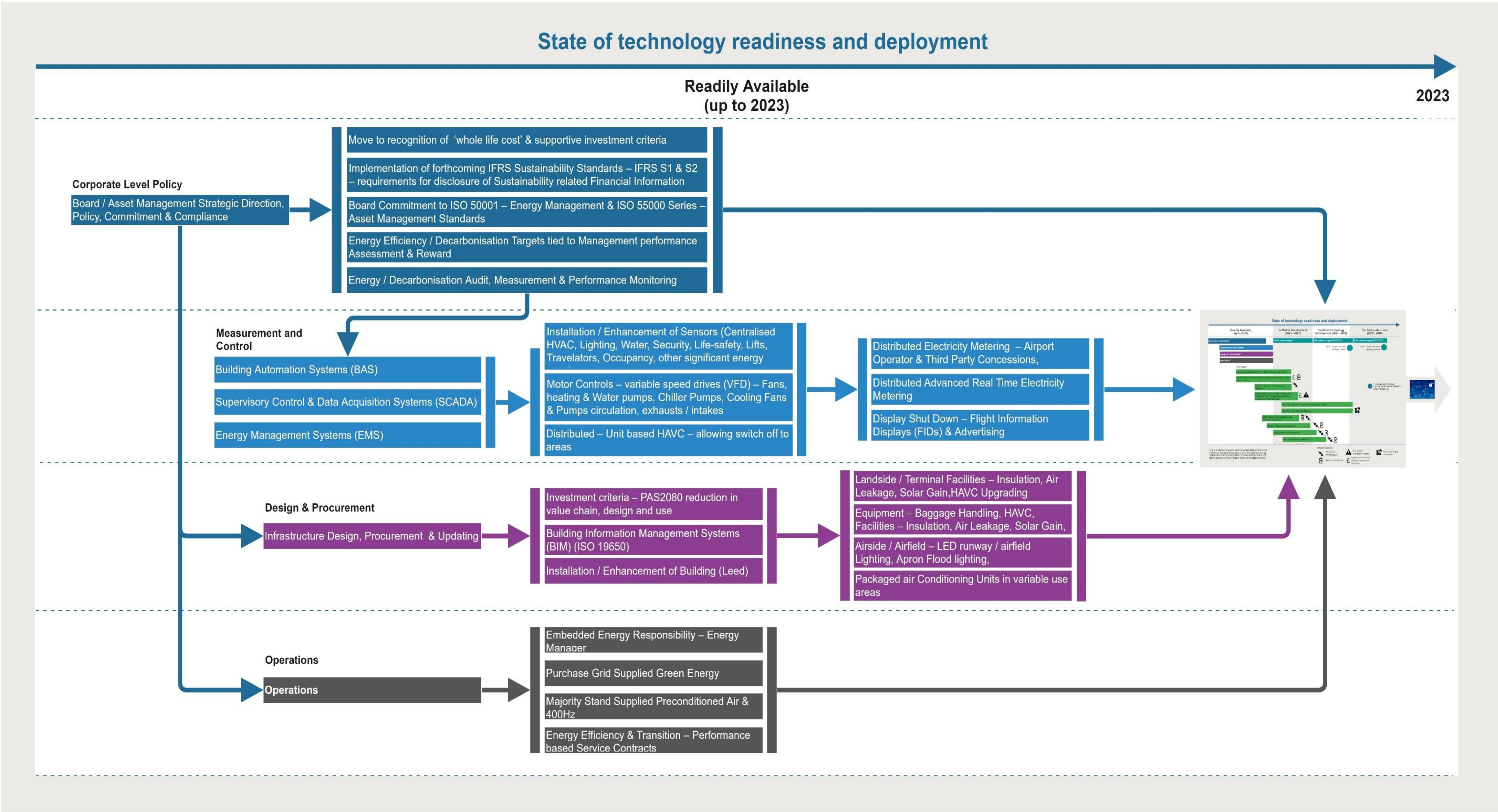
Source: Mott MacDonald and Jet Zero strategy

The precise mix and timing of the individual elements will vary from airport to airport, but the overall logic is that actionable investment should not be waiting for some major technological change to arrive. The pathway is summarised in figures 5-2 and 5-3 below.

[9] Department for Transport, *Jet Zero Strategy: Delivering Net Zero Aviation by 2050* (19 July 2022, updated 2 August 2022), *https://www.gov.uk/government/publications/jet-zero-strategy-delivering-net-zero-aviation-by-2050*, accessed 7 November 2023

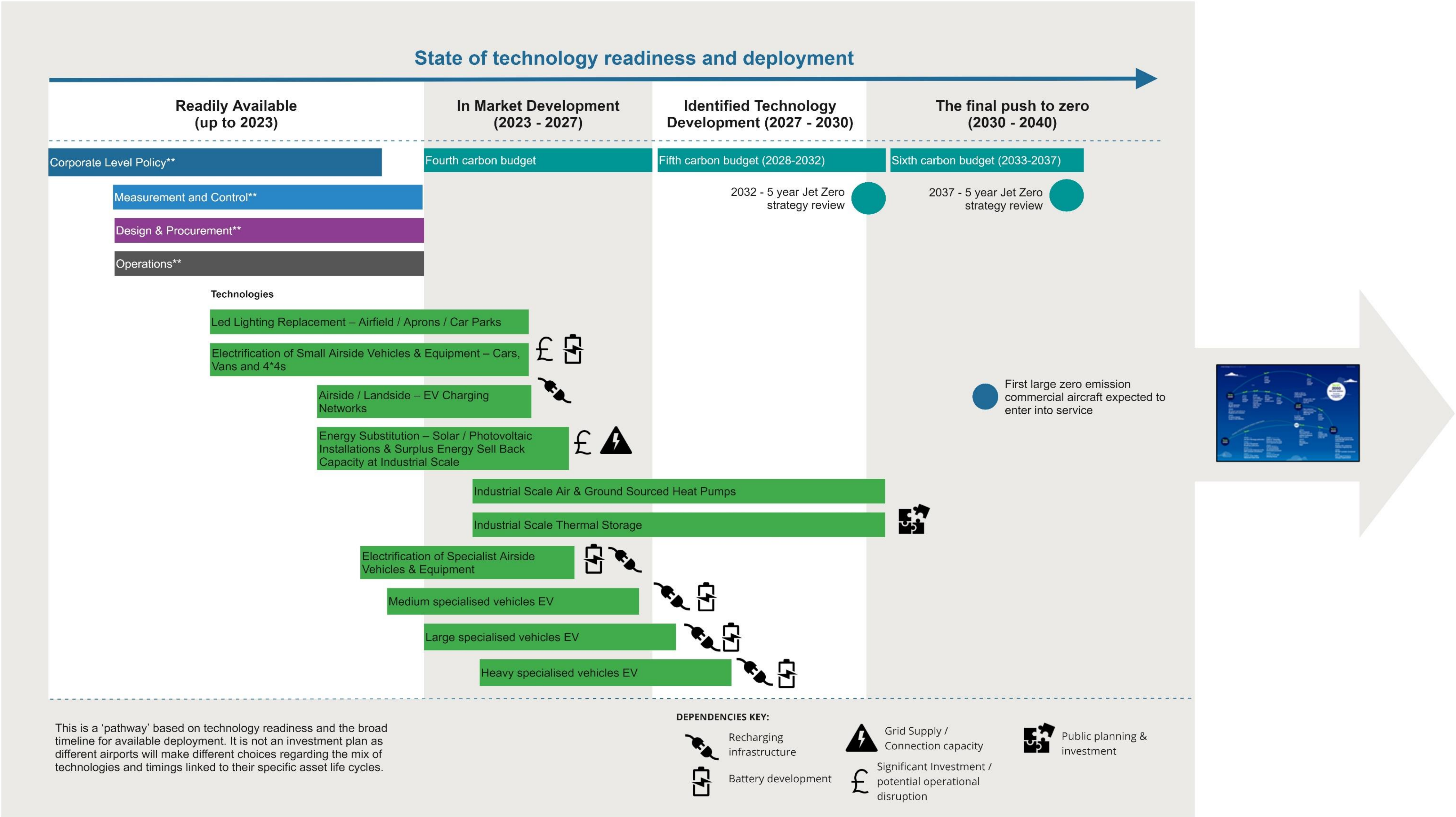
Some of the decisions within this pathway will need a system level approach across organisations – for example, in agreeing charging/cost recovery models and timing for implementation. They may also require operators to act as drivers for change across organisations operating on the site to a greater extent than occurs today – and potentially beyond their current mandates.

Figure 5-2: Immediate precursor energy transition, reduction and emissions mitigation initiatives



Source: Mott MacDonald

Figure 5-3: Technology and maturity dependent energy transition, reduction and emissions mitigation initiatives



Source: Mott MacDonald

6 Conclusions

1. In this report, the project team confirms the conclusions reached in Mott MacDonald's previous report prepared on behalf of Connected Places Catapult.[10] These are that it is reasonable to assume that the technology challenges related to the zero emissions objective will be largely overcome by 2040 and that the principal challenges lie in the commercial financing and in the scale and timing of investment.
2. While the Jet Zero pathway to 2040 remains a reasonable basis for monitoring the achievement of the zero emissions objective, the team has produced a complementary pathway. This points to the immediate availability of policy, organisational and technology mitigations at a corporate or airport level that do not depend on uncertain technology maturity. These are based on good asset management practice and parallel the stepped approach embodied in the ACI carbon accreditation programme.
3. With regard to the study itself, its scope is confined to the airside operations of English airports, including vehicles, systems and terminal infrastructure, which account for a minor proportion of airport related emissions for airports with significant commercial passenger operations. Publicly reported data suggests that, at large and medium-sized airports, this could be in the region of 5% of total emissions.
4. The bulk of airport emissions relate to the actual flying of aircraft and were beyond the scope of this study. This includes commercial questions around the cost, pricing and supply of sustainable aviation fuels (SAF), the introduction of hydrogen at scale and other emissions mitigation measures, such as carbon capture and storage.
5. At a data level, the team encountered significant difficulties in accessing detailed cost, investment and emissions data at an airport level to inform the commercial modelling. This was due to the arm's length nature of the study, which required the team to construct a limited number of airport archetypes without direct access to detailed cost and investment data. Reliance, therefore, has had to be placed on publicly available information, with little emissions mitigation costs and investment information available in a public setting.
6. The application of the MACC approach has limitations of the current collection and analysis of emissions cost and investment data at an airport level. While considerable effort is expended in assessing and reporting the quantum of greenhouse gas emissions for scope category reporting, accessible evidence for the commercial, business case investment in the various technologies for emissions mitigation was not forthcoming. Four issues were encountered:
   - Commercial confidentiality regarding costs and investment decisions yet to be made by the owners and operators of the airports.
   - General uncertainty regarding the costs of emerging technologies, critical supply issues associated with them and fiscal issues, such as carbon pricing, which would materially affect investment cases.
   - A lack of granularity in the data currently held by airports.
   - Despite the current reporting of airport emissions following international frameworks and specific UK legislation, there remains significant inconsistencies in reporting between airports.
   - In part, this is due to the differences in the scope and scale of in-house and outsourced operations but also due to the discrepancy regarding scope 3 emissions reporting. For example, airside vehicles can be classified as either scope 1 or scope 3 depending on who owns and/or operates them. This leads to

[10] Mott MacDonald, *Feasibility of Zero Emissions Airport Operations in England by 2040* (April 2022)

inconsistent reporting and leaves an airport's claim for emissions mitigation open to challenge as being partial. Consistency is required and needs the agreement of the English airports and the government.

7. Given the above, the true scale and cost of achieving zero emissions operations at an airport level will be visible only when identifying and reporting emissions, and the responsibility for their mitigation, are considered at a whole-airport level, overriding the current distinction embedded in scope categorisation. This is not a simple task as it cuts across individual corporate reporting and responsibility. Moreover, airport owners and operators do not have the authority to require and enforce investment in emissions mitigation by third parties. Nevertheless, visibility, allocation and recognition of the complex operational interdependence of an airport, and the fact that third parties need to contribute to a coordinated plan to 2040, is an important step and included in the recommendations which follow.
8. Given the above limitations, the MACC modelling contained here must be considered indicative or illustrative of the approach. Nevertheless, it suggests that emissions abatement costs for the main on-ground airport activities and infrastructure are low compared with the current UK emissions trading scheme (UK ETS carbon price of £83.03/tCO_2e).[11] More than half of the potential zero emissions target could be achieved at close to zero cost, meaning the investments would pay for themselves without any carbon credit. The MACC modelling in this analysis shows that all the emissions could, in principle, be implemented at less than £9/tCO_2e in 2040, compared with £15/tCO_2 in 2019.
9. From the work undertaken, electrification is seen as the most immediate route to emissions reduction to 2030. This includes all the airport archetypes, based on the transfer to zero carbon energy supply from the national grid and investment in solar arrays, with some airports investing to become independent energy hubs.
10. It has to be recognised that, while the term 'zero emissions' is a convenient statement of intent, in a public setting it is potentially misleading as it does not openly acknowledge the issue of residual emissions – those that are difficult to abate and may never be abated by reduction alone. Despite all the action taken, zero emissions in 2040 may not mean zero but some close approximation. Government should be open and honest about this and provide a clear description of what zero emissions will mean in practice and how technologies such as carbon capture are to be financed and treated as part of the 2040 target.
11. The modelling undertaken for this report is, by virtue of its scope and arm's length nature, partial and subject to significant assumptions, and it is not based on a specific airport. The model provides some guidance on the type of approach that could be adopted at an airport level, and its outputs should not be seen as an answer or accurate basis of unit costs. This requires a level of internal financial investment trajectory and operational detail the team has not had access to. As a contribution to the zero emissions consultation process, the model and its outputs should be seen as a useful starting point for the development of more precise local unit abatement cost assessments.

6.1 Recommendation for further work

The MACC analysis in this report provides an indicative guide to the fundamental economic costs of decarbonisation of airport emissions and concludes that the marginal costs are extremely low. However, this analysis provides limited insight on the commercial viability of the various interventions, which will depend on the ownership structures and the incentives and regulation faced by the owners and operators. Section 6.2 discusses some of these ownership and control issues. Mott MacDonald's view is that the next stage in the quantitative costing assessment of decarbonisation is to consider

[11] DBEIS/DESNZ, 'UK ETS: Carbon Prices for Use in Civil Penalties, 2023' (updated 29 November 2022)

where ownership, control and regulatory arrangements constrain decarbonisation investments. A secondary issue to consider is the requirement for significant investment to address infrastructure constraints, such as grid connections capacity. Lastly, it may be useful to estimate the total investment which needs to be mobilised to bring about the carbon abatement indicated in the MACCs.

6.2 Beyond science – devolved business models and responsibilities

One further conclusion which requires greater consideration relates to the range of operating models encountered in English airports. This affects the scope allocation of emissions and raises questions around the responsibility for their mitigation.

The scale and complexity of the emission abatement for an airport operator is not just about infrastructure and technology. It is fundamentally intertwined in the business model found at most airports of any operational scale and the ability of an airport owner/operator to change and/or enforce the behaviours of third parties.

An airport operator has a significant degree of authority and agency in matters affecting the safety and security of airport operations, backed by statute, regulatory standards and official oversight, with enforceable obligations embodied in published conditions-of-use statements and lease agreements for property. However, the obligation to abate emissions across an airport system is divided among the balance sheets, investment horizons and business plans of multiple actors.

These organisational and business boundaries are reinforced by the very language and frameworks of emissions reporting and abatement, with scope 3 emissions being clearly identified as the responsibility of others at an operational and investment level.

This has direct economic costs in terms of delayed investment, discontinuities in integrated planning and uncertainty in cost recovery. For price regulated airports, this includes competing policy objectives related to charges minimisation and environmental investment related to government policy objectives driven by pathways along a timeline.

Individual airport operators and service providers will pursue the public good of environmental emissions abatement out of moral commitment and self-interest in the face of hostile public pressures questioning the right to trade and develop. However, they will do so within a fiduciary duty to deliver reasonable and sustainable financial returns to public and private owners or shareholders.

In a multi-actor or multistakeholder setting, the ultimate point of integration lies with government, as it is the body with agency over all the actors and owns the highest level of commitment to national environmental objectives and international policy commitments. While the core of the work that has been undertaken has focused on quantification of the costs of emissions abatement and the development of an arm's length model, the principal outcomes lie in setting the rules of the game – in the policy implications and actions of government. Based on the work undertaken and the specific conclusions referenced here, the next section sets out five high-level policy recommendations. This is followed by a series of appendices, which provide additional background information and analysis.

7 Five specific recommendations

Policy recommendation 1: Consistent emissions information and integrated whole-airport reporting

The first, most immediate, necessary and least-cost intervention is to address the inconsistencies in emissions reporting identified in the previous sections, with additional commentary contained in Appendix 1 – 'Background on Emissions Terminology and Reporting).

There are a number of overlapping national and international standards, requirements and guidance, with carbon accounting at UK airports having to adhere to the UK's Streamlined Energy and Carbon Reporting legislation (SECR). While this establishes a basic framework for compliance, this and other internationally accepted emissions reporting standards allow a degree of interpretation regarding the allocation of specific emissions. Incompatibility arises due to differences in the devolved business models and divided responsibilities at English airports.

The SECR legislation does not impose a prescribed methodology under the legislation, relying on an airport to use recognised independent standards for disclosure, such as the GHG Protocol corporate standard, ISO 14061-1:2018 and the Climate Disclosure Standards Board Framework. This allows different methodologies and approaches to be used to calculate or measure emissions.

English airports have different reporting requirements under the SECR legislation, dependent on whether they are a quoted or unquoted large company. Incompatibilities arise due to the outsourcing of facilities and services, with some airports accounting for emissions as insourced scope 1 emissions while others account for them as scope 3 emissions. Emissions allocation and GHG reporting are, therefore, influenced by whether the airport owner or operator owns an asset or has direct enforceable agency over it.

Government and the trade bodies representing UK airports need to agree a single methodology for whole-airport emissions reporting and abatement implementation. This should identify the different emissions contributions and abatement actions signed off by all contributors. This is important for the following reasons:

- Comparable data is essential for reliable comparisons between airports, for progress monitoring and pathway implementation, and for ensuring that airport operators are not unfairly judged for business activities and investment or non-investment decisions over which they have little agency.
- Industry agreement should be sought on how fragmented reporting by different stakeholders could usefully be brought together to provide whole-airport visibility of the costs of emissions abatement and the scale, timing and form of supporting investment required at an airport level. The intent would be to identify the true costs of achieving zero emissions at an airport level, provide an integrated pathway (timetable) and a clearer appreciation of the scale, nature and targeting of government policy intervention and support. Information-led airport operators may require statutory support to ensure that third party actors engage with meaningful operational and financial investment.
- The separation of scope 3 from scope 1 and 2 emissions is not something that the public recognises. As an immovable, physical entity, the airport bears the cost of public perception as being responsible for emissions. Fragmented reporting leaves it open to accusations of greenwashing, partial reporting or even deliberate misrepresentation. As a result, different business models and degrees of insourcing and outsourcing lead to inconsistencies in reporting among airports with different scope 3 inventories.

Policy recommendation 2: The zero emissions label and residuals

The label of zero emissions represents a policy and environmental objective and one that captures public support. However, it fails to convey the fact that some airport activities may not be able to achieve zero emissions. The most obvious example would be the statutory requirements regarding fire training. While virtual approaches to training are available or in development, it is unlikely that they can replace the human experience of entering a burning aircraft. The chemicals in aircraft operation, maintenance and repair present challenges that should be recognised similarly to other operational and engineering activities.

As part of its zero emissions policy for English airports, the government and trade bodies representing English and UK airports need to develop an agreed list of excluded activities and sources that can be consistently applied across the airport network.

This should include clear recognition of what will be regarded as acceptable approaches to dealing with the residuals from hard-to-abate activities.

There is a need for public-facing honesty on what type and level of residuals will be regarded as allowed in recognising the achievement of zero emissions at an airport level, and whether mechanisms such as offsetting will be considered as acceptable mitigations.

The same would be true of carbon capture and storage, as well as capture and conversion. These are emergent technologies, the installed costs of which are uncertain and depend on the development of centralised large-scale facilities outside an airport's boundaries – in effect a form of locational outsourcing.

Policy recommendation 3: The level playing field and avoidance of market distortion

The different archetypes that have been the required focus of this report operate in very different economic settings. There exist different trade-offs among the scale of the financial resources generated and available to them, the scale of the emissions abatement they face, and their competitive position regarding airlines, as well as competing regional, national and international airports.

The policies and incentives supporting emissions abatement and the 2040 zero emissions target need to work in a way that supports the English airports as a network, without shifting demand between regions or among airports. Some airports may proceed with immediate and progressive emissions abatement, leading to investment costs which may potentially impact charges. Meanwhile, others might either be unable to invest or delay such costs to manage cash flow recovery and rebuild their balance sheets.

Government intervention may be required across the archetypes to address this potential for market distortion. Government will need to consider whether such interventions, if introduced, target maximum impact, potentially favouring the largest airports in the network, or seek to strike some form of balanced or stratified approach, which may favour smaller airports more exposed to costs associated with the transition to zero emissions.

Policy recommendation 4: Incentivisation of system-wide emissions mitigation

Recognising that government intervention may be required, it will be important to consider what form this could take. In particular, such intervention would need to focus on the scale or acceleration of progress to achieve zero emissions.

There are a variety of potential mechanisms that could be utilised to encourage airports to accelerate progress towards zero emission airports. These include:

- Establishing a bespoke biddable airports abatement fund. This would need to have a balance between scale and impact maximisation, as well as different routes for funding.
- Greater transparency in progress towards zero emissions, including the potential publication of a league table to highlight progress made in emissions reductions.
- Introducing legislation related to the target with a financial penalty for non-compliance.

Clearly designed to kick-start and accelerate progress towards this target in a general sense, the forthcoming consultation should examine whether such incentives could be put in place. The ultimate aim would be to accelerate the 2040 objective for airports, recognising the challenges associated with achieving zero emissions on that timescale.

Policy recommendation 5: Avoidance of additional complexity and administrative burden in emissions monitoring and validation or accreditation

While self-reporting is a relatively light-touch approach to achieving a public policy objective, public mistrust of greenwashing and the ability to monitor the momentum and achievement of the zero emissions pathway requires a mechanism that incorporates some form of independent, external monitoring and validation.

With numerous national and international standards already in place, government should not seek to impose a new, additional reporting and validation burden on English airports. To avoid adding to complexity, duplication and administrative burden, it is recommended that government builds on the current industry carbon accreditation scheme provided by ACI Europe. This is already accepted and well embedded in the industry and provides a stepped approach combining the type of policy, organisational and management actions set out in the complementary pathway included in this report.

While the ACI framework is industry accepted and provides the necessary independent validation, imposing a UK government requirement would potentially create a de facto validation monopoly if only one validation organisation is accredited to undertake ongoing monitoring and validation. This should be avoided. The government and the trade bodies representing the English airports should agree an accreditation scheme that forms part of, or is as closely aligned as possible with, the ACI scheme, with multiple options for validation. This recognises that not all airports are part of ACI and their Level 4+ achievement is not as ambitious as the zero emissions target. Additional information on the ACI carbon accreditation scheme is included as Appendix D.

Appendices

A. Carbon terminology – key terms

A.1 Broad terminology

Scope 1 emissions	Direct greenhouse gas (GHG) emissions that occur from sources which are owned or controlled by an organisation, for instance, emissions associated with fuel combustion in boilers, furnaces and vehicles.
Scope 2 emissions	Indirect GHG emissions associated with the purchase of electricity, steam, heat or cooling. While they physically occur at the facility where they are generated, they are accounted for in an organisation's GHG inventory because they are a result of that organisation's energy use.
Scope 3 emissions	Result of activities from assets not owned or controlled by the reporting organisation, but which the organisation indirectly impacts in its value chain. These are often referred to as 'value chain emissions'.
Zero emissions carbon	All activities under direct control of the airport and its users produce zero measurable emissions, contributing nothing to global GHG levels and requiring no offsets to achieve this balance.
Net zero	To reach net zero emissions at the corporate level, companies must achieve a scale of value chain emissions reduction consistent with the depth of abatement achieved in pathways that limit warming to 1.5°C with no or limited overshoot and neutralise the impact of any source of residual emissions that remains unfeasible to be eliminated.
Jet Zero	Jet Zero is the UK's strategy to deliver net zero in the aviation sector by 2050.
tCO_2e	Stands for tonnes (t) of carbon dioxide (CO_2) equivalent €. Carbon dioxide equivalent is a standard unit for counting GHGs regardless of whether they are from carbon dioxide or another gas.
Intensity ratio	Defining emissions data in relation to an appropriate business metric such as tCO_2e per 1000 passengers.

B. Emissions scope and reporting

This section introduces some of the methodologies employed to account for carbon dioxide and other greenhouse gases (GHGs) across English airports, explains the multiple frameworks and reporting standards at a national and international level and highlights the efforts made to develop a standardised approach to aviation emission accounting.

B.1 Scope 1, 2 and 3 emissions for airports

For UK airports, emissions reporting must be conducted under the streamlined energy and carbon reporting (SECR) legislation. There is no prescribed methodology under the SECR legislation and it relies on airport organisations to use recognised independent standards for disclosure. This includes, but is not limited to, the GHG Protocol Corporate Standard (the GHG Protocol), ISO 14061-1:2018 and the Climate Disclosure Standards Board Framework for reporting environmental and social information. Greenhouse gas emissions are reported under the Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC) for all six Kyoto GHGs (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6)[12] as carbon dioxide equivalents (CO_2e).

B.2 Scope definitions in an airport environment

Scope 1: Direct airport GHG emissions that come from sources and assets owned by the airport organisation, such as emissions from airport owned vehicles and infrastructure fuel consumption.

Scope 2: Indirect GHG emissions associated with the purchase of electricity, steam, heat or cooling. While they physically occur at the facility where they are generated, they are accounted for in an organisation's GHG inventory because they are a result of that organisation's energy use. Location-based and market-based emissions reporting falls under scope 2 emissions.

Location-based emissions are based on the intensity of the local grid area where the energy services usage occurs (using mostly grid average emission factors).

Market-based emissions come from electricity that companies have purposefully chosen, often specified in contracts or instruments such as renewable energy guarantees of origin (REGOs).[13]

Scope 3: Indirect GHG emissions associated with all other activities in the airport environment that are not captured by scope 1 or 2 emissions. These may be the result of activities from assets not owned or controlled by the reporting organisation, but which the organisation indirectly impacts in its value chain. These are often referred to as 'value chain emissions'.

These emissions are defined by the GHG Protocol and are split into upstream (indirect GHG emissions from purchased or acquired goods and services) and downstream (indirect GHG emissions from sold goods and services). The typical categorisation of these is shown in Table 7-1[14] below.

[12] UN Framework Convention on Climate Change, 'What Is the Kyoto Protocol?' (n.d.), https://unfccc.int/kyoto_protocol, accessed 7 November 2023

[13] World Resources Institute, *GHG Protocol Scope 2 Guidance* (2015), https://ghgprotocol.org/sites/default/files/2023-03/Scope%202%20Guidance.pdf, accessed 7 November 2023

[14] World Resources Institute/World Business Council for Sustainable Development, *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* (2011), https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf, accessed 7 November 2023

Table 7-1: GHG Protocol scope 3 emissions categories

Upstream scope 3 emissions	Downstream scope 3 emissions
• Purchased goods and services	• Downstream transportation and distribution
• Capital goods	• Processing of sold products
• Fuel and energy related activities (not included in scope 1 or 2)	• Use of sold products
• Upstream transportation and distribution	• End-of-life treatment of sold products
• Waste generated in operations	• Downstream leased assets
• Business travel	• Franchises
• Employee commuting	• Investments
• Upstream leased assets	

B.3 Streamlined energy and carbon reporting (SECR)

The Companies (Directors' Report) and Limited Liability Partnerships (Energy and Carbon Report) Regulations 2018 (the 2018 regulations)[15] implement the government's policy on streamlined energy and carbon reporting (SECR). This can apply to airport organisations.

Airports will have different reporting requirements under the SECR legislation depending on whether they are a quoted or unquoted large company or a large limited liability partnership (LLP) company, as shown in Table 7-2.[16] A quoted company is defined by the Companies Act 2006 as "a company that is UK incorporated and whose equity share capital is listed on the main market of the London Stock Exchange UK or in an EEA state or admitted to trading on the New York Stock Exchange or Nasdaq." An unquoted company is a company that is not a quoted company. Scope 1 and 2 emissions are mandatory for quoted and unquoted large LLP companies. However, the reporting requirements change for scope 3 emissions.

Table 7-2: Reporting requirements for companies under the SECR legislation

GHG Protocol scope	Quoted companies	Large unquoted companies and LLPs
Scope 1	Mandatory for quoted companies to report global scope 1 emissions	Mandatory for large unquoted companies and LLPs to report UK scope 1 emissions as far as they relate to their UK energy (as a minimum, electricity, gas and transport fuels)
Scope 2	Mandatory for quoted companies to report global scope 2 emissions	Mandatory for large unquoted companies and LLPs to report UK scope 2 emissions as far as they relate to their UK energy use (as a minimum, grid-sourced electricity, gas and electricity consumption relating to transport)

[15] The Companies (Directors' Report) and Limited Liability Partnerships (Energy and Carbon Report) Regulations 2018, https://www.legislation.gov.uk/ukdsi/2018/9780111171356, accessed 7 November 2023

[16] HM Government, *Environmental Reporting Guidelines* (March 2019), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/850130/Env-reporting-guidance_inc_SECR_31March.pdf, accessed 7 November 2023

Scope 3	Voluntary for quoted companies but strongly encouraged, especially where this is a material source of emissions	Mandatory for large unquoted companies and LLPs to disclose energy use and related emissions from business travel in rental cars or employee-owned vehicles where they are responsible for purchasing the fuel. Other scope 3 emissions voluntary, but strongly encouraged where this is a material source of emissions

Source: The Companies (Directors' Report) and Limited Liability Partnerships (Energy and Carbon Report) Regulations 2018

Overlaps may occur with indirect (scope 2 and 3) emissions reporting in the airport environment depending on whether the airport owns an asset or not. For example, an employee commuting is generally considered scope 3, but the airport may provide an electric shuttle bus service which the employee can use. This will contribute to a scope 2 or 3 emission if the airport owns and operates the service. Assuming the bus service is from a third party supplier (scope 3), scope 2 emissions can increase if electric charging points are provided by the airport. This can lead to emissions reporting at airports being complex and, as such, a standardised reporting methodology should be developed to clearly define the boundaries for airport emissions reporting.

B.4 WBCSD/WRI GHG Protocol corporate standard

The World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI) jointly convened the GHG Protocol in 1998. It has defined and detailed the emissions scopes required for emissions reporting; they can be split into scope 1, 2 and 3 emissions and can be applied to the airport environment. As such, the GHG Protocol may be a possible emissions reporting methodology to standardise the SECR reporting.

Required information for reporting

The GHG Protocol Corporate Accounting and Reporting Standard states that a public GHG emissions report, which is in accordance with the standard, shall include the following information:[17]

- Total scope 1 and 2 emissions independent of any GHG trades such as sales, purchases, transfers or banking of allowances
- Emissions data separately for each scope
- Emissions data for all six GHGs separately (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) in metric tonnes and in tonnes of CO_2 equivalent
- Year chosen as base year and an emissions profile over time that is consistent with, and clarifies, the chosen policy for making base year emissions recalculations
- Appropriate context for any significant emissions changes that trigger base year emissions recalculation (acquisitions or divestitures, outsourcing/insourcing, changes in reporting boundaries or calculation methodologies, etc)
- Emissions data for direct CO_2 emissions from biologically sequestered carbon (such as CO_2 from burning biomass or biofuels) reported separately from the scopes
- Methodologies used to calculate or measure emissions, providing a reference or link to any calculation tools used
- Any specific exclusions of sources, facilities or operations

[17] World Business Council for Sustainable Development/World Resources Institute, *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition)* (2004), https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf, accessed 7 November 2023

The GHG Protocol Corporate Accounting and Reporting Standards also provides guidance on optional information for reporting, which is stated as:[18]

- Generation of electricity, heat or steam that is purchased for resale to non-end users
- Emissions from GHGs not covered by the Kyoto Protocol (such as CFCs or NOx,), reported separately from scopes
- Relevant ratio performance indicators (for example, emissions per kilowatt-hour generated, tonne of material production or sales)
- Information on offsets that have been purchased or developed outside the inventory boundary, subdivided by GHG storage or removals and emissions reduction projects; specify if the offsets are verified, certified or approved by an external GHG programme
- Information on reductions at sources inside the inventory boundary that have been sold or transferred as offsets to a third party; specify if the reduction has been verified, certified or approved by an external GHG programme.

B.5 Decarbonisation status

In addition to the above standards and reporting frameworks, Airports Council International (ACI), the international trade body for airports, oversees the Airport Carbon Accreditation (ACA) programme, which assesses and accredits the efforts of airports to manage and reduce carbon emissions. It is a voluntary emissions reporting methodology and is not required by UK legislation to be disclosed. It was developed in line with the GHG Protocol and ISO14064[19] and defines six levels of accreditation, with an airport's application for initial accreditation and subsequent monitoring being subject to independent assessment.

The list below summarises the progressive levels of carbon accreditation:

- Level 1 (mapping) – carbon footprint and policy
- Level 2 (reduction) – emissions reduction target, carbon management plan and annual reductions
- Level 3 (optimisation) – engagement with third parties and measurement of their emissions
- Level 3+ (neutrality) – offsetting of residual scope 1 and 2 emissions
- Level 4 (transformation) – extended carbon footprint, absolute emissions reduction in line with the Paris Agreement and enhanced third party engagement
- Level 4+ (transition) – offsetting of residual scope 1 and 2 emissions

All of the above are useful but allow for differing interpretations and allocation of emissions producing infrastructure and operations at a local level, in part due to the different business models at different airports. An unregulated compliance industry is now beginning to emerge, with various organisations and actors offering to record, report and validate emissions reporting. Various approaches are being taken at different levels from the airports themselves, including among the investors and providers of finance.

B.6 A whole-airport perspective

The reporting that is currently taking place is helpful and becoming more sophisticated over time but is still based on the performance of individual entities, and the whole-airport perspective across multiple stakeholders is difficult to assemble. This comes back to an airport's ability to control the emissions performance of third parties and to have visible and agreed commitment to an airport-wide investment plan or pathway.

[18] WBCSD/WRI, *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition)* (2004)

[19] Airport Carbon Accreditation, *Annual Report 2021-2022* (ACI, 2022), https://www.airportcarbonaccreditation.org/aca-media/annual-reports.html, accessed 7 November 2023

This may require the support of government to strengthen the hand of airports and is an issue returned to in the recommendations at the end of this report.

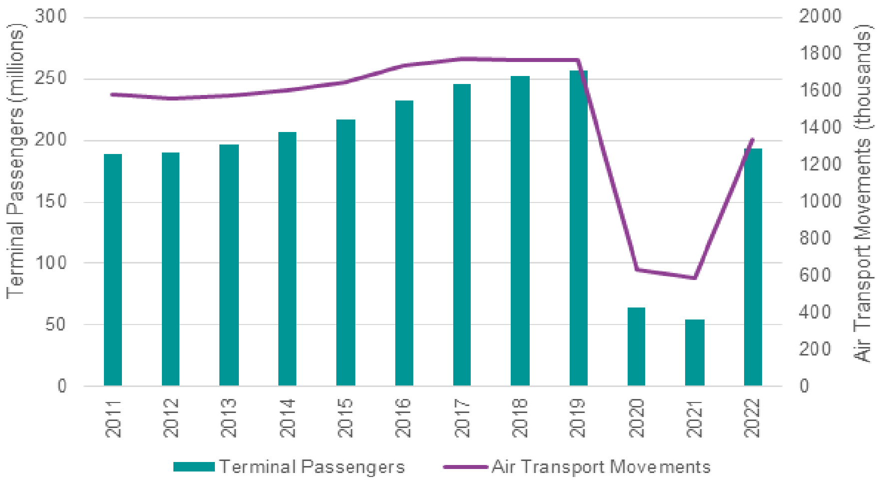
C. Air traffic data and forecasts

C.1 Summary of traffic volumes

As this report focuses on emissions mitigation at English airports, the air traffic movements (ATM) and commercial passenger data for those airports has been extracted and is summarised below. It presents historic growth rates, the dramatic resetting that occurred during the Covid period and potential expectations for future growth should demand return to its historic pattern.

As can be seen from Figure 7-1 below, total air transport movements (a commercial aircraft landing or taking off) grew at an average of 1.4% per year between 2011 and 2019 (pre-pandemic). Commercial passenger volumes grew at an average of 3.9% per year. The higher growth of passengers compared with ATMs reflects change in the average number of passengers carried per aircraft, due to either increased load factor on existing aircraft or the introduction of larger aircraft. The ATM and passenger traffic developments across the English airports between 2011 and 2022 are shown graphically below:

Figure 7-1: Historic traffic development at English airports 2011-2022



Source: Department for Transport, 'Air transport movements at reporting airports by airport, United Kingdom, from 2011'; 'Terminal passengers at reporting airports by airport, United Kingdom, from 2011'

The Covid-19 pandemic, with its ensuing lockdowns and travel restrictions, severely impacted air traffic at English airports. ATMs in 2020 reached little more than a third of 2019 levels and passenger numbers and passenger volumes were approximately a quarter of 2019 levels.

The greater decrease in passenger volumes is indicative of the travel restrictions that came into force during 2020. ATM volumes remained higher as airlines began flying all-cargo flights as passenger volumes fell, transporting items such as pharmaceutical products.[20] Volumes of both passengers and ATMs at airports across England fell further during 2021 as the UK remained under varying degrees of lockdown and travel restrictions for much of the year.

[20] N. Clarkson, 'Virgin Atlantic Prepares Cargo Operation to Carry Covid-19 Vaccines', *Virgin* (19 November 2020), https://www.virgin.com/about-virgin/latest/virgin-atlantic-prepares-cargo-operation-to-carry-covid-19-vaccines, accessed 7 November 2023

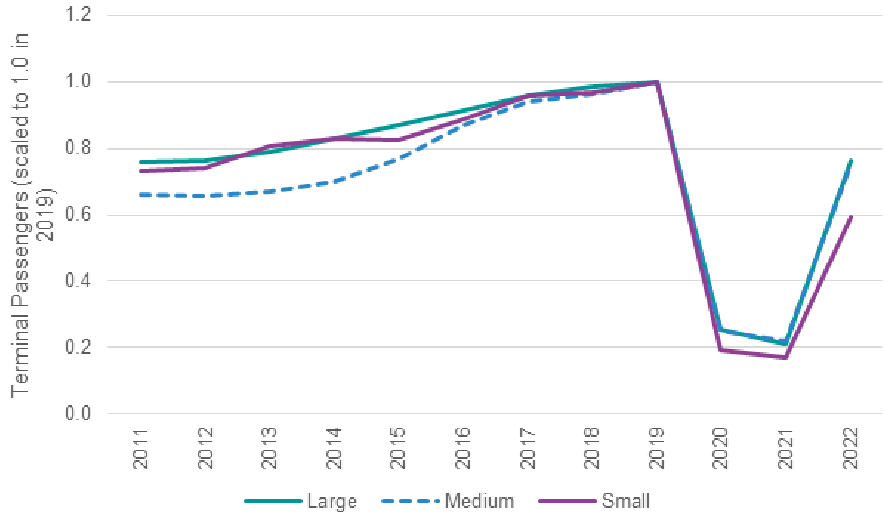
However, following the easing of travel restrictions, passenger and ATM volumes recovered significantly during 2022, with both ATM and passenger volumes reaching approximately 75% of 2019 (pre-pandemic) levels. Industry forecasts suggest that in Europe, 2019 ATM and passenger volumes are likely to be reached once more in 2025.[21]

C.2 Traffic volumes at English airport archetypes

The above passenger and ATM figures for England have been extracted for the archetype groups, and the development of passenger volumes is shown in Figure 7-2 below, and similarly for ATMs in Figure 7-3.

Passenger volumes have been scaled to 1.0 in 2019 for ease of comparison between the groupings.

Figure 7-2: Historic passengers for archetype groupings 2011-2022 (scaled to 1.0 in 2019)



Source: Department for Transport, ‘Air transport movements at reporting airports by airport, United Kingdom, from 2011’; ‘Terminal passengers at reporting airports by airport, United Kingdom, from 2011’

Growth between 2011 and 2019 was strongest at the medium airports, which grew at an average of 5.3% per year, compared with an average of 3.6% per year at the large airports and an average of 4.0% per year at the small airports. Airports in the medium archetype that achieved particularly strong growth were London Luton (an average of 8.5% growth per year, driven by growth from low-cost airlines such as EasyJet and Wizz Air[22]) and London City (an average growth of 6.9%, driven by growth from BA Cityflyer[23]).

[21] ATM figures from: Eurocontrol, *Forecast Update 2022-2028* (October 2022), https://www.eurocontrol.int/sites/default/files/2022-10/eurocontrol-seven-year-forecast-2022-2028-october-2022.pdf, accessed 7 November 2023. Passenger figures from: ACI Europe, *Airport Traffic Forecast – 2023 Scenarios & 2023-2027 Outlook* (December 2022), https://www.aci-europe.org/economic-forecasts.html, accessed 7 November 2023

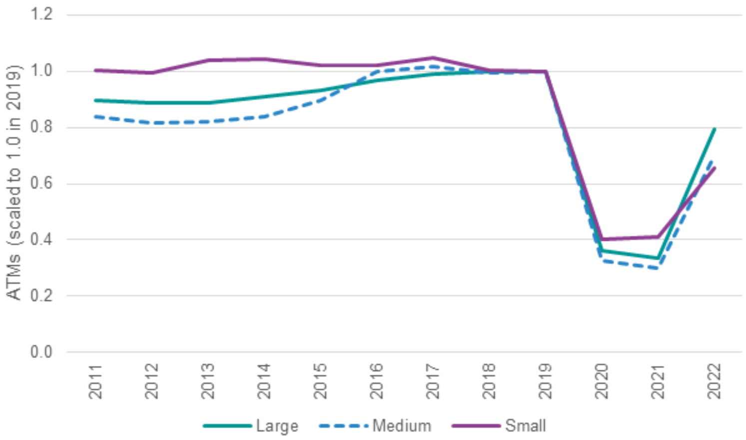
[22] Mott MacDonald analysis of SRS Schedules Analyser data, March 2023

[23] Ibid

Passenger volumes have recovered most strongly following the Covid-19 pandemic at airports in the large and medium groupings, which is likely to be the result of airlines prioritising the larger airports as they have reinstated capacity.

Figure 7-3 shows the development of commercial ATMs across each of the main English airport archetype groupings (large, medium and small). Commercial ATM volumes have been scaled to 1.0 in 2019 for ease of comparison between the groupings.

Figure 7-3: Historic ATMs for archetype groupings 2011-2022 (scaled to 1.0 in 2019)



Source: Department for Transport, 'Air transport movements at reporting airports by airport, United Kingdom, from 2011'; 'Terminal passengers at reporting airports by airport, United Kingdom, from 2011'

Similar trends are apparent between the archetype groupings for commercial ATMs as for passengers. The more rapid average annual growth between 2011 and 2019 of the medium archetype grouping is again apparent (an average annual growth of 2.3% versus an annual average growth of 1.4% for the large archetype grouping and 0.0% for the small). A more rapid recovery during 2022 is also seen for the large and medium groupings.

C.3 Future demand

DfT published a passenger and aircraft movements forecast in 2017 and later partially updated the forecast for the Jet Zero strategy. The model forecasts the passenger demand at national level, which is then allocated to UK airports based on a number of factors, including destination, availability of flights and relative cost of travel, accounting for capacity constraints.[24] Simultaneously, the volume of ATMs is calculated to meet this demand.

The model provides forecasts by UK airport, destination and journey purpose.[25] Since the 2017 forecast, the airport capacity assumptions and the fleet mix have been updated.[26]

[24] Department for Transport, *Jet Zero Strategy: Delivering Net Zero Aviation by 2050* (updated 2 August 2022), Department for Transport, *Jet Zero Consultation: Evidence and Analysis* (July 2021), Annex A; Department for Transport, *Jet Zero Illustrative Scenarios and Sensitivities* (July 2022)

[25] Department for Transport, *UK Aviation Forecasts 2017* (October 2017), Chapter 2

[26] Department for Transport, *Jet Zero Consultation: Evidence and Analysis* (July 2021), Annex A

The capacity assumptions are not a prediction but have been chosen as a reasonable upper bound.[27] The GDP input includes the impact of Covid, but the impact of Covid has not been separately considered.[28]

Mott MacDonald was not commissioned to develop an independent forecast of future passenger and ATM demand for the English airports and, for consistency, has relied on the partially updated post-Covid forecast assessments prepared by DfT as part of the Jet Zero strategy development process.

These are partial updates which recognise changes in economic activity (GDP) but have not updated the full range of variables included in DfT's sophisticated aviation demand model. In particular, it is noted that the DfT updating was focused on deriving UK volume totals for the strategy development process and did not address the allocation of those totals among specific airports to the same level of detail and assurance involved in a full update of the DfT traffic model. Recognising this limitation, it was judged to be better to use the partially updated DfT forecast figures than rely on a 2017 forecast that took no account of the severe aviation market disruption associated with the Covid pandemic.

Although this forecast has not been fully updated post-pandemic, the historic forecast provides a reference point for growth between airports, with an indication of the different growths for the archetype airports provided in Figure 7-4, Figure 7-5 and Figure 7-6 below.

These demonstrate high forecasted compound annual growth rates for the smaller airports; however, this is indicative of the much smaller absolute volume of traffic.

The forecasts have been used for modelling purposes and may not match the internal forecasts of the individual airports.

Heathrow's capacity for aircraft movements has been increased from its current levels (~479,000 ATMs between 2016 and 2019) to 738,000 by 2040. Passenger growth is higher than ATM growth, at 2.8% to 2.1% respectively of compound annual growth rate (CAGR) during 2019-2040.

London Gatwick, despite an overall increase between 2019 and 2040 (0.5% CAGR for passengers during 2019-2040), is forecast to see a passenger reduction between 2030 to 2040. This is possibly due to the passenger increase at Heathrow. At Manchester, the ATM capacity does not increase significantly throughout the forecast (0.1% CAGR 2019-2040). However, the terminal passengers continue to increase by 1% CAGR between 2019-2040.

Bristol's terminal passengers are forecast to reduce from 8.3M in 2019 to 8.0M in 2040 (-0.2% CAGR 2019-2040), which possibly reflects an impact of the 10M total passenger cap in effect at the time, although this is being lifted to 12M.[29]

The other archetype medium airports, London Luton and Birmingham, grow during the forecast period (respectively, 2.9% and 2.0% CAGR of terminal passengers during 2019-2040).

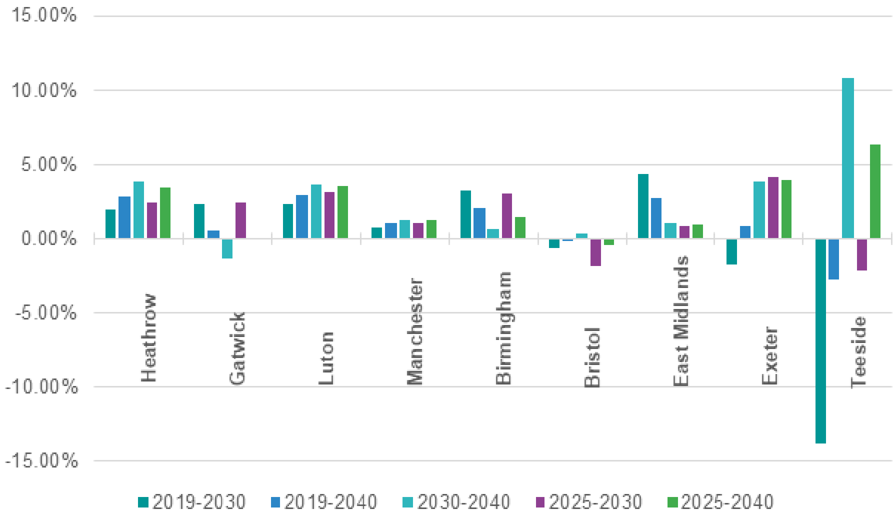
The forecasts for the small airports (East Midlands, Exeter and Teesside) cover a range of growths. East Midlands has the largest growth of the three for passengers (2.7% CAGR in between 2019-2040), while Exeter sees a smaller growth of passengers and ATMs (0.8% and 0.7% CAGR in 2019-2040). Teesside Airport is forecast to decrease in size by 2.8% in passenger numbers and 2.9% in ATMs CAGR during 2019-2040. This is possibly due to the increase in size at Manchester and Newcastle.

[27] Ibid

[28] Department for Transport, airport level forecasts – Jet Zero strategy dataset

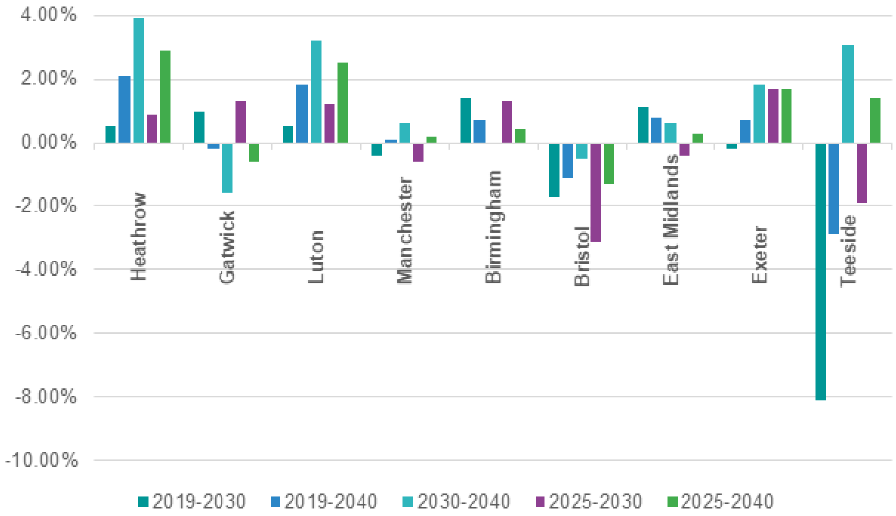
[29] E. Elgee, 'Bristol Airport Expansion Granted at High Court', *BBC News* (31 January 2023), https://www.bbc.co.uk/news/uk-england-bristol-64465440, accessed 7 November 2023

Figure 7-4: DfT updated passenger forecasts (compound annual growth rates)



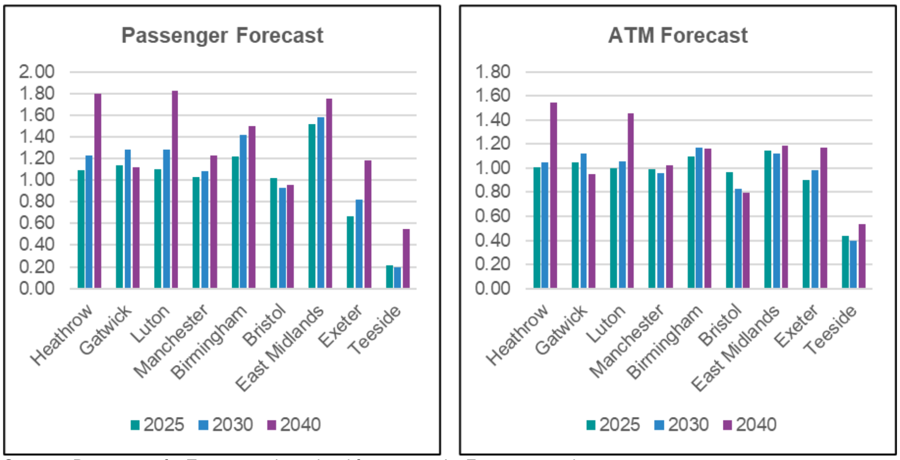
Source: Department for Transport, airport level forecasts – Jet Zero strategy dataset

Figure 7-5: DfT updated ATM forecasts (compound annual growth rates)



Source: Department for Transport, airport level forecasts – Jet Zero strategy dataset

Figure 7-6: DfT forecasts, scaled to 1.0 in 2019



Source: Department for Transport, airport level forecasts – Jet Zero strategy dataset

Table 7-3: DfT passenger forecasts (millions)

	Heathrow	Gatwick	Luton	Manchester	Birmingham	Bristol	East Midlands	Exeter	Teesside	Newcastle
2025	89.91	54.07	19.04	30.07	13.54	8.57	8.17	0.64	0.04	5.44
2030	101.45	60.75	22.23	31.55	15.74	7.76	8.51	0.78	0.03	5.57
2040	147.94	53.02	31.7	35.72	16.65	7.99	9.42	1.13	0.09	6.19

Source: Department for Transport, airport level forecasts – Jet Zero strategy dataset

Table 7-4: DfT ATM forecasts (thousands)

	Heathrow	Gatwick	Luton	Manchester	Birmingham	Bristol	East Midlands	Exeter	Teesside	Newcastle
2025	479,083	301,966	119,970	199,615	102,495	58,003	72,692	11,955	1,764	44,106
2030	502,011	322,730	127,196	193,255	109,220	49,592	71,420	12,989	1,606	42,531
2040	738,420	274,328	175,016	205,738	108,996	47,405	75,470	15,489	2,188	45,883

Source: Department for Transport, airport level forecasts – Jet Zero strategy dataset

C.4 Key demand, constraints and assumptions for modelling

The scope of the work undertaken did not include a requirement to develop new independent forecasts for the English airports. For consistency with past forecasts, partially updated forecast numbers provided by the DfT have been used for modelling purposes. These are broadly in line with the high ambition scenario presented in the Jet Zero strategy and are based on the 2017 forecast, with updated assumptions for the capacity and fleet mix and updated GDP inputs that take account of the impact of Covid-19.

D. ACI carbon accreditation and status of the English airports

D.1 Decarbonisation status

The Airports Council International (ACI) publishes the Airport Carbon Accreditation (ACA), which is a global standard for aviation's management of carbon that assesses and recognises the efforts of airports to manage and reduce carbon emissions. It is a voluntary emissions reporting methodology and is not required by UK legislation to be disclosed. The standard was developed in line with the GHG Protocol and ISO14064.[30] It defines six levels of accreditation to encourage airports to improve their carbon management, with an airport's application for initial accreditation and subsequent monitoring being subject to independent assessment.

Table 7-5: Emissions sources and reporting requirements at levels 1 to 4 below summarises the reporting requirements for the six accreditation levels:

- Level 1 (mapping) – carbon footprint and policy
- Level 2 (reduction) – emissions reduction target, carbon management plan and annual reductions
- Level 3 (optimisation) – engagement with third parties and measurement of their emissions
- Level 3+ (neutrality) – offsetting of residual scope 1 and 2 emissions
- Level 4 (transformation) – extended carbon footprint, absolute emissions reduction in line with the Paris Agreement and enhanced third party engagement
- Level 4+ (transition) – offsetting of residual scope 1 and 2 emissions

While many airports provide detailed emissions reporting in their annual reports and community social responsibility statements or in separate environmental reporting, ACI carbon accreditation is important as it provides a parallel framework for the reporting of carbon reduction and mitigation and a convenient public understanding and attestation of an airport's commitment and progress. To quote the ACI:

"Airport Carbon Accreditation is the only institutional endorsed carbon certification programme for airports. […] It is also the only airport-specific carbon standard which relies on internationally recognised methodologies. It provides airports with a common framework for active carbon management with measurable goalposts. [It is] site-specific, allowing flexibility to take account of national or local legal arrangements that individual airport operators have to comply with."

Apart from independently verified public evidence of commitment and progress in reporting terms, its importance lies in the requirement for data collection and verification, providing a basis for identifying and prioritising areas for emissions reduction against a set of comparative best practice benchmarks.

[30] Airport Carbon Accreditation, *Annual Report 2021-2022* (ACI, 2022)

Table 7-5: Emissions sources and reporting requirements at levels 1 to 4[31]

<table>
<tr><th>Emissions source</th><th>Level 1 (mapping)</th><th>Level 2 (reduction)</th><th>Level 3 (optimisation)
Level 3+ (neutrality)</th><th>Level 4 (transformation)
Level 4+ (transition)</th></tr>
<tr><td>Vehicles and machinery, including ground support equipment</td><td colspan="2" rowspan="6">Scope 1</td><td rowspan="4">Scopes 1 & 3</td><td rowspan="6">Scopes 1 & 3</td></tr>
<tr><td>Fuel used for fire training, including hand-held extinguishers</td></tr>
<tr><td>Emergency generators</td></tr>
<tr><td>Furnaces, boiler houses, energy plants</td></tr>
<tr><td>Solid waste processing, scope 1</td><td rowspan="2">Scopes 1 & 3 voluntary</td></tr>
<tr><td>Wastewater (sewage) processing</td></tr>
<tr><td>Non-road construction machinery and equipment (contracted)</td><td colspan="3">-</td><td>Scope 3</td></tr>
<tr><td>De-icing substances for surface and aircraft de-icing</td><td colspan="3" rowspan="2">-</td><td>Scopes 1 & 3</td></tr>
<tr><td>Refrigerant losses</td><td>Scopes 1 & 3 (voluntary)</td></tr>
<tr><td>Electricity produced or purchased from offsite generation</td><td colspan="2" rowspan="2">Scope 2</td><td colspan="2" rowspan="2">Scopes 2 & 3</td></tr>
<tr><td>Heating or cooling generated offsite and/or resold onsite</td></tr>
<tr><td>Aircraft main engine fuel (LTO only)</td><td colspan="2">-</td><td>Scope 3</td><td>-</td></tr>
<tr><td>Aircraft main engine fuel (full flight, on halfway or one-way method)</td><td colspan="3">-</td><td>Scope 3</td></tr>
<tr><td>Aircraft APU fuel use</td><td colspan="2" rowspan="5">-</td><td colspan="2" rowspan="5">Scope 3</td></tr>
<tr><td>Aircraft APU fuel use – scope 3 aircraft engine maintenance (run-ups)</td></tr>
<tr><td>Landside vehicle access (origin to destination and back)</td></tr>
<tr><td>Landside train or rail access</td></tr>
<tr><td>Company staff business travel (all modes)</td></tr>
<tr><td>Landside maritime access</td><td colspan="3">-</td><td>Scope 3</td></tr>
</table>

Source: Airport Carbon Accreditation, 'How to Apply', *ACA* (ACI Europe, 2020)

[31] Airport Carbon Accreditation, 'How to Apply' (ACI Europe, 2020), https://www.airportcarbonaccreditation.org/airport/technical-documents.html, accessed 7 November 2023

In 2021-2022, 17 of a possible 28 English airports achieved one of the Airport Carbon Accreditation levels. These are described in table 7-6 below.

Of these airports, nine have achieved level 3 or above, where the airport is considering scope 3 emissions and developing a stakeholder engagement plan to reduce wider airport emissions.

Table 7-6: Extracted accredited airports list for England

Level	Airport	Code	Type
4+	London Heathrow Airport	LHR	Upgrade
3+	London Gatwick Airport	LGW	Renewal
3+	Manchester Airport	MAN	Renewal
3+	London Stansted Airport	STN	Renewal
3	London Luton Airport	LTN	Upgrade
3+	Bristol Airport	BRS	Renewal*
1	Newcastle International Airport	NCL	Entry
3+	London City Airport	LCY	Renewal
3+	East Midlands Airport	EMA	Renewal
2	Leeds Bradford International Airport	LBA	Upgrade
1	London Southend Airport	SEN	Entry
2	Southampton International Airport	SOU	Renewal
1	Exeter Airport	EXT	Entry
1	Bournemouth International Airport	BOH	Entry
1	Norwich Airport	NWI	Entry
1	Cornwall Airport Newquay	NQY	Renewal*
3+	Farnborough Airport	FAB	Renewal

* Covid-19 had a significant impact on the operations of some airports. As a result, some airports have been delayed in submitting data for the latest year, with the renewal of the accreditation also being delayed. In these cases, the annual report uses the most recent available data as reported by these airports.

Source: Airport Carbon Accreditation, *Annual Report 2021-2022* (ACI, 2022)

Heathrow Airport has been upgraded to a level 4+ in 2021/22, demonstrating its commitment to decarbonisation with policy decisions, development of a carbon management plan and a long term emissions reduction target. The other airports classed as large have achieved a renewal of their level 3+ accreditation.

In the medium airport category, Bristol Airport and London City Airport were accredited again with a level 3+ as they are offsetting their residual emissions on top of the activities in level 3. ACI upgraded London Luton Airport's accreditation to level 3, reflecting its engagement with third parties and measuring its emissions. Newcastle Airport has achieved its first ACI accreditation with a level 1.

The small airports have a mix of accreditation from level 1 to level 3+. East Midlands' level 3+ accreditation was renewed and Exeter, like Newcastle, achieved its first ACI accreditation with a level 1. Teesside has not yet been accredited by ACI.

D.2 Limitations of the current emissions reporting legislation

In closing this appendix, attention is drawn to three remaining issues:

Zero emissions versus net zero

To reach net zero emissions at the corporate level, companies must achieve a scale of value chain emissions reduction. This must be consistent with the depth of abatement achieved in pathways that limit warming to 1.5°C with no or limited overshoot and neutralise the impact of any source of residual emissions that remain unfeasible to be eliminated.

(Absolute) zero emissions is all activities under direct control of the airport and its users producing zero measurable emissions, contributing nothing to global GHG levels and requiring no offsets to achieve this balance. For the majority of airports analysed, targets centred around net zero with an understanding that an element of residual emissions will remain. Any future targets around zero carbon airports should ensure that the definition of zero is clearly set out, so companies can correctly align their trajectories.

Emissions reporting standards

Under the current SECR legislation, English airports have to report their GHG emissions annually. However, the reporting methodology under the SECR legislation is dependent on airports using independent standards for disclosure, such as the GHG Protocol Corporate Standard, ISO14064-1:2018 and the Climate Disclosure Standards Board. The SECR legislation provides flexibility in the reporting standard being used and, even though the reporting methodologies may be closely aligned, this poses a risk of inconsistent emissions reporting when emissions between airports are compared.

The ACA may currently offer the best scope boundaries and definitions in relation to airport-specific activities since it states: "The programme has adopted the principles of the GHG Protocol to ensure that the reported information is a fair representation of an airport's emissions."[32] This is also because confidence in the ACA programme is implied through its institutional endorsements. An example of airport-specific activities that have been defined by the ACA is: "Emissions from fuel sold by the airport to third parties for use in their operations (eg vehicles, equipment) shall not be part of scope 1 emissions. They shall be included in scope 3 emissions."[33] The ACA approach may offer the best basis on which to develop reporting requirements and scope boundaries for airport related activities in the UK.

Defining the airport boundary

Another risk present is the boundary between the two scopes of indirect GHG emissions (scope 2 and 3). While the independent standards have definitions and boundaries for the emission scopes, in the airport environment there is a risk of boundaries overlapping which may impact emissions reporting, especially due to the blend of in-house and outsourced activities in the airport.

As scope 3 emissions make up the majority of an airport's GHG emissions, it poses a risk of incorrect and inaccurate reporting as airports will rely on third parties for the reporting of emissions. A particular challenge for airports is the use of third party suppliers, which may not be consistent across airports. For example, an airport may have an in-house managed security team with access to fuel data, whereas another site may outsource security and may not have the same access to such data.

In the former case, the security emissions would sit in scope 1, but for the latter they would be categorised as scope 3. However, for the government, there is a clear drive to decarbonise this area of

[32] Ibid
[33] Ibid

operation, so for one airport this will be mainly in-house through new equipment and behaviour change and for the other entirely external through contract management and indirect influence.

E. Airport reported emissions data

E.1 Analysis of airport emissions

This section updates the previous 2019 baseline data for England's 10 largest airports contained in the previous Mott MacDonald report prepared for Connected Places Catapult,[34] with a comparison to their most recent emissions reporting figures, generally 2021/22. It builds on the airport descriptions in the previous report, highlighting new information which has been published since February 2022. Emissions data has been included to demonstrate the current state of affairs for airports, as well as inconsistencies around emissions reporting and context.

E.2 Heathrow Airport

Heathrow's plan to deliver net zero is outlined in its 2022 Heathrow Net Zero Plan.[35]

In 2019 Heathrow Airport published the *Heathrow 2.0 2019 Sustainability Progress* report,[36] and it released an updated report in 2022 called *Heathrow's Sustainability Report 2022*.[37] Within this, it made a few clarifications and modifications:

- In 2019, it committed to "accelerate the production and use of sustainable alternative fuels (SAFs)".[38] It has shown its commitment in 2022 by stating: "At least 0.5% of fuel delivered to airlines at Heathrow during the year was sustainable aviation fuel."[39]
- In 2019, emissions reporting followed the GHG Protocol and ACA guidelines. In 2022, it continues to follow these guidelines.
- In 2019, it stated that the target net zero plan was centred on eliminating carbon on the ground, from its own assets and those of its partners, and eliminating carbon in the air. However, in 2022, it has shown that its goals are to cut carbon in the air and on the ground, with additional targets relating to reductions in specific sources of emissions. It has brought clarity by mapping out goals and targets to the GHG Protocol scopes, in the air emissions being entirely part of the GHG Protocol scope 3 emissions.
- In 2022, a new sustainable travel zone has been introduced to bring together the ways Heathrow employees travel to work more sustainably, including enhancements to 14 local bus and coach routes.
- In 2019, the plan for investment into decarbonisation was not stated but, in 2022, it clarifies a £200M investment in decarbonisation for its next five-year business plan, backed by the CAA.

[34] Mott MacDonald, *Feasibility of Zero Emissions Airport Operations in England by 2040* (April 2022)

[35] Heathrow Airport, *Heathrow's Net Zero Plan* (February 2022), https://www.heathrow.com/content/dam/heathrow/web/common/documents/company/heathrow-2-0-sustainability/futher-reading/Heathrow%20Net%20Zero%20Plan%20FINAL.pdf, accessed 8 November 2023

[36] Heathrow Airport, *Heathrow 2.0 2019 Sustainability Progress* (2020), https://www.heathrow.com/content/dam/heathrow/web/common/documents/company/heathrow-2-0-sustainability/futher-reading/Sustainability-Report-2019.pdf?msclkid=1e61b367b0f811ec95d71aa0c3df8eb7, accessed 8 November 2023

[37] Heathrow Airport, *Heathrow's Sustainability Report 2022* (March 2023), https://www.heathrow.com/content/dam/heathrow/web/common/documents/company/heathrow-2-0-sustainability/futher-reading/Heathrows_Sustainability_Report_2022.pdf, accessed 8 November 2023

[38] Heathrow Airport, *Heathrow 2.0 2019 Sustainability Progress* (2020)

[39] Heathrow Airport, *Heathrow's Sustainability Report 2022* (March 2023)

E.3 Gatwick Airport

In 2019, Gatwick Airport published its *Decade of Change: 2019 Performance Report*.[40] It released an updated report in 2021 called *Sustainability Policy: Our Second Decade of Change to 2030*.[41] Within this, it has made a few clarifications and modifications:

- In 2019, Gatwick retained level 3+ (neutral) ACA accreditation, an 8% reduction in emissions from fuel and energy showing that it was halfway to net zero for its own operations. It also stated that the path from carbon neutral to net zero operations was going to require continued focus on energy efficiency and electrification (where feasible) of heating, cooling, vehicles and equipment. In 2021, it has shown its commitment by sourcing 50% of airport network electricity and 50% of heat network from UK renewable sources via onsite generation and direct purchase agreements (PPAs), requiring all Gatwick Airport (GAL) and airport duty vehicles, ground support equipment and mobile construction equipment to meet zero or ultra-low emission standards. This is the goal stated to achieve Net Zero for GAL Scope 1 and 2 GHG emissions by 2030.
- In 2021, it has shown its commitment by working with transport partners to increase airport passenger and staff usage of public transport and zero and ultra-low emissions journey modes to 60% by 2030. This compares with 2019, when it stated its investment in electric vehicle infrastructure for airport operations and public transport but did not go into detail on what the target percentage goal was.
- Full accounts state that the board is committed to promoting long term sustainable success by identifying opportunities to create and preserve value and establishing oversight for identification and mitigation of risk. Four growing areas of focus for the board are: extension of commitments regulatory framework; managing the impact of Covid; delivering sustainable growth by engaging and delivering stakeholders; and maintaining an effective risk management culture and internal control environment.[42]

Commented [SW1]: New acronym, needs spelling out in the first instance

E.4 Manchester Airport

Manchester Airports Group (MAG) outlined its decarbonisation plans in the Manchester Airport Group 2021/2022 CSR Strategy.[43]

Since the 2020/2021 CSR report, Manchester Airport Group (MAG) has reported:

- 1.7% increase in the use of renewable energy
- 7.3% reduction in gross location-based emissions
- 52% reduction in the location-based intensity ratio
- 3.9% reduction in gross market-based emissions
- 53% reduction in the market-based intensity ratio

Manchester Airports Group holds ACI accreditation at level 3+ (neutrality).

[40] Gatwick Airport, *Decade of Change: 2019 Performance Report* (June 2020), https://www.gatwickairport.com/globalassets/company/sustainability/reports/2019/2019-decade-of-change-report.pdf, accessed 8 November 2023

[41] Gatwick Airport, *Sustainability Policy: Our Second Decade of Change to 2030* (June 2021), https://www.gatwickairport.com/on/demandware.static/-/Sites-Gatwick-Library/default/dw10c8906f/images/Corporate-PDFs/Sustainability/Second_Decade_of_change_policy_to_2030.pdf, accessed 8 November 2023

[42] Full accounts for 2020 available at https://find-and-update.company-information.service.gov.uk/company/01991018/filing-history, accessed 8 November 2023

[43] Manchester Airports Group, *Working Together for a Brighter Future: Our 2021/2022 Corporate Social Responsibility Report* (2022), https://www.magairports.com/media/1805/mag_csr_interactive_final.pdf, accessed 8 November 2023

The CSR and future airspace director mentioned that Manchester Airports Group was hoping to "make progress in the airspace modernisation programmes" and deliver "on the pledges set by MAG to support the government's Jet Zero strategy".

E.5 London Luton Airport

London Luton Airport has committed to achieving carbon neutrality by 2026 or sooner and net zero by 2040, as outlined in its *Net Zero 2040* plan[44] published in 2020. Since its publication, London Luton Airport has launched the DART (direct air-rail transit) line to replace the shuttle bus service from Luton Airport Parkway rail station to the main terminal.

E.6 Birmingham Airport

Birmingham Airport outlines its strategy to achieve a net zero carbon airport in its *Sustainability Strategy 2020-2025*,[45] published in 2020.

The aim is to be a net zero carbon airport by 2033.

Scope 1 and 2 emissions reduction actions are:

- Implement a carbon management plan to deliver a roadmap to become a net zero carbon airport by 2033, prioritising zero carbon airport operations and minimising carbon offsets
- Annual carbon emissions reporting
- Review of energy efficiency investment
- Replace all lighting with LED where possible
- Install solar controlled window film on airport buildings
- Develop a heating and cooling and ventilation strategy to improve energy efficiency
- Onsite generation of renewable energy
- Develop energy and sustainable building standards and monitor implementation

- Scope 3 emissions reduction actions are:
  - Encourage transition to electric vehicles for airport vehicle fleet
  - Provide additional EV infrastructure for use by passengers and staff
  - Encourage modal shift of transport to and from the airport, target 35% public transport modal share by 2030 and improve cycling routes and bicycle parking provision
  - Collaborate with NATS and the Civil Aviation Authority to identify and deliver changes to airspace to reduce aircraft operation emissions

Commented [SW2]: New acronym, needs spelling out in the first instance

E.7 Bristol Airport

Bristol Airport outlines its net zero target in its 2019 carbon roadmaps document.[46]

- Scope 1 and 2 targets are:
  - Be carbon neutral by 2025
  - Be net zero by 2050
- Scope 3 targets are:

[44] London Luton, *Net Zero 2040: Reducing Our Carbon Emissions* (2020), https://www.london-luton.co.uk/LondonLuton/files/af/af6067e9-0fd6-438d-ac28-8a1c1423d8e6.pdf, accessed 8 November 2023

[45] Birmingham Airport, *Sustainability Strategy 2020-2050* (2020), https://www.birminghamairport.co.uk/media/5975/mb22164_airport-sustainability-strategy-booklet_v8-3.pdf, accessed 8 November 2023

[46] Bristol Airport, *Becoming a Net Zero Airport: Our Roadmap to Reduced Carbon Emissions* (2019), https://www.bristolairport.co.uk/media/4gxh01b1/bristol_airport_carbon_road_map.pdf, accessed 8 November 2023

- Be carbon neutral by 2020 for journeys to and from the airport
- Stabilise net carbon emissions from flights at 2020 levels through implementation of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

Bristol Airport holds ACI accreditation at level 3+ (neutrality).

E.8 Newcastle Airport

Newcastle Airport remains committed to its *Net Zero Carbon 2035* strategy,[47] which was published in 2020. Work has continued with energy efficiency measures, a planning application for a possible solar farm investment and planning for a large area of woodland planting. The main electricity supply for the airport moved to a renewable contract from October 2021. The airport has continued to manage its pollution control system, ensuring compliance with its Environment Agency water discharge consents, and diverting waste from landfill by recycling or generating energy from waste.[48]

E.9 London City Airport

London City Airport's ACI level 3+ accreditation (carbon neutrality) was retained and reconfirmed in January 2022. Its electricity contract is solely sourced from renewable energy and, during 2021, the initial set of photovoltaic panels was added to the roof of the temporary immigration centre. By the end of 2021, a number of electric vehicle charging points had been installed as a trial to allow assessment of the preferred type and typical usage before completion of a further rollout. London City Airport also introduced an electric car leasing scheme for its employees to encourage the transfer to electric vehicles for those unable to use public transport. Trials of electric buses have been carried out during 2021, along with implementation of electric ground power units.

E.10 Liverpool John Lennon Airport

The airport has set an annual carbon reduction target of 3% in its *Masterplan to 2050* document, published in 2018.[49] It will develop a carbon management plan to mitigate and reduce the construction and operation emissions of its expansion, with additional scope to reduce emissions significantly further. Following the government's CRC (Carbon Reduction Commitment) Energy Efficiency Scheme Order 2018 coming into force on 1 October 2018, the group recognised its duty under the CRC to record and report the annual CO_2 emissions of its operations.

E.11 Data summary tables

The following scope 1, 2 and 3 emissions data for the 10 largest airports in England, shown in table 7-7 below, was obtained from the airports' official accounts disclosures and annual reports:

[47] Newcastle International, *Net Zero Carbon 2035* (2020), https://www.newcastleairport.com/about-your-airport/environment/net-zero-carbon-2035/, accessed 8 November 2023

[48] Full accounts for 2021 available at: https://find-and-update.company-information.service.gov.uk/company/02077766/filing-history, accessed 8 November 2023

[49] Liverpool John Lennon Airport, *Master Plan to 2050* (February 2018), https://www.liverpoolairport.com/media/2953/liverpool-john-lennon-airport-master-plan-to-2050-consultation-report-february-2018.pdf, accessed 8 November 2023)

Table 7-7: Scope 1 emissions for airports reporting for each calendar year starting in 2019

	2019	2020	2021	2022
Heathrow Airport[50]	26,998	23,209	29,091	29,806
Gatwick Airport[51]	12,223	7,778	10,163	N/A
Manchester Airport* [52] [53]	9,681	9,008	8,719	9,562
Stansted Airport* [54] [55]	3,302	3,516	3,814	2,939
London Luton Airport[56]	2,965	2,325	2,321	N/A
Birmingham Airport* [57] [58]	5,309	4,319	3,431	4,087
Bristol Airport[59]	N/A	1,086	828	N/A
Newcastle Airport[60] [61]	2,049	1,125	803	N/A
Liverpool John Lennon Airport* [62] [63]	N/A	1,272	569	883
London City Airport[64]	712	275	137	N/A

Source: Various reports

* Reporting for the financial year

[50] Heathrow Airport, *Heathrow's Sustainability Report 2022* (March 2023)

[51] Gatwick Airport, *Decade of Change: 2019 Performance Report* (June 2020)

[52] Manchester Airports Group, *MAG Greenhouse Gas Emissions Report 2021/22* (2022), mag-emissions-report-2021-22_final.pdf, accessed 8 November 2023

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[55] MAG GHG Emission report, 2019/20 Available at: https://www.magairports.com/media/1688/mag-emissions-report_2019-20_final.pdf (Accessed April 2023)

[56] London Luton Airport, *Sustainability Report 2021* (2021), https://www.london-luton.co.uk/LondonLuton/files/bc/bcda7bc7-2cb8-4d1d-89b2-7c98e6a1cc86.pdf, accessed 8 November 2023

[57] Birmingham Airport, *Greenhouse Gas Emissions Report 2021/22* (2022), https://www.birminghamairport.co.uk/media/6853/greenhouse-gas-emissions-report-2021-22.pdf, accessed 8 November 2023

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[59] Bristol Airport, *Annual Monitoring Report 2021* (n.d.), https://www.bristolairport.co.uk/media/paslvh3b/annual-monitoring-report-2021.pdf, accessed 8 November 2023

[60] Full accounts 2021 available at https://find-and-update.company-information.service.gov.uk/company/02077766/filing-history, accessed 8 November 2023

[61] Newcastle International, *Net Zero Carbon 2035* (2020)

[62] Full accounts 2021 available at https://find-and-update.company-information.service.gov.uk/company/02116704/filing-history, accessed 8 November 2023

[63] Full accounts 2020 available at https://find-and-update.company-information.service.gov.uk/company/02116704/filing-history, accessed 8 November 2023

[64] Full accounts 2021 available at https://find-and-update.company-information.service.gov.uk/company/01963361/filing-history, accessed 8 November 2023

Table 7-8: Scope 2 emissions for airports reporting for each calendar year starting in 2019 or financial year starting in 2018-2019

	2019		2020		2021		2022	
Airport	Location-based	Market-based	Location-based	Market-based	Location-based	Market-based	Location-based	Market-based
Heathrow Airport	0		0		0		0	
Gatwick Airport	25,443	5	15,394	0	13,024	128	N/A	
Manchester Airport*	18,622	0	18,399	0	13,675	0	13,890	0
Stansted Airport*	12,071	0	11,189	0	7,870	0	7,106	0
London Luton Airport	4,981	6,772	3,418	5,059	3,538	1,332	N/A	
Birmingham Airport*	11383	5996			4218		4518	
Bristol Airport	N/A		2,724		2,219		N/A	
Newcastle Airport	3,662		1,256		1,290		N/A	
Liverpool John Lennon Airport	N/A	1,588			1,048		1,196	
London City Airport	2,566	3,769	1,945	1,482	1,767	377	N/A	

Source: Various reports

* Reporting for the financial year

Table 7-9: Scope 3 emissions for airports reporting for each calendar year starting in 2019 or financial year starting in 2018-2019

	2019		2020		2021		2022	
Airport	Location-based	Market-based	Location-based	Market-based	Location-based	Market-based	Location-based	Market-based
Heathrow Airport	20,782,751		8,845,890		8,125,487		14,734,239	
Gatwick Airport	696,628	683,512	193,125	193,126	136,973	131,087	N/A	
Manchester Airport*	3,408,320	3,395,385	3,422,995	3,411,822	665,356	658,955	1,489,801	1,482,139
Stansted Airport*	2,204,132	2,193,754	2,213,343	2,193,550	499,019	493,715	1,148,139	1,142,254
London Luton Airport	278,269	275,012	109,093	92,971	93,845	82,082	N/A	
Birmingham Airport*	259,216		N/A		N/A		77,928	
Bristol Airport	N/A		N/A		139,015		N/A	
Newcastle Airport	75,192		N/A		N/A		N/A	

Liverpool John Lennon Airport*	N/A	N/A	N/A	N/A
London City Airport	68,284	N/A	N/A	N/A

Source: Various reports

* Reporting for the financial year

E.12 Passenger numbers and intensity ratio

All passenger numbers were obtained from the UK Civil Aviation Authority (CAA).[65] Intensity ratios are used in defining emissions data in relation to an appropriate business metric. In this report, the intensity ratio is in tCO_2e per 1000 passengers. The intensity ratios were obtained from the airports' official accounts disclosures and annual reports. It should be noted that scope 3 emissions have not been included in the intensity ratios and, where applicable, market-based intensity ratios have been used.

Table 7-4: Passenger numbers and intensity ratios for airports reporting for each calendar year starting in 2019 or financial year starting in 2018-2019

	Passenger numbers ('000)				Intensity ratio (tCO_2e /1000 passengers)			
Airport	2019	2020	2021	2022	2019	2020	2021	2022
Heathrow Airport	80,887	22,110	19,392	61,597	0.33	1.05	1.50	N/A
Gatwick Airport	46,575	10,172	6,260	32,831	0.81	2.30	0.75	3.71
Manchester Airport*	29,367	7,029	6,083	23,340	0.33	0.31	2.95	2.31
Stansted Airport*	28,124	7,537	7,146	23,290	0.11	0.12	0.74	0.23
London Luton Airport	14,734	5,550	4,674	13,322	1.51	0.75	1.30	N/A
Birmingham Airport*	12,646	2,866	2,477	9,596	0.85	7.81	2.34	N/A
Bristol Airport	8,960	2,193	2,086	7,945	0.64	1.73	1.46	N/A
Newcastle Airport	5,199	1,061	1,023	4,127	N/A	2.20	2.00	N/A
Liverpool John Lennon Airport*	5,044	1,338	1,166	3,491	N/A	0.59	3.00	1.27
London City Airport	5,122	908	721	3,009	0.70	1.94	0.71	N/A

Source: Various reports

* Reporting for the financial year

[65] Civil Aviation Authority, 'UK Airport Data 2023', *CAA*, https://www.caa.co.uk/data-and-analysis/uk-aviation-market/airports/uk-airport-data, accessed 8 November 2023

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