Aviation Decarbonisation

Monitoring and Evaluation Framework

March 2025

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Aviation Decarbonisation

Monitoring and Evaluation Framework

A report submitted by ICF Consulting Services Limited

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Abbreviations and acronyms	
ACOG	Airspace Change Organising Group
ANSP	Air Navigation Service Provider
ATI	Aerospace Technology Institute
CA	Contribution Analysis
CAA	Civil Aviation Authority
CCC	Climate Change Committee
CCUS	Carbon Capture, Utilisation and Storage
CIE	Counterfactual Impact Evaluation
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO2e	Estimated Carbon Dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
DBT	Department for Business and Trade
Defra	Department for the Environment, Food and Rural Affairs
DESNZ	Department for Energy Security and Net Zero
DfT	Department for Transport
ETS	Emissions Trading Scheme
FASI	Future Airspace Strategy Implementation
FE	Further Education
FRA	Free Route Airspace
FTE	Full Time Equivalent
GGRs	Greenhouse Gas Removals
GVA	Gross Value Added
HE	Higher Education
ICAO	International Civil Aviation Organisation
M&E	Monitoring and Evaluation
M&R	Markets and Removals
MI	Management Information
MRV	Measurement, Reporting and Verification
MtCO2e	Million Tonnes of Carbon Dioxide Equivalent
NATS	National Air Traffic Services
NOx	Nitrogen Oxides
PCA	Pre-Conditioned Air
PSO	Public Service Obligations
PT	Process Tracing
R&D	Research and Development

Abbreviations and acronyms	
ROAMEF	Rationale, Objectives, Appraisal, Monitoring, Evaluation and Feedback
SAF	Sustainable Aviation Fuels
SMS	Scientific Maryland Scale
SO_2	Sulphur Dioxide
ToC	Theory of Change
TRL	Technology Readiness Level
UK	United Kingdom
UKADS	UK Airspace Design Service
ZEF	Zero Emission Flight

1 Introduction

The Department for Transport (DfT) commissioned ICF to develop a monitoring and evaluation (M&E) framework for activities relating to the decarbonisation of the aviation sector, and its contribution to the economy-wide achievement of net zero by 2050. This document presents the M&E framework, which describes high-level approaches to monitoring and evaluation, sets out theories of change for aviation decarbonisation activities as a whole and for five policy areas, and presents the key monitoring indicators and evaluation questions. It is important to note that the M&E framework provides broad coverage of aviation decarbonisation activities and intended outcomes, including many for which delivery is outside of DfT's control and likely to be influenced by external factors. Its purpose is to take a whole sector perspective to inform where government policy is best focused.

1.1 Context

The UK Government aims to decarbonise the UK aviation sector and achieve an economy-wide target of net zero carbon emissions by 2050. In June 2019, the UK became the first major economy in the world to set a legally binding target to reduce greenhouse gas emissions to net zero by 2050[1]. As well as contributing to this national goal, the aviation sector is also subject to a long-term global aspirational goal of net zero carbon emissions by 2050 that was adopted by International Civil Aviation Organisation (ICAO) Member States in 2022[2].

Between 1990 and 2019, the total carbon emissions from UK aviation more than doubled, but due to the ongoing work to improve efficiency in the sector, carbon emissions per passenger reduced by 22% over the same period[3]. However, significant emissions reductions are still needed for aviation to play its role in achieving net zero targets by 2050. The scale of the challenge is considerable as aviation is a 'hard to decarbonise' sector and has unique impacts on the climate in the form of non-CO_2 emissions delivered at altitude.

There are multiple pathways and solutions that could contribute to reducing these climate impacts. The scope of this framework largely focuses on the development and deployment of technological measures to reduce emissions from the aviation sector. It also covers carbon markets, which provide a well-established mechanism for controlling emissions in the aviation industry. Other measures, including those aimed at influencing consumers and direct demand management measures, are not included within this framework but may be subject to M&E activities in the future.

This M&E framework focuses on the five policy areas set out below. Each area represents a range of activities and enablers that could be utilised to reduce aviation's climate impact. It is important to note that some, but not all,

[1] https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law

[2] https://www.icao.int/Newsroom/Pages/States-adopts-netzero-2050-aspirational-goal-for-international-flight-operations.aspx

[3] https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2022

of these activities and enablers are currently covered by government policy, and the framework takes a 'whole sector' view to identify and better understand the areas where interventions are required and how they can be delivered to best achieve aviation decarbonisation objectives.

- **System efficiencies** - improving the efficiency of the existing aviation system (including aircraft, airlines, airports and airspace).
- **Sustainable aviation fuels (SAF)** - stimulating demand for SAF, whilst building a UK SAF industry to support commercialisation of SAF supply.
- **Zero emission flight (ZEF)** - developing and commercialising aircraft and technologies in the UK that offer zero carbon tailpipe emissions.
- **Markets and removals** - creating carbon markets and investing in greenhouse gas removals (GGRs) to compensate for residual emissions in 2050.
- **Addressing non-CO_2** - working with academia and industry to better understand the science and develop potential mitigation options for addressing aviation's non-CO_2 impacts.

The achievement of aviation decarbonisation objectives will require action across these different policy areas, supported by:

- **Joint working across government, industry and academia**: Collaboration and joint working across all parts of the aviation sector and different partners to develop, test, implement and invest in the required solutions.
- **International leadership and collaboration**: Leading coordinated global efforts to tackle international aviation emissions, including through the UK's role and ongoing work in ICAO.

While contributing to the delivery of the UK's net zero target is the primary objective of aviation decarbonisation, the activities delivered within these policy areas are also expected to deliver additional benefits for the environment, boost the economy, create new jobs, promote energy security and increase resilience.

1.2 Aims and objectives of the M&E framework

The aim of this project was to develop a comprehensive M&E framework to support DfT in understanding aviation decarbonisation activities in the five areas in scope of this work and how they could be monitored and evaluated. This will support DfT to track progress and evaluate the effectiveness of these activities within each policy area and at a total, combined level.

The development of the M&E framework has been guided by a theory of change (ToC), which uses summary logic models to present a visual summary that articulates how aviation decarbonisation activities are expected to affect change and deliver their intended outcomes and impacts. This has helped to identify indicators of the progress and performance of initiatives within each policy area that will need to be monitored over time. It has also helped to explain the theory of how aviation decarbonisation activities are intended to achieve their target outcomes, and helped to identify the causal

links and underlying assumptions that will need to be tested through future evaluation activities.

The structure of aviation decarbonisation activities and initiatives means that the ToCs and the M&E framework need to be presented at two levels: one positioned at the total portfolio level; and another covering the five component policy areas.

1.3 Structure of the framework

The remainder of the framework is structured as follows:

- Section 2 summarises the methodology used to develop this M&E framework including the ToCs and describes high level approaches for monitoring and evaluation.
- Section 3 provides a summary of the ToCs, the priority monitoring indicators and evaluation questions for the five individual policy areas and for aviation decarbonisation as a whole.

There are also five annexes providing: a long list of monitoring indicators for aviation decarbonisation activities and each component policy area (Annex 1); a description of the methodology used to develop and prioritise monitoring indicators (Annex 2); a tool for prioritising the evaluation of aviation decarbonisation sub-measures (Annex 3); evaluation questions covering process, impacts and economic (value for money) evaluation for all policy areas (Annex 4); and a description of high-level options for potential evaluation approaches (Annex 5).

2 Methodology for developing the M&E framework

This section describes the methodology used to develop this M&E framework. It provides an initial overview of the methodology and provides further details for the core tasks of:

- **developing theories of change (ToCs)** for aviation decarbonisation initiatives at a portfolio-level and for the five key policy areas to articulate how they are expected to affect change.
- **developing a high-level monitoring plan** that identifies indicators for monitoring all outputs (i.e. the direct results of activities) and intended outcomes (i.e. the resulting consequences and impacts) in the ToCs and selects a shortlist of high priority indicators that should be the primary focus of monitoring activities.
- **developing a high-level evaluation plan** that defines the scope and purpose of evaluation activities, introduces the core evaluation questions and describes potential approaches for prioritising future evaluations of aviation decarbonisation measures.

2.1 Overview

The M&E framework presented in this report has been developed through the following tasks:

- **Scoping interviews with DfT aviation decarbonisation policy experts.** The scoping interviews provided insights into the development and implementation of aviation decarbonisation initiatives across the five policy areas, including boundaries and interdependencies, the wider context, and existing M&E activities.
- **A review of key documents and data** relating to aviation decarbonisation and the individual policy areas, and other relevant research and evaluation reports. This aimed to provide an understanding of aviation decarbonisation, the five policy areas and the wider policy context, both within the UK and internationally.
- **Development of ToCs**. Information gathered through the scoping interviews and literature review was used to develop draft ToCs for aviation decarbonisation and the five policy areas. The draft ToCs were presented, discussed, and developed through a series of online workshops attended by DfT representatives involved in the development and/or implementation of aviation decarbonisation initiatives, and evaluators and aviation specialists from ICF. The ToCs were revised following the workshop and shared with the attendees and other DfT colleagues for further review, to inform the final versions presented in this report.
- **Development of M&E indicators**. The ToCs show the aviation decarbonisation activities that could be delivered, alongside the direct outputs of those activities and the outcomes that they are intended to

influence and/or deliver (e.g. increased investment in zero carbon and low carbon technologies). Each output and outcome was then assessed to identify potential indicators and data sources that could be used to monitor progress over time, and as a source of evidence to inform evaluation activities.

- **Prioritising M&E activities**. The above tasks identified 32 activities, 52 enablers and 186 outputs and outcomes across the five policy areas and aviation decarbonisation as a whole. It is not feasible for DfT to monitor indicators for all of these outputs and outcomes, and/or evaluate all activities and enablers, so a proportionate approach needs to be applied. This task has identified and selected monitoring indicators that should be prioritised to ensure that monitoring activities are feasible, proportionate and sufficient to capture and track progress of key aspects of aviation decarbonisation over time. It also describes an approach that can be used to prioritise policy measures for evaluation activities in the future.

The results and outputs of the above tasks are presented in this report. It is expected that the framework will require revisions over time and should be accompanied by a detailed implementation plan for evaluation activities, when there is greater understanding of the interventions required to help achieve aviation decarbonisation objectives.

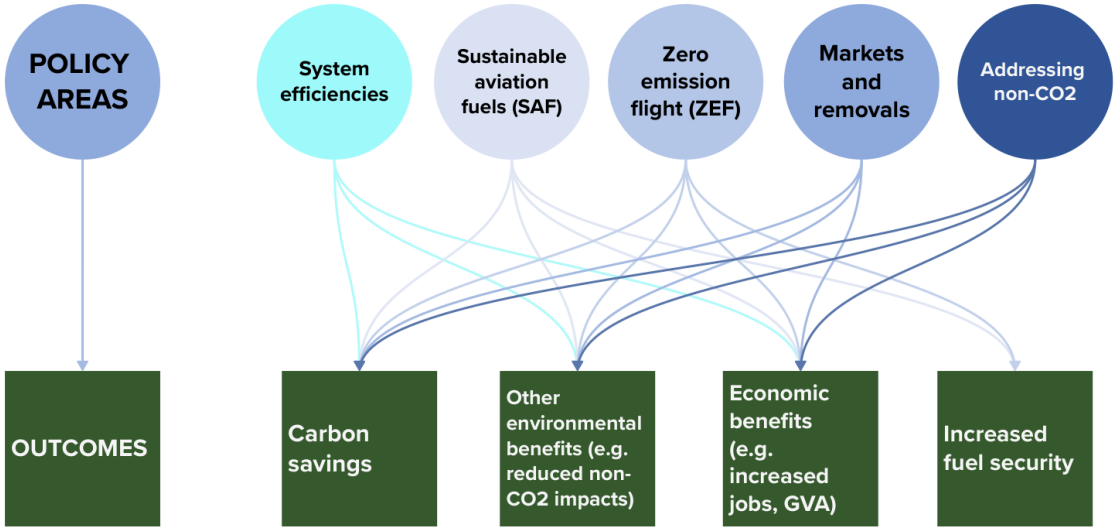
2.2 Developing theories of change (ToCs) for aviation decarbonisation

ToCs have been developed for aviation decarbonisation as a whole and for the five individual policy areas and are included below in Section 3. They are presented as a series of summary logic models that illustrate how aviation decarbonisation activities are expected to deliver their intended outcomes and impacts. The ToCs provide a robust basis for developing the M&E framework and have informed the development of monitoring indicators and evaluation activities described in the following sections. The boxes in each ToC have been numbered so that they can be matched to their respective monitoring indicators as set out in Section 3 and in the tables in Annex 1.

2.2.1 Linkages between policy measures

While the ToCs describe how each policy area is expected to deliver its outputs and outcomes, it is also useful to consider the inter-relationships between policy areas and how they combine to deliver the core objectives of aviation decarbonisation. Figure 2.1 illustrates how the individual policy areas work together to enhance their impacts. It shows how all of the policy measures provide opportunities to deliver economic benefits from delivering activities that will support the transition to net zero, in addition to their expected carbon savings and reductions of non-CO_2 impacts. The development of SAF and hydrogen supply chains also support ambitions for the UK to become a more energy secure nation.

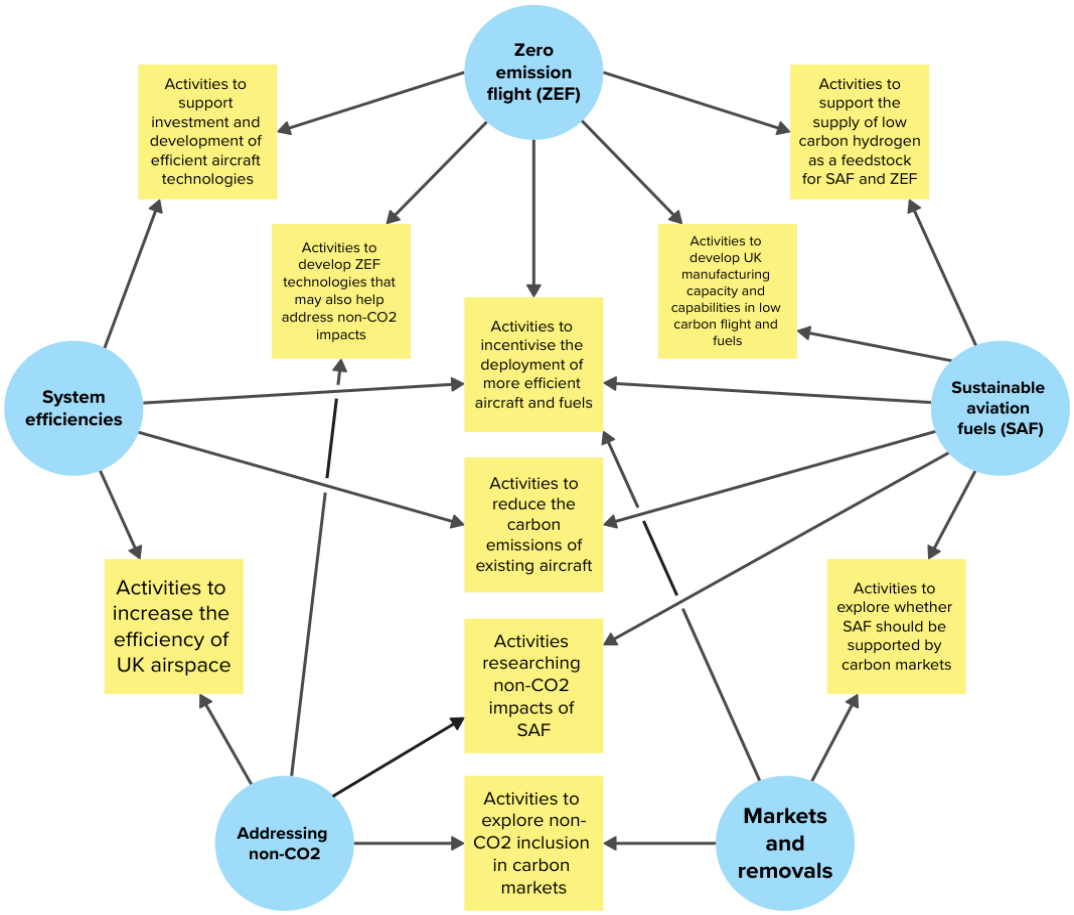
Figure 2.1 Linkages between policy areas and outcomes



The linkages and inter-relationships between policy areas are presented in Figure 2.2. This identifies several shared activities including those aiming to:

- Support investment and the development of more efficient aircraft technologies across existing aircraft designs and future generations of zero emission aircraft.
- Strengthen carbon pricing to provide greater incentives for airlines to adopt and deploy more efficient and less carbon intensive aircraft, fuels, etc.
- Increase the development and use of ZEF technologies that may also help to address non-CO_2 impacts.
- Reduce the carbon emissions of existing aircraft, including the use of SAF.
- Support the development and supply of low carbon hydrogen as a source of feedstocks for SAF and for zero emission aircraft.
- Develop UK capacity and capabilities in the production of zero emission aircraft and low carbon fuels including hydrogen and SAF.
- Support more efficient use of UK airspace, with more direct flights expected to reduce carbon emissions and the potential to also use new routes to reduce non-CO_2 emissions.
- Research and demonstrate the use of SAF, which are also expected to increase understanding of non-CO_2 impacts.
- Develop carbon markets and consider how they should support future SAF uptake and investment, and whether they should be extended to cover non-CO_2 impacts.

Figure 2.2 Inter-relationships between the activities of different policy measures



2.3 Developing an approach for monitoring aviation decarbonisation activities

This section describes the development of a suite of indicators for monitoring the achievement and progress towards the outputs and outcomes of aviation decarbonisation initiatives. It also sets out an approach for prioritising key performance indicators and provides details of potential sources of evidence.

2.3.1 Introduction to monitoring

Monitoring is a key step in the policy cycle. The HM Treasury Green Book[4] uses the acronym ROAMEF to describe the different steps of the policy cycle: Rationale, Objectives, Appraisal, Monitoring, Evaluation and Feedback. It defines monitoring as the collection of qualitative and quantitative data, before, during and after an intervention. DfT's Transport

[4] HM Treasury (2022), The Green Book. Central Government Guidance on Appraisal and Evaluation. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1063330/Green_Book_2022.pdf

Analysis Guidance[5] also describes the importance of monitoring for tracking the progress of the implementation of an intervention by collecting and analysing data on its inputs, outputs and outcomes.

Monitoring should therefore play an important role in tracking the progress of aviation decarbonisation and the individual policy areas over time. It can also help to ensure that initiatives are being delivered effectively, identifying any issues arising and corrective or mitigating actions to support aviation decarbonisation objectives. Monitoring data also provides an important source of evidence for evaluations. Monitoring activity will not only provide valuable data on the inputs, outputs and outcomes of aviation decarbonisation activities, but can also inform the specification of baselines against which to assess impacts.

2.3.2 Monitoring indicators

Monitoring indicators can play an important role in tracking the progress of policy measures over time and for providing evidence for future evaluation activities. A series of monitoring indicators have been developed to provide coverage of all of the outputs (i.e. the direct results of aviation decarbonisation activities) and the intended outcomes (i.e. the resulting consequences and impacts) for each of the policy measures included in the ToCs presented in Section 3. The indicators have been designed to have a clear and explicit relationship with the underpinning ToCs and are directly linked to the numbered boxes in the ToCs.

The full list of potential indicators is included in Annex 1 and provides indicators for all 183 outputs and outcomes that have been identified across the six ToCs. Some of these indicators can be monitored using existing datasets, while others are expected to generate requirements for new research and evaluation activities. Given the large number of potential indicators, it has been necessary to select a subset of high priority indicators to produce a monitoring plan that is feasible and proportionate, yet still provides sufficient coverage for tracking progress across all relevant policy areas. The process used to prioritise indicators is presented in Annex 2, while the selected 'priority' indicators are listed in Section 3 for each policy area.

[5] Department for Transport (November 2022), Transport Analysis Guidance – Unit 1: Evaluation. Available at: https://assets.publishing.service.gov.uk/media/63a32db0e90e07586dacf4e4/TAG_Unit_E1_-_Evaluation_Nov_2022_v1.0.pdf

2.4 Developing an approach for evaluating aviation decarbonisation activities

This section describes an approach that could be used in future to inform evaluations of aviation decarbonisation activities. It covers the purpose and scope of evaluation, introduces potential evaluation questions, and suggests an approach that could be used to prioritise aviation decarbonisation measures for evaluation.

2.4.1 Introduction to evaluation

Evaluation is the systematic assessment of the design, implementation and outcomes of an intervention[6] to test how it was implemented, whether it is working as expected, whether the costs and benefits were as anticipated, and whether there were unexpected consequences. Evaluation also provides a means of informing the ongoing design and delivery of interventions through a process of adaptive management (i.e. learning from experience and adapting delivery in response to challenges and to achieve the best portfolio objectives) as well as identifying lessons to inform and improve other interventions in the future.

Evaluations can employ a variety of analytical methods, the most appropriate of which depend on a range of factors including:

- The nature, scale and complexity of the intervention and its implementation.
- The objectives of the evaluation and the key evaluation questions.
- The timing of key decisions and the information on which they need to be based.
- The types and timings of impacts and the availability of supporting evidence.
- The time and resources available for undertaking the evaluation.

DfT's Evaluation Strategy[7] describes how DfT aims to use evaluation to collect evidence on the effectiveness of its interventions and to help it to understand *"what works, what doesn't work and why"*. The aim is to provide a strong and robust evidence base that can inform DfT's ongoing development of interventions and to appraise and plan for new initiatives. Evaluation should therefore play an important role in the future to ensure aviation decarbonisation activities are informed and supported by a strong evidence base.

[6] HM Treasury (2022), The Green Book. Central Government Guidance on Appraisal and Evaluation. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1063330/Green_Book_2022.pdf

[7] Department for Transport (June 2022), DfT evaluation strategy and programme 2022. Available at: https://www.gov.uk/government/publications/dft-monitoring-and-evaluation-programme/dft-evaluation-strategy-and-programme-2022

2.4.2 Evaluation purpose

The HM Treasury Magenta Book[8] and DfT's Transport Analysis Guidance for evaluation[9] both state that the two main purposes of evaluation are:

- **Learning**: to help manage risk and uncertainty regarding aviation decarbonisation; to improve the delivery of interventions; to understand what works, for whom, when and why; and to inform future interventions and policy decisions.
- **Accountability**: to provide evidence to demonstrate the outcomes and impacts of aviation decarbonisation, and provide evidence of cost effectiveness for public scrutiny and challenge.

The following sections present some potential approaches and high-level plans for evaluating aviation decarbonisation to deliver learning and provide accountability.

2.4.3 Priorities for evaluation

The breadth of policy activities which could be possible in aviation decarbonisation, combined with the complexity and international nature of the aviation sector, and the long timeframes for delivering outcomes and impacts, mean that there will inevitably be gaps in the evidence base for evaluation activities. In addition, it will not be possible to measure and understand all potential factors that may have contributed to a particular outcome. It also may not always be possible to construct a 'counterfactual', to identify what activities and outcomes might have been delivered anyway, in the absence of aviation decarbonisation policy measures. This means that some prioritisation of evaluation activities is likely to be necessary and the proportionality principle should be used to consider what and how to evaluate.

This approach is consistent with DfT's Evaluation Strategy[10], which aims to conduct proportionate evaluation of its activities to provide good quality evidence and maximise value for money. The Strategy also provides three broad criteria for prioritising interventions, which include: the scale of the investment; the strategic importance of the intervention; and the opportunities for evaluation activities to contribute to DfT's evidence base.

These criteria have been further developed in this framework to support the prioritisation of aviation decarbonisation interventions for evaluation. An approach has been developed to ensure prioritisation decisions are based on an assessment of each policy measure against the following criteria:

[8] HM Treasury (March 2020), Magenta Book. Central Government guidance on evaluation. Available at: https://assets.publishing.service.gov.uk/media/5e96cab9d3bf7f412b2264b1/HMT_Magenta_Book.pdf

[9] Department for Transport (November 2022), Transport Analysis Guidance – Unit 1: Evaluation. Available at: https://assets.publishing.service.gov.uk/media/63a32db0e90e07586dacf4e4/TAG_Unit_E1_-_Evaluation_Nov_2022_v1.0.pdf

[10] Department for Transport (June 2022), DfT evaluation strategy and programme 2022. Available at: https://www.gov.uk/government/publications/dft-monitoring-and-evaluation-programme/dft-evaluation-strategy-and-programme-2022

- The projected contribution of policy measures to aviation decarbonisation.
- The scale of investments and expenditures.
- The potential for evaluation to fill gaps in the evidence base and/or target innovative activities with high potential for learning.
- The level of uncertainty and risk associated with the delivery of activities.
- The timeliness of activities and value of undertaking evaluations in the short-term.
- The feasibility of undertaking evaluation activities.

These prioritisation criteria aim to assess the appropriateness and value of evaluation and can be used to prioritise evaluation activities for the five policy areas, their sub-measures and/or for individual interventions. This approach is intended to be used as a discussion-based tool to support decision-making. The criteria were chosen to facilitate the selection of evaluation activities that are likely to provide the greatest added value for learning and accountability and inform the ongoing development and refinement of aviation decarbonisation initiatives. A tool is provided in Annex 3 that can be used to assess the policy sub-measures against the prioritisation criteria and compare results to select priorities for evaluation.

2.4.4 Evaluation questions

Evaluation questions help to define the focus of evaluations. The evaluation activities will need to focus on collating the evidence necessary to respond to each question. In line with Magenta Book guidelines, the proposed evaluation questions cover process, impact and economic (value for money) evaluation. These correspond to three overarching questions that should guide evaluation activities, namely:

1) **Process evaluation: Have the aviation decarbonisation and individual policy measures been delivered as intended?**

   Process evaluation should be used to understand how aviation decarbonisation and its policy measures are operating in practice. It should focus on the process of delivery and provide evidence of 'how' aviation decarbonisation inputs and activities are delivering their intended outputs and outcomes and aim to capture learning to inform revisions and adjustments to the delivery of individual policy measures.

2) **Impact evaluation: What impacts (positive and/or negative) have been delivered by the aviation decarbonisation and individual policy measures? Have they achieved their intended outcomes?**

   Impact evaluation should be used to understand and assess the nature and scale of the outputs and outcomes of aviation decarbonisation measures. It should focus on progress towards the intended outcomes of aviation decarbonisation and the policy measures that are articulated in the ToCs and the extent to which targets and objectives have been achieved. Evidence should be collected to demonstrate: direct outputs of activities; short-term outcomes (such as changes in attitudes, confidence and knowledge); intermediate outcomes (such as changes in behaviours,

investments and innovations), and ultimate or end outcomes (such as reduced carbon emissions, and other environmental and economic benefits). The long-term nature of the aviation decarbonisation activities and objectives also means that evaluations will need to focus on progress towards these different outcomes as well as their ultimate achievement.

As well as evaluating the total outcomes and impacts of each policy area, it will also be important to assess the extent to which observed changes in outcomes can be attributed to the aviation decarbonisation policy measures. Counterfactuals will also need to be considered, where it is feasible to do so, to compare observed results with what would have happened if an activity had not been implemented. Furthermore, although positive outcomes are intended, the evaluation will also need to consider unintended consequences or negative outcomes.

3) **Value for money evaluation: Have the aviation decarbonisation and individual policy measures provided good value for money, taking account of their impacts compared to the resources invested?**

   Economic evaluation should be used to understand whether individual policy measures and aviation decarbonisation as a whole have been cost-effective and provided value for money. The long-term nature of many of the outcomes and impacts suggests that a full economic evaluation will only be possible after a significant period of time. However, evaluation plans will need to consider the extent to which value for money can be assessed using partial economic evaluation to deliver results at an earlier stage.

To answer these three broad questions, a more comprehensive list of evaluation questions will be required for aviation decarbonisation and the individual policy areas. Some proposed themes for detailed evaluation questions are provided in Section 3, while some examples of evaluation questions are presented in Annex 4. These should be further developed alongside the ongoing development of policy measures and then used to inform the planning and delivery of evaluation methodologies. Some high-level options for potential approaches to the evaluation of aviation decarbonisation measures are included in Annex 5.

Findings from these different types of evaluation can also be combined to inform decisions about whether to amend, reduce or extend different policy measures or adjust the mix of initiatives to achieve the best portfolio objectives. Since aviation decarbonisation will be delivered over a long time period, evaluation plans will need to help DfT develop an understanding of how aviation decarbonisation and its policy measures are contributing to change, and the extent of that change.

It is expected that initial evaluation activities are more likely to focus on individual policy measures, while longer-term activities will seek to understand the impact of aviation decarbonisation as a whole, including system-level transformation.

3 Monitoring and Evaluation framework

This section presents the core components of the M&E framework. It summarises the ToCs for aviation decarbonisation as a whole and for each of the five component policy areas and sets out the priority monitoring indicators and evaluation questions.

3.1 Aviation decarbonisation

The UK Government aims to decarbonise the UK aviation industry by identifying and implementing a mix of measures capable of reducing emissions, whilst also maintaining the benefits of air travel for trade, travel and tourism. This section focuses on aviation decarbonisation activities at a portfolio level. The key portfolio-level activities, outputs and outcomes are described below and presented in the ToC diagram in Figure 3.1.

Identifying and developing initiatives – The first set of activities relate to the development of a coherent set of policy measures capable of delivering aviation decarbonisation objectives. This is intended to consolidate and coordinate measures to provide the vision, intent and direction that is needed from the UK Government to obtain the buy-in and commitment from key stakeholders and transform the industry.

Management and implementation of aviation decarbonisation initiatives – These activities are associated with the ongoing management and implementation of aviation decarbonisation measures. They include efforts to provide international influence and leadership to promote international collaboration and consensus, to enhance the outcomes of aviation decarbonisation, and ensure the UK remains competitive with other countries. They also include activities to develop partnerships between government, academia and industry that can deliver aviation decarbonisation objectives. Other key activities include the delivery of the individual policy measures, which aim to influence consumer and industry behaviours, attract investment, promote innovation and target a range of objectives (i.e. increased efficiency of existing systems, development of new fuels and technologies, increased effectiveness of carbon markets and increased removals).

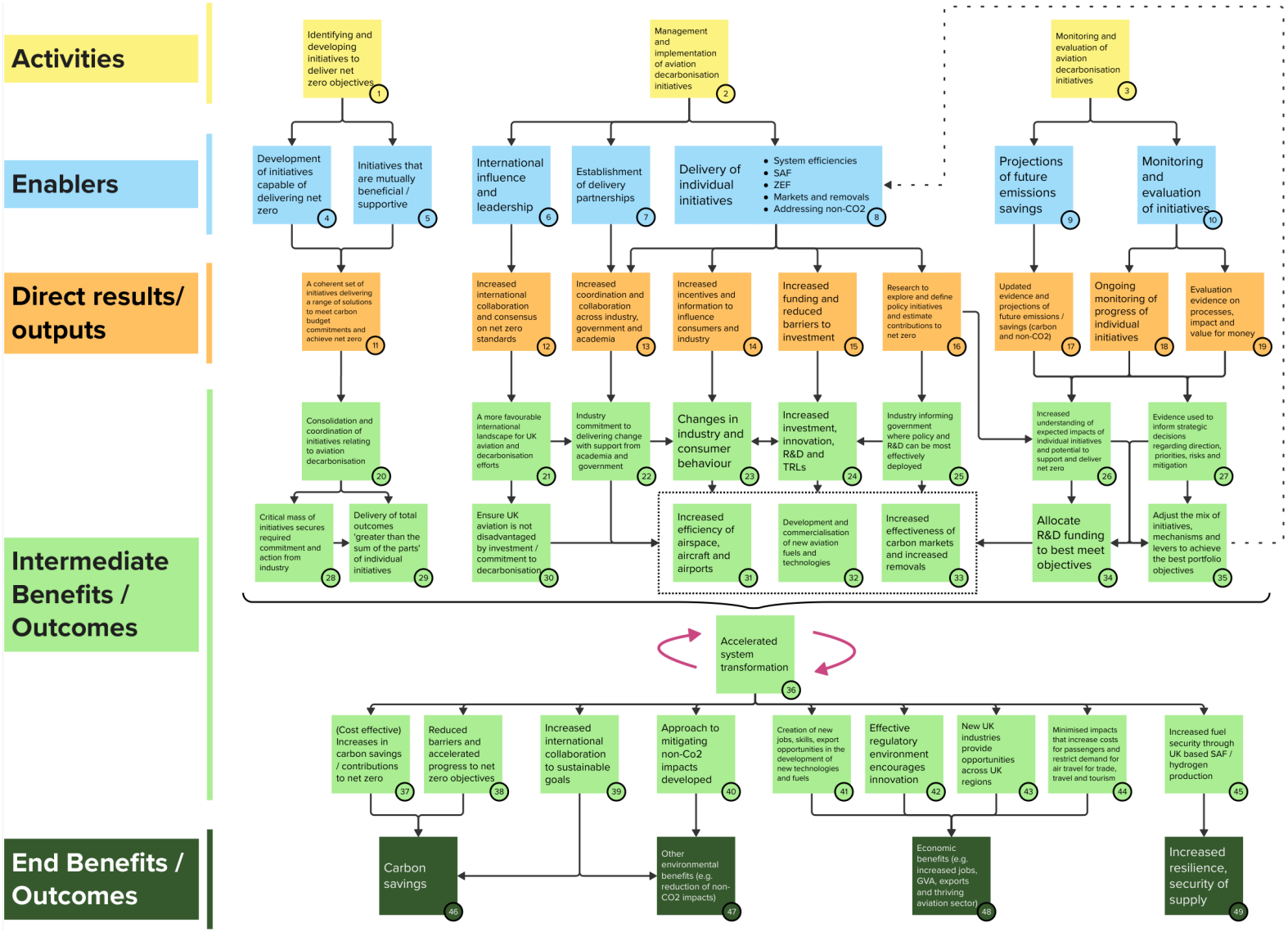
Monitoring and evaluation – The final set of activities are associated with the monitoring and evaluating of aviation decarbonisation initiatives. They include tracking and projecting emissions and savings as well as the ongoing monitoring and evaluation of aviation decarbonisation and its individual policy measures. These combined activities are intended to provide improved understanding of the expected impacts of individual initiatives and their potential to reduce emissions, whilst also providing evidence to inform strategic decisions regarding the optimal mix of initiatives to achieve the best portfolio objectives.

It is assumed that the combination of above activities can deliver the required system transformation and support, i.e.:

- The carbon savings required from aviation to help achieve net zero across the economy by 2050.
- Mitigation of non-CO_2 impacts.

Aviation decarbonisation measures are also expected to generate wider impacts including: increased resilience and fuel security (through the production of SAF and hydrogen in the UK); and economic benefits from developing new industries, export opportunities, jobs and incomes across the UK regions, whilst minimising any adverse impacts (i.e. increased costs for passengers and lower demand for air travel).

Figure 3.1 Aviation decarbonisation: Theory of change



3.1.2 Aviation decarbonisation: Priority monitoring indicators

A full list of monitoring indicators is provided in Annex 1 and covers all of the outputs and outcomes listed in Figure 3.1. A shortlist of priority monitoring indicators is presented in Table 3.1 (selected using the approach described in Section 2.3). It describes nine priority indicators covering one output and eight of the outcomes listed in the ToC. Most of these indicators will need to be tracked across the full period to 2050. The output indicators draw heavily on DfT's management information and should be possible to monitor with minimal resource, while the outcome indicators will require more effort to gather data from a mix of DfT and external datasets.

Table 3.1 Priority indicators: Aviation decarbonisation

Output/ Outcome	ToC box no.	Output/outcome description	Indicator description	Data source			Timing				
				DfT MI	DfT dataset	Other dataset	2025-29	2030-34	2035-39	2040-44	2045-50
Output	TOT:17	Updated evidence and projections of future emissions / savings (carbon and non-CO_2)	• Annual monitoring and reporting of CO_2 emissions in the UK • (Potential future) annual monitoring and reporting of non-CO_2 emissions in the UK	Y	Y	Y	Y	Y	Y	Y	Y
Outcome	TOT:20	Consolidation and coordination of initiatives relating to aviation decarbonisation	• Number of aviation decarbonisation initiatives in the UK	Y			Y	Y	Y	Y	Y
Outcome	TOT:33	Increased effectiveness of carbon markets and increased removals	• Number of CORSIA / UK ETS credits purchased by the UK aviation industry • Average price (£) of CORSIA / UK ETS credits purchased by the UK aviation industry • Purchases / investments (£) of offsets and removals by the UK aviation industry			Y	Y	Y	Y	Y	Y
Outcome	TOT:35	Adjust the mix of initiatives, mechanisms and levers to achieve the best portfolio objectives	• Changes made to aviation decarbonisation measures, initiatives, mechanisms and levers in the UK	Y			Y	Y	Y	Y	Y
Outcome	TOT:37	(Cost effective) Increases in carbon savings / contributions to net zero	• Estimated / modelled carbon emissions / savings by aviation decarbonisation policy measure (MtCO2e) • Costs (£) of delivering aviation decarbonisation policy measures in the UK [from additional research activities] • Assessment of cost effectiveness of the UK's aviation decarbonisation policy measures (£ per MtCO2e)		Y	Y	Y	Y	Y	Y	Y
Outcome	TOT:40	Approach to mitigating non-CO_2 impacts developed	• Approaches developed in the UK to mitigate non-CO_2 impacts	Y			Y	Y			
Outcome	TOT:46	Carbon savings	• Estimated carbon emissions / savings (MtCO2e) – current and projected from the UK's aviation decarbonisation measures • Projected contribution to total carbon savings by 2050		Y	Y	Y	Y	Y	Y	Y

Output/ Outcome	ToC box no.	Output/outcome description	Indicator description	Data source			Timing				
				DfT MI	DfT dataset	Other dataset	2025-29	2030-34	2035-39	2040-44	2045-50
Outcome	TOT:48	Economic benefits (e.g. increased jobs, GVA, exports and thriving aviation sector)	• UK jobs (FTE) and GVA (£) in aviation, aerospace and related sub-sectors (incl. supply chains) • UK exports of aviation, aerospace and related products and services (volume and value) • UK share (%) of global aviation, aerospace and related markets		Y	Y	Y	Y	Y	Y	Y
Outcome	TOT:49	Increased resilience, security of supply	• UK imports & exports of SAF, low carbon hydrogen and other aviation fuels (volume and value)			Y	Y	Y	Y	Y	Y

Note: A full list of output and outcome indicators is provided in Annex 1

In addition to the indicators listed in Table 3.1, there will also be requirements for additional research with industry to explore the costs, investments and impacts associated with aviation decarbonisation activities as well as research to explore stakeholder perceptions of aviation decarbonisation delivery processes and impacts. It should be possible to combine this with other research targeting the individual policy measures. However, there is also likely to be some more targeted research that overlaps with addressing non-CO_2 measures, exploring industry perceptions of aviation decarbonisation policies and the development of methodologies and approaches for measuring non-CO_2 impacts.

3.1.3 Aviation decarbonisation: Evaluation questions

Opportunities for evaluation at the overall portfolio level will likely focus on interactions with industry and international partners, the additionality of policy measures to reduce emissions, and the overarching benefits and impacts of aviation decarbonisation. Potential areas of focus for evaluation questions include:

Process evaluation – Questions about: the process of selecting and developing relevant policy measures and working with industry stakeholders; the rationale for different policy measures; the effectiveness of management and implementation processes; the appropriateness, timeliness and adaptability of measures and delivery processes; and any lessons learned that could improve delivery.

Impact evaluation – Questions about: the impact of policy measures (individually and in combination); progress towards targets and overarching objectives; the scale of decarbonisation and transformation in the UK aviation sector; the benefits to the UK including environmental, economic and resilience benefits; the extent to which the international landscape has influenced (positively or negatively) the delivery of impacts in the UK; and considerations of any unintended consequences or impacts.

Value for money evaluation – Questions about: the scale of resources used to deliver aviation decarbonisation; the benefits delivered; comparisons of the value for money delivered by different policy areas and measures, and any lessons learned that could help to improve value for money in the future.

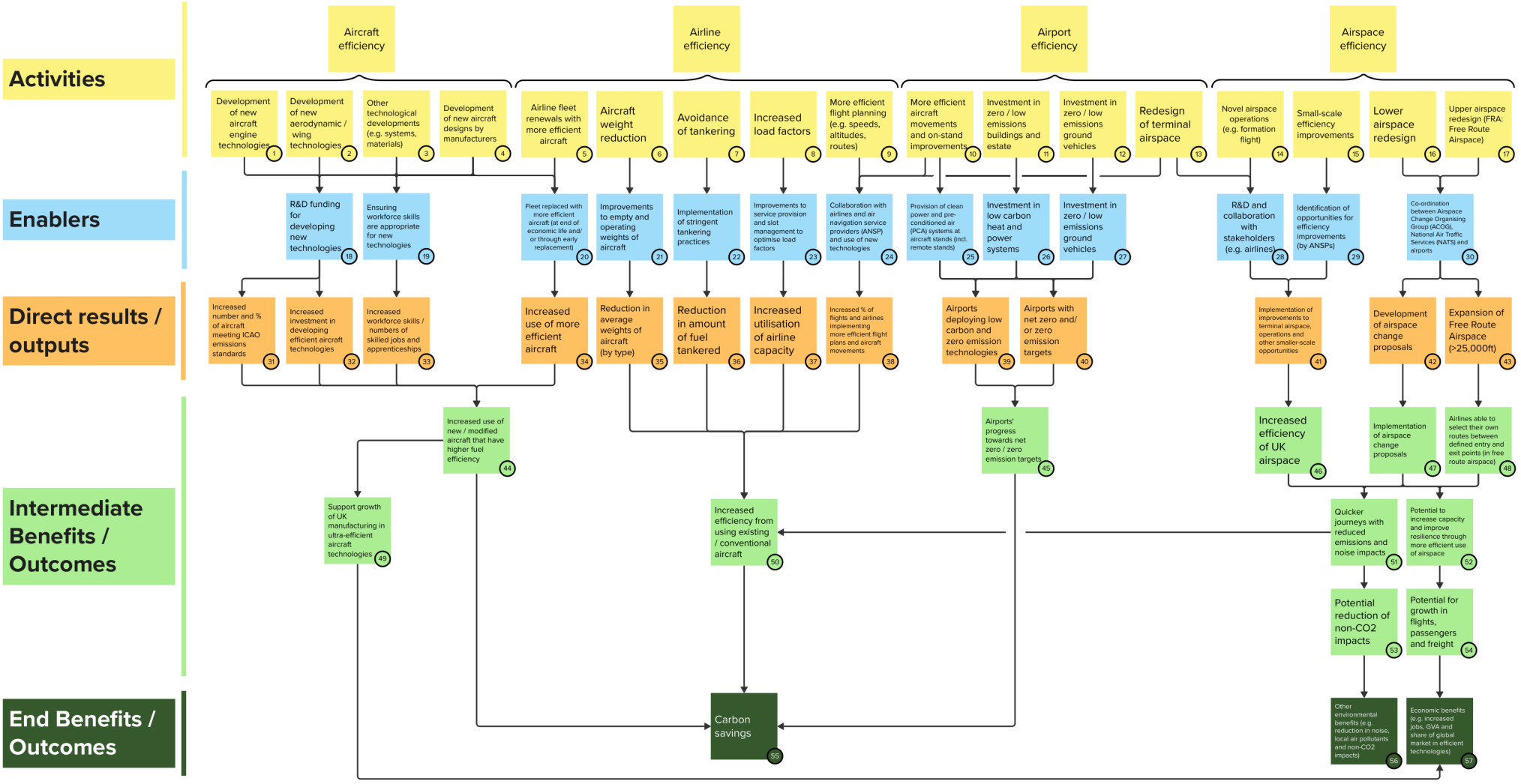
3.2 System efficiencies

System efficiencies are short to medium term measures that aim to reduce emissions in the existing aviation system. Measures in this area include the development of new aircraft technologies over the medium-term, while also making more efficient use of existing aircraft. It also includes: better operational practices for airlines, airports and ANSPs; increased investment in, and deployment of, low carbon and zero emission technologies at airports; and modernisation of UK airspace to improve the efficiency of air traffic movements. The key activities and their expected outputs and outcomes are described below:

- Activities to **increase the efficiency of aircraft** including the development of new aircraft designs such as engines, wings, systems and materials, supported by the provision of a workforce with appropriate skills and through targeted R&D funding (e.g. funding provided by the Aerospace Technology Institute (ATI) programme). This is intended to reduce carbon emissions by increasing the fuel efficiency of new aircraft designs and technologies, but is dependent upon the decisions and actions of airlines to invest in, and deploy, these technologies (described below). It is assumed that the development of new technologies will also generate economic benefits from having a higher skilled workforce and delivering growth of the associated manufacturing industry in the UK.
- The development of new aircraft technologies is expected to be complemented by efforts to **increase the efficiency of airlines** and reduce carbon emissions of existing aircraft. This is expected to include airlines renewing their aircraft fleets with more efficient aircraft, and potentially implementing mechanisms to reduce aircraft weights, restrict tankering (i.e. carrying excess fuel unnecessarily), and increase flight loads / utilisation of airline capacity as well as using more efficient operational practices (e.g. optimal aircraft speeds, altitudes, ascents/descents, etc.).
- Activities to increase the **efficiency of airports** through the adoption of low carbon and zero emission technologies and targets. This includes activities to increase the efficiency of aircraft movements and on-stand improvements (through the provision of clean power and pre-conditioned air (PCA) systems), increase investments in low carbon heat and power systems and zero / low emission ground vehicles, and deliver a redesign of terminal airspace. These activities are expected to deliver carbon savings for airports and accelerate their progress towards net zero and zero emission targets.
- Activities to **increase the efficiency of airspace** include: working with industry to: redesign lower and upper airspace; develop airspace change proposals and support the roll-out of Free Route Airspace (>25,000ft); and

identify and implement improvements to terminal airspace and other smaller-scale opportunities through provision of R&D funding and increased collaboration and coordination between stakeholders. These activities are expected to increase the resilience and efficiency of UK airspace and support quicker, quieter and cleaner journeys, thereby delivering environmental benefits through reduced carbon emissions and non-CO_2 impacts per flight. However, it is possible that some environmental benefits may be offset by the ability to use the more efficient airspace to facilitate future growth in flights, passengers and air freight, which has the potential to support additional economic benefits.

Figure 3.2 System efficiencies: Theory of change



3.2.2 System efficiencies: Priority monitoring indicators

A shortlist of ten priority monitoring indicators has been identified for the system efficiencies policy measure (Table 3.2). It covers three of the outputs and seven of the outcomes listed in the ToC. Four of these are relatively short-term indicators that will only need to be tracked in the five to ten years, while the others will need to be monitored over the whole period to 2050. Most indicators should be relatively easy to track using DfT's management information and datasets.

Table 3.2 Priority indicators: System efficiencies

Output/ Outcome	ToC box no.	Output/outcome description	Indicator description	Data source			Timing				
				DfT MI	DfT dataset	Other dataset	2025-29	2030-34	2035-39	2040-44	2045-50
Output	SE:40	Airports with net zero and/or zero emission targets	• Number of UK airports with net zero targets • Number of UK airports with zero emission targets			Y	Y	Y			
Output	SE:42	Development of airspace change proposals	• Development of airspace change proposals in the UK	Y			Y	Y			
Output	SE:43	Expansion of Free Route Airspace (>25,000ft)	• Implementation of Free Route Airspace across UK regions (i.e. implemented in the North of England by Autumn 2025 and in London and the South East by Autumn 2026)	Y			Y				
Outcome	SE:44	Increased use of new / modified aircraft that have higher fuel efficiency	• Number of new / modified aircraft in use in the UK (and % of total) • Distance travelled by new / modified aircraft (and % of total)		Y		Y	Y	Y	Y	Y
Outcome	SE:45	Airports' progress towards net zero / zero emission targets	• Estimated carbon emissions / savings of UK airports (MtCO2e) • Airports' reports of progress towards net zero / zero emission targets		Y	Y	Y	Y	Y	Y	Y
Outcome	SE:46	Increased efficiency of UK airspace	• Estimated efficiency of UK airspace (NATS 3Di metric)			Y	Y	Y	Y	Y	Y
Outcome	SE:47	Implementation of airspace change proposals	• Implementation of the Future Airspace Strategy Implementation (FASI) element of the Airspace Modernisation Strategy and other airspace change proposals	Y			Y	Y			
Outcome	SE:49	Support growth of UK manufacturing in ultra-efficient aircraft technologies	• UK jobs (FTE) and GVA (£) in aviation sub-sectors (and supply chains) relating to ultra-efficient aircraft technologies		Y		Y	Y	Y	Y	Y
Outcome	SE:50	Increased efficiency from using existing / conventional aircraft	• Average flight loads for flights departing the UK (% of total passenger and freight capacity) • Estimated carbon emissions / savings per passenger or metric ton of freight for flights departing the UK		Y	Y	Y	Y	Y	Y	Y
Outcome	SE:55	Carbon savings	• Estimated carbon emissions / savings (MtCO2e) - current and projected from system efficiencies measures • Projected contribution to total carbon savings by 2050		Y	Y	Y	Y	Y	Y	Y

Note: A full list of output and outcome indicators is provided in Annex 1

Additional research activities are expected to focus on industry costs, investments and impacts associated with the system efficiencies measures and stakeholder perceptions of delivery processes and impacts. It should be possible to cover much of this alongside research of the other policy measures, although there is also likely to be some bespoke research requirements into the outcomes of airspace changes and the extent to which this has influenced airline decisions regarding flight routes.

3.2.3 System efficiencies: Evaluation questions

Potential areas of focus for evaluation questions relating to the system efficiencies policy measures include:

Process evaluation – Questions about: the rationale for different policy measures; their effectiveness in engaging relevant partners and coordinating tasks to facilitate the development of efficient aircraft technologies and increase the efficiency of UK airspace, airports and airlines; the extent to which R&D funding and activities have been targeted at the right areas; the appropriateness and timeliness of measures and delivery processes; and any lessons learned that could improve delivery.

Impact evaluation – Questions about: the impacts of system efficiencies policy measures for carbon savings, non-CO2 emissions and other environmental and economic benefits; progress towards targets and their expected / actual contribution to overall aviation decarbonisation objectives; the extent to which impacts can be attributed to the system efficiencies measures; and considerations of any unintended consequences or impacts.

Value for money evaluation – Questions about: the scale of resources used to deliver the system efficiencies measures; their costs and benefits; comparisons of the value for money delivered by different activities, and any lessons learned that could help to improve value for money in the future.

3.3 Sustainable aviation fuels (SAF)

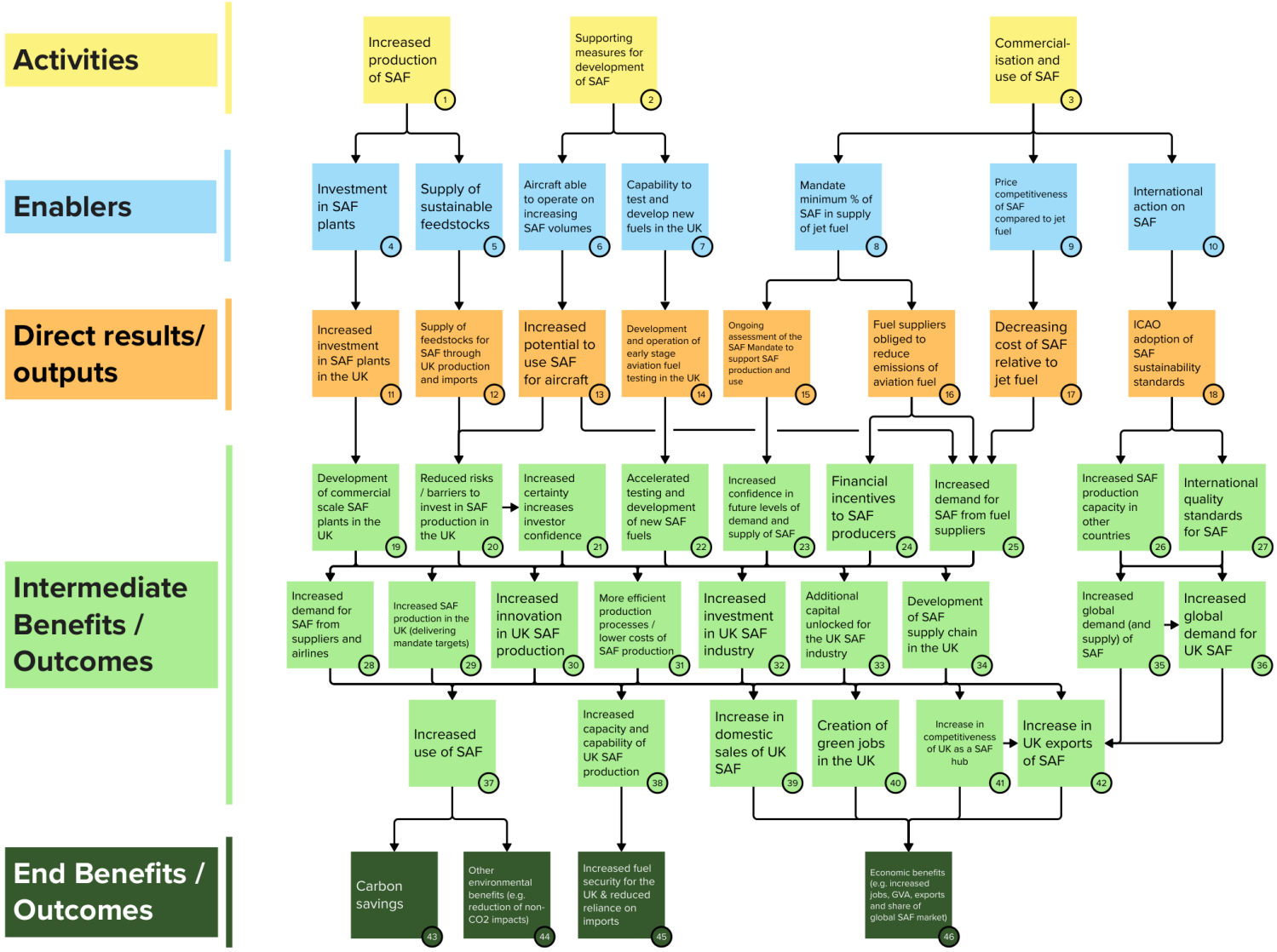
SAFs are one of the key technologies available to reduce emissions by blending alternative fuels with jet fuel in conventional aircraft. This area includes the production and commercialisation of SAF, supply-side activities include working between industry and investors to increase SAF production in the UK, and using measures to support the development of SAF technologies. These are complemented by demand-side activities to increase the commercialisation and use of SAF. The key SAF activities, expected outputs and outcomes are:

- **Increased production of SAF** through: the development of commercial scale SAF plants in the UK; and an increased supply of feedstocks for SAF through UK production and imports to reduce risks and barriers to investment in UK production and increase investor confidence in the future supply and demand of SAF for aviation.
- **Measures for the development of SAF** including: technological developments to increase the potential for aircraft to use SAF and operate on increasing SAF volumes; and the testing and development of new SAF fuels in the UK.
- **Commercialisation and use of SAF** through: the implementation and ongoing assessment of the Government's SAF mandate to incentivise the use of SAF; activities to increase the price stability and competitiveness of SAF relative to conventional jet fuel in order to support increases in demand from fuel suppliers and airlines; combined with activities focused on international action and collaboration to support the development of international standards and implementation support for SAF (including through ICAO), which would be expected to support increases in the global supply and demand of SAF, including increases in the demand for SAF produced in the UK.

The combination of above activities is expected to support increased investment and innovation to grow SAF production and develop supply chains in the UK, while also helping to develop more efficient production processes that will lower the costs of production over time. It is assumed that increasing the capacity and capabilities of SAF production in the UK will help secure the supply of SAF in the UK as well as deliver economic benefits from increased domestic sales and exports of SAF and from the creation of green jobs and incomes in the UK.

The above activities are also expected to support increased demand for SAF from fuel suppliers and airlines, which is expected to support lower carbon emissions (and potentially non-CO_2 impacts) by replacing conventional fuels with SAF.

Figure 3.3 SAF: Theory of change



3.3.2 SAF: Priority monitoring indicators

Table 3.3 shows the 12 priority monitoring indicators that have been identified for the SAF policy measure. These indicators cover five of the outputs and seven of the outcomes listed in the ToC. Many of these indicators are expected to draw on multiple, external data sources and the majority will need to be tracked across the full period to 2050, so are likely to take more effort to monitor compared to the other policy measures.

Table 3.3 Priority indicators: SAF

Output/ Outcome	ToC box no.	Output/outcome description	Indicator description	Data source			Timing				
				DfT MI	DfT dataset	Other dataset	2025-29	2030-34	2035-39	2040-44	2045-50
Output	SAF:11	Increased investment in SAF plants in the UK	• Investment (£) in SAF plants in the UK (public / private / total)	Y	Y	Y	Y	Y	Y	Y	Y
Output	SAF:12	Supply of feedstocks for SAF through UK production and imports	• UK production (volume & value) of feedstocks (in total and for SAF/aviation use) • UK imports (volume & value) of feedstocks (in total and for SAF/aviation use)			Y	Y	Y	Y	Y	Y
Output	SAF:14	Development and operation of early stage aviation fuel testing in the UK	• Number of testing facilities associated with SAF testing in the UK	Y	Y	Y	Y	Y	Y		
Output	SAF:15	Ongoing assessment of the SAF Mandate to support SAF production and use	• SAF supplied and rewarded through the SAF Mandate (volume)	Y			Y	Y	Y	Y	Y
Output	SAF:17	Decreasing cost of SAF relative to jet fuel	• Average costs (£) of SAF and conventional jet fuel in the UK (including taxes and carbon prices)			Y	Y				
Outcome	SAF:19	Development of commercial scale SAF plants in the UK	• Number of SAF plants under construction in the UK • Number of SAF plants in operation in the UK		Y	Y	Y	Y	Y	Y	Y
Outcome	SAF:24	Financial incentives to SAF producers	• Funding / incentives (£) provided to SAF producers in the UK		Y		Y	Y	Y	Y	Y
Outcome	SAF:28	Increased demand for SAF from suppliers and airlines	• SAF consumption by airlines departing the UK (volume and value)			Y	Y	Y	Y	Y	Y
Outcome	SAF:29	Increased SAF production in the UK (delivering mandate targets)	• UK SAF production (volume and value) • Progress against SAF mandate targets	Y		Y	Y	Y	Y	Y	Y
Outcome	SAF:36	Increased global demand for UK SAF	• Total global consumption of SAF produced in the UK (volume and value)			Y	Y	Y	Y	Y	Y
Outcome	SAF:42	Increase in UK exports of SAF	• UK SAF exports (volume and value)			Y	Y	Y	Y	Y	Y
Outcome	SAF:43	Carbon savings	• Estimated carbon emissions / savings (MtCO2e): current/projected from use of SAF on flights departing the UK • Projected contribution to total carbon savings by 2050		Y	Y	Y	Y	Y	Y	Y

Note: A full list of output and outcome indicators is provided in Annex 1

Requirements for additional research activities are expected to be lighter-touch than for most other policy measures. This is because a relatively large proportion of the indicators for SAF can be monitored using existing datasets. Additional research is expected to focus on industry costs, investments and impacts associated with SAF measures, consumer research to explore awareness and attitudes towards SAF and stakeholder perceptions of SAF delivery processes and impacts, and it should be possible to combine some of these activities with other policy measures.

3.3.3 SAF: Evaluation questions

Potential areas of focus for evaluation questions relating to the SAF policy measures include:

Process evaluation – Questions about: the rationale for different policy measures; their effectiveness in collaborating with UK and international partners to facilitate the development of SAF and alignment of international policies and regulation; the appropriateness and timeliness of measures and delivery processes; and any lessons learned that could improve delivery.

Impact evaluation – Questions about: the impacts of SAF policy measures for investment in the UK SAF industry, for the demonstration, production and commercialisation of SAF, and for the demand, supply and use of SAF; their wider impacts for carbon savings, non-CO2 emissions, the UK economy and for resilience and fuel security in the UK; any impacts for international ambition, standards and the development of a global SAF industry; progress towards individual targets for SAF measures and their expected / actual contribution to overall aviation decarbonisation objectives; the extent to which impacts can be attributed to the SAF measures; and considerations of any unintended consequences or impacts.

Value for money evaluation – Questions about: the scale of resources used to deliver the SAF measures; their costs and benefits; comparisons of the value for money delivered by different activities, and any lessons learned that could help to improve value for money in the future.

3.4 Zero emission flight (ZEF)

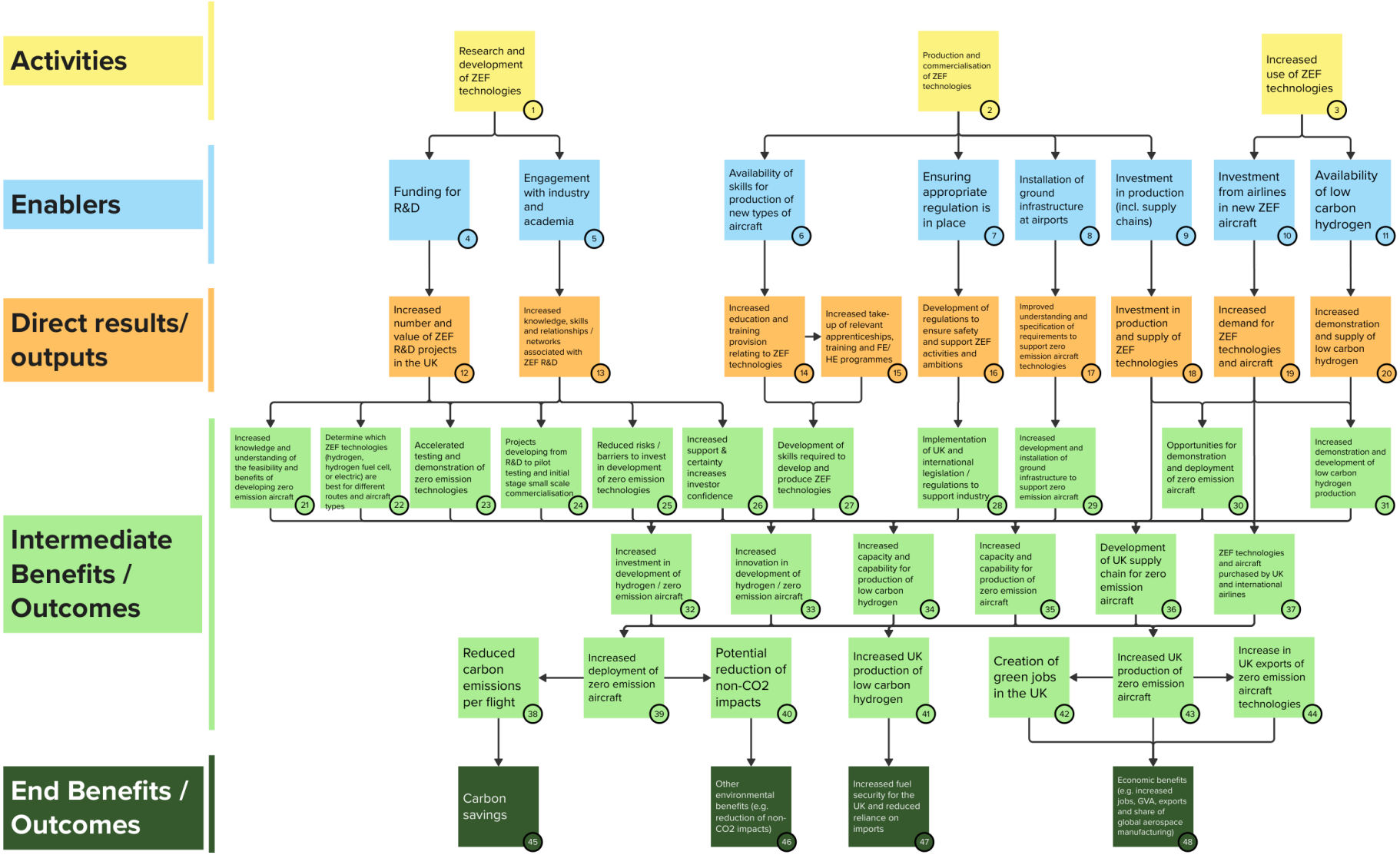
The ZEF policy measures aim to develop and bring into commercial service novel forms of aircraft that offer zero carbon tailpipe emissions (e.g. hydrogen powered aircraft). The transition to zero emission aircraft requires a system that supports research and development, production and commercialisation, and the increased use of ZEF technologies. This includes interventions to stimulate innovation, skills development and support the installation of supporting infrastructure, as well as interventions focusing specifically on the availability and regulation of hydrogen fuels.

The key ZEF activities and expected outputs and outcomes are:

- Support for the **R&D of ZEF technologies** through the provision of R&D funding and engagement between industry and academia to increase the knowledge, skills and networks associated with ZEF R&D. These activities aim to increase knowledge and understanding of the feasibility and potential benefits of zero emission technologies and their applicability to different aircraft and routes; accelerate the testing and demonstration of different technologies, deliver small scale commercialisation projects; and reduce the risks and barriers to investment to increase confidence amongst investors.
- Increasing the **production and commercialisation of ZEF technologies** through: increased education and training provision to help develop the skills required to produce ZEF technologies; the development and implementation of UK and international legislation and regulations to ensure safety and support ZEF activities and ambitions; the development and deployment of ground infrastructure required to support ZEF aircraft and technologies; and increased investment in the production and supply of ZEF technologies, including supply chains.
- **Increasing the use of ZEF technologies** through activities to increase the demonstration, supply and availability of low carbon hydrogen and increase demand and investment from airlines in new ZEF aircraft and technologies.

The combination of above activities is expected to deliver a series of intermediate outcomes that include: increased investment, innovation, capacity and capability in the development of low carbon hydrogen and zero emission aircraft; the establishment and ongoing development of a UK supply chain; and stimulation of demand from airlines in the UK and overseas. It is assumed that these intermediate outcomes will also deliver: economic benefits that arise from the production of zero emission technologies and aircraft and the creation of green jobs in the UK and an increase in exports; increased fuel security and reduced reliance on fuel imports due to increased production of low carbon hydrogen in the UK; and a significant contribution to net zero objectives from reduced carbon emissions (and potential reduction of non-CO_2 impacts) that are expected to arise from the deployment of zero emission aircraft in commercial air transport.

Figure 3.4 ZEF: Theory of change



3.4.2 ZEF: Priority monitoring indicators

A shortlist of 12 priority monitoring indicators has been identified for the ZEF policy measure (Table 3.4). The list includes six indicators for tracking outputs and another six indicators for tracking outcomes from the above ToC. However, most of these indicators are expected to use multiple data sources and/or need to be tracked over the full period to 2050, so will require some effort and resource to collate and analyse monitoring data over time.

Table 3.4 Priority indicators: ZEF

Output/ Outcome	ToC box no.	Output/outcome description	Indicator description	Data source			Timing				
				DfT MI	DfT dataset	Other dataset	2025-29	2030-34	2035-39	2040-44	2045-50
Output	ZEF:12	Increased number and value of ZEF R&D projects in the UK	• Number of ZEF R&D projects in the UK • Funding provided for ZEF R&D projects in the UK • Investment in ZEF R&D projects in the UK (public / private / total)	Y		Y	Y	Y	Y	Y	Y
Output	ZEF:14	Increased education and training provision relating to ZEF technologies	• Number of UK apprenticeships / training programmes / FE/HE programmes relating to ZEF technologies		Y	Y	Y	Y	Y	Y	Y
Output	ZEF:15	Increased take-up of apprenticeships, training and FE/HE programmes	• Take-up of relevant apprenticeships / training programmes / FE/HE programmes in the UK		Y	Y	Y	Y	Y	Y	Y
Output	ZEF:16	Development of regulations to ensure safety and support ZEF activities and ambitions	• Regulations developed to ensure safety and support ZEF activities and ambitions		Y	Y	Y	Y	Y		
Output	ZEF:17	Improved understanding and specification of requirements to support zero emission aircraft technologies	• Number of UK projects researching requirements for supporting zero emission aircraft technologies • Investment (£) in UK projects to improve understanding of requirements (public / private / total)		Y	Y	Y	Y	Y	Y	Y
Output	ZEF:18	Investment in production and supply of ZEF technologies	• Investment (£) in the production of zero emission technologies in the UK (public / private / total)		Y	Y	Y	Y	Y	Y	Y
Outcome	ZEF:24	Projects developing from R&D to pilot testing and initial stage small scale commercialisation	• Number of zero emission R&D projects progressing to pilot testing / small scale commercialisation stages in the UK • Investment (£) in UK projects progressing to pilot testing / small scale commercialisation stages (public / private / total)		Y	Y	Y	Y	Y	Y	Y
Outcome	ZEF:31	Demonstration and development of low carbon hydrogen production	• Number and value of UK project(s) demonstrating the use of low carbon hydrogen for aviation		Y	Y	Y	Y	Y		
Outcome	ZEF:39	Increased deployment of zero emission aircraft	• Number of zero emission aircraft in operation (and % of total number of operational aircraft) by UK and international airlines • Number (and %) of flights departing the UK using zero emission aircraft (domestic and international) • Distance (and % of total) of flights departing the UK using zero emission aircraft (domestic and international)			Y	Y	Y	Y	Y	Y
Outcome	ZEF:41	Increased UK production of low carbon hydrogen	• UK production of low carbon hydrogen (volume and value)			Y	Y	Y	Y	Y	Y

Output/ Outcome	ToC box no.	Output/outcome description	Indicator description	Data source			Timing				
				DfT MI	DfT dataset	Other dataset	2025-29	2030-34	2035-39	2040-44	2045-50
Outcome	ZEF:42	Creation of green jobs in the UK	• UK jobs (FTE) in sectors relating to the production, distribution and use of zero emission aircraft (incl. supply chains)		Y	Y	Y	Y	Y	Y	Y
Outcome	ZEF:45	Carbon savings	• Estimated carbon emissions / savings (MtCO2e): current/projected from flights departing the UK using zero emission aircraft • Projected contribution to total carbon savings by 2050		Y	Y	Y	Y	Y	Y	Y

Note: A full list of output and outcome indicators is provided in Annex 1

There are also expected to be requirements for additional research with industry and stakeholders to support the monitoring of the ZEF policy measures. These requirements could be relatively large for ZEF, particularly in terms of research with industry to explore the costs, investments and impacts associated with ZEF measures and the wider development of zero emission aircraft. There will also be requirements for consumer research to explore awareness and attitudes towards zero emission aircraft and research into stakeholder perceptions of ZEF delivery processes and impacts, which should be possible to combine with other policy measures.

3.4.3 ZEF: Evaluation questions

Potential areas of focus for evaluation questions relating to the ZEF policy measures include:

Process evaluation – Questions about: the rationale for different policy measures; their effectiveness in engaging relevant partners and coordinating tasks to develop relevant skills in the workforce and deliver appropriate demonstration activities; the ability to access funding for ZEF projects from UK and international sources; the extent to which R&D funding and activities have been targeted at the right areas to maximise impacts; the appropriateness and timeliness of measures and delivery processes; and any lessons learned that could improve delivery.

Impact evaluation – Questions about: the impacts of ZEF policy measures for the development and deployment of zero emission technologies and aircraft, for the development of appropriate skills in the workforce and for the development and production of low carbon hydrogen in the UK; their wider impacts for carbon savings, non-CO2 emissions, the UK economy and for resilience and fuel security in the UK; progress towards individual targets for ZEF measures and their expected / actual contribution to overall aviation decarbonisation objectives; the extent to which impacts can be attributed to the ZEF measures; and considerations of any unintended consequences or impacts.

Value for money evaluation – Questions about: the scale of resources used to deliver the ZEF measures; their costs and benefits; comparisons of the value for money delivered by different activities, and any lessons learned that could help to improve value for money in the future.

3.5 Markets and removals

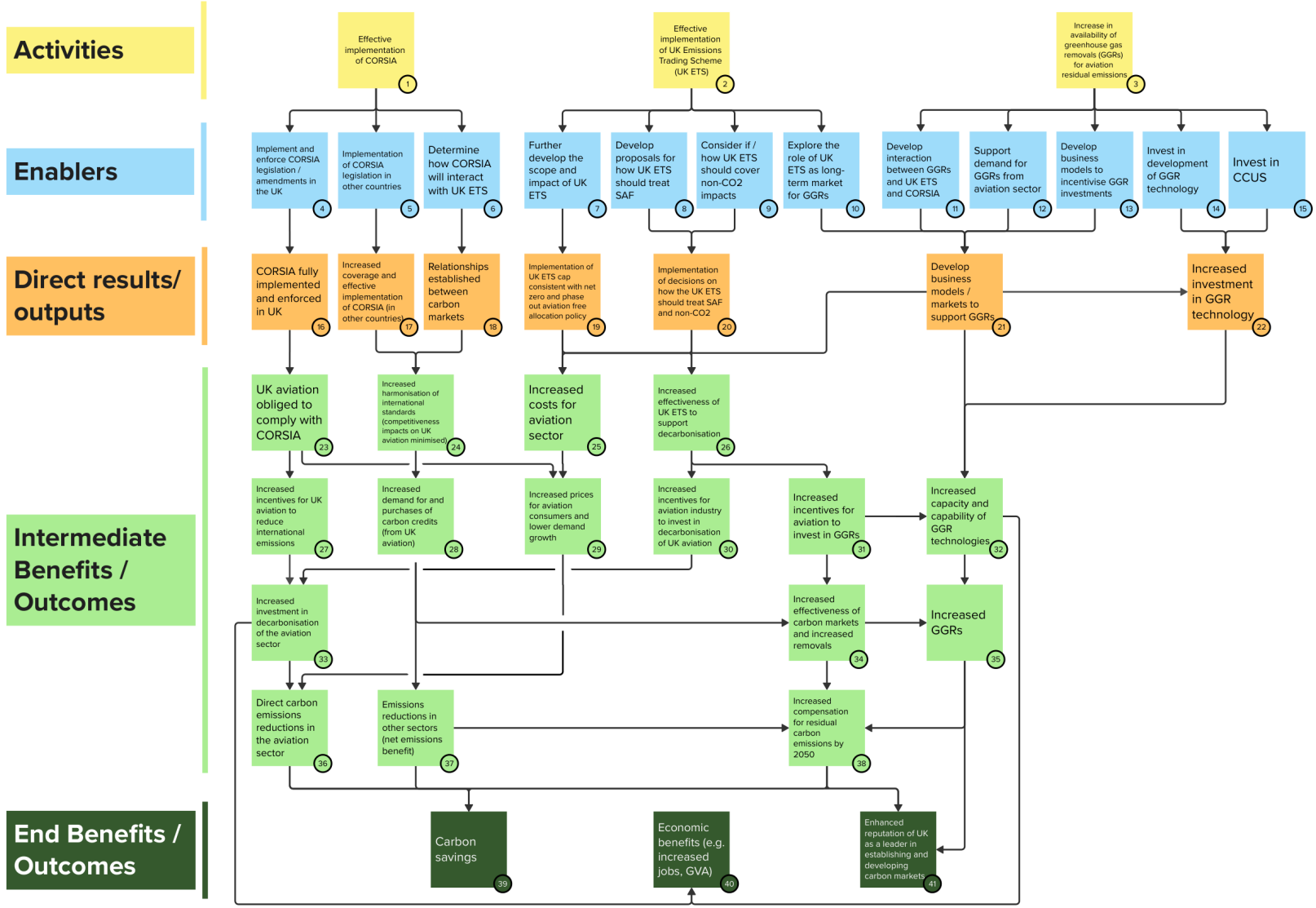
The 'Markets and Removals' policy measures aim to create successful carbon markets, creating an incentive for airlines to invest in decarbonisation, and support the aviation sector to invest in greenhouse gas removals (GGRs) to compensate for residual emissions in 2050. The main priorities for UK policy in this area have been to implement and enhance the effectiveness of the UK Emissions Trading Scheme (UK ETS) and Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The key activities include:

- **The effective implementation of CORSIA** by: implementing and enforcing CORSIA legislation in the UK to incentivise the UK aviation industry to reduce emissions from international flights, including determining how CORSIA will interact with the UK ETS and supporting the implementation and increased coverage of CORSIA across other countries. These activities aim to support a standardised global approach and ensure the UK industry is incentivised to decarbonise but is not disadvantaged relative to other countries.
- **The effective implementation of the UK ETS** and maintaining its reputation for supporting aviation decarbonisation by: further developing its scope and impact; considering how it should support SAF uptake and investment, and whether it should be extended to cover non-CO_2 impacts; and exploring the role of the UK ETS as a long-term market for GGRs, which could increase incentives for aviation to invest in GGRs and support the development of GGR technologies. These activities build on existing commitments made following the Developing UK ETS consultation which include phasing out aviation free allocation by 2026 and aligning the cap with a trajectory that is consistent with net zero objectives. The changes being considered are intended to increase the effectiveness of the UK ETS in supporting decarbonisation by pricing carbon emissions and incentivising investment in decarbonisation of aviation and other sectors in line with net zero targets.
- Activities to **increase the availability of GGRs** for aviation residual emissions, which are likely to include: the development of interactions between GGRs, the UK ETS, CORSIA and other activities to support demand for GGRs from the aviation sector; the development of business models and markets for GGRs; and supporting investments in GGR technologies from the aviation sector. These activities are intended to support investment in GGR technologies from the aviation sector to increase GGR capacity and capability in the UK.

The ultimate outcomes of these activities are expected to include reduced net carbon emissions in the aviation industry, increased investment from the aviation sector in the decarbonisation and sustainable development of other

sectors via the use of verified carbon credits, and an increase in negative emissions via the use of GGRs and the development of GGR technologies. These are expected to provide important contributions to net zero targets (by creating incentives for the aviation sector to decarbonise and compensating for residual emissions in 2050), as well as enhancing the UK's reputation as a global leader in carbon markets and delivering economic benefits from investments in decarbonisation and GGR technologies.

Figure 3.5 Markets and removals: Theory of change



3.5.1 Markets and removals: Priority monitoring indicators

A shortlist of ten priority monitoring indicators has been identified for the markets and removals policy measure (Table 3.5). This covers five of the outputs and five of the outcomes from the above ToC. The output indicators should be relatively straightforward to monitor using DfT's management information and should only require tracking in the short to medium term. However, most of the outcome indicators are expected to draw on external datasets and will need to be tracked over the full period to 2050.

Table 3.5 Priority indicators: Markets and removals (M&R)

Output/ Outcome	ToC box no.	Output/outcome description	Indicator description	Data source			Timing				
				DfT MI	DfT dataset	Other dataset	2025-29	2030-34	2035-39	2040-44	2045-50
Output	M&R:16	CORSIA fully implemented and enforced in UK	• Implementation of CORSIA legislation in UK	Y			Y	Y	Y		
Output	M&R:18	Relationships established between carbon markets	• Implementation of decisions regarding interactions between CORSIA and UK ETS	Y			Y	Y	Y		
Output	M&R:19	Implementation of UK ETS cap consistent with net zero and phase out aviation free allocation policy	• Implementation of net-zero consistent UK ETS cap • Implementation of decision to phase out the aviation free allocation policy	Y			Y				
Output	M&R:20	Implementation of decisions on how the UK ETS should treat SAF and non-CO_2	• Implementation of decisions regarding treatment of SAF and non-CO_2 in UK ETS	Y			Y	Y	Y		
Output	M&R:21	Develop business models / markets to support GGRs	• Implementation of decisions regarding interactions between GGRs and UK ETS / CORSIA • Development of UK business models to support GGRs	Y			Y	Y	Y		
Outcome	M&R:27	Increased incentive for UK aviation to reduce international emissions	• Price (£) of UK ETS allowances / CORSIA emission units		Y	Y	Y	Y	Y	Y	Y
Outcome	M&R:28	Increased demand for and purchases of CORSIA / UK ETS credits (from UK aviation)	• Number of CORSIA / UK ETS credits purchased by the UK aviation industry • Estimated carbon emissions / savings relating to international flights to and from the UK (MtCO2e)			Y	Y	Y	Y	Y	Y
Outcome	M&R:31	Increased incentives for aviation to invest in GGRs	• Aviation investments (£) in GGRs in the UK			Y	Y	Y	Y	Y	Y
Outcome	M&R:32	Increased capacity and capability of GGR technologies	• Total capacity of GGR facilities in the UK (MtCO2e)			Y	Y	Y	Y	Y	Y
Outcome	M&R:39	Carbon savings	• Estimated carbon emissions / savings (MtCO2e): current/projected from M&R measures in the UK • Projected contribution to total carbon savings by 2050		Y	Y	Y	Y	Y	Y	Y

Note: A full list of output and outcome indicators is provided in Annex 1

There are no bespoke research activities identified for the markets and removals policy measure at this stage and requirements for additional research activities are expected to be lighter-touch than for most other policy measures. This is because the causal links between markets and removals measures and their respective outputs and outcomes are relatively direct and straightforward, compared to the other policy areas, and a relatively large proportion of the indicators can be monitored using existing datasets rather than generating a requirement for new research. It is assumed that the additional research requirements are expected to focus on industry costs, investments and impacts associated with relevant measures and stakeholder perceptions of delivery processes and impacts, and there should be potential to combine some of these activities with other policy measures.

3.5.2 Markets and removals: Evaluation questions

Potential areas of focus for evaluation questions relating to the markets and removals policy measures include:

Process evaluation – Questions about: the rationale for different policy measures; their effectiveness in incentivising decarbonisation within the aviation sector; the extent to which measures have been aligned with developments in the industry; the appropriateness and timeliness of measures and delivery processes; and any lessons learned that could improve delivery.

Impact evaluation – Questions about: the impacts of markets and removals policy measures in incentivising decarbonisation of UK aviation and supporting the other policy measures to reduce carbon emissions; any impacts for the coverage and implementation of CORSIA in other countries; any impacts for increasing connections between the aviation and GGR sectors, and on GGR capacity and capabilities in the UK; progress towards individual targets for markets and removals measures and their expected / actual contribution to overall aviation decarbonisation objectives; the extent to which impacts can be attributed to the markets and removals measures; and considerations of any unintended consequences or impacts including any impacts on connectivity of the UK and UK regions.

Value for money evaluation – Questions about: the scale of resources used to deliver the markets and removals measures; their costs and benefits; comparisons of the value for money delivered by different activities, and any lessons learned that could help to improve value for money in the future.

3.6 Addressing non-CO_2

Aviation has non-CO_2 climate impacts, in addition to those from CO_2 emissions, which include nitrogen oxides (NOx), water vapour, soot (particulates), sulphur aerosols and condensation trails (contrails). Current scientific evidence estimates that aviation's non-CO_2 impacts on the climate could be two to three times greater than the impact from CO_2 emissions[11], although significant uncertainties remain about the interaction between aviation's non-CO_2 impacts and the atmosphere. The evidence also suggests that non-CO_2 emissions are relatively short-lived compared to CO_2 emissions, highlighting the need to consider potential trade-offs of any non-CO_2 policy interventions on CO_2 emissions. Measures in this area are expected to involve close working between government, academia and industry in the UK and internationally to develop a better understanding of aviation's non-CO_2 impacts and potential mitigation options. There is also a need for greater sharing of information and data on non-CO_2 impacts to reduce uncertainties, gain a better understanding of potential trade-offs, and develop metrics for measuring non-CO_2 impacts. The key activities, outputs and outcomes in this area are expected to include:

- **Improving our understanding of non-CO_2 impacts**. This is likely to involve funding for both academic and industry research to improve understanding of aviation's non-CO_2 impacts, and reduce uncertainties relating to their climate impacts. This will be complemented by collaboration between government, industry and academia to build UK and international consensus on non-CO_2 impacts, their measurement and potential regulation. This could support the development of non-CO_2 mitigation options in the UK, and help to influence and shape the development of international standards, regulations and measures to address non-CO_2 impacts, aiming for internationally-coordinated approaches.
- **Improving the monitoring of non-CO_2 impacts**. This would require the exploration, development and implementation of methodologies for measuring and monitoring non-CO_2 emissions and impacts from aviation. These activities are expected to support an increase in the collection of data on non-CO_2 emissions and impacts to reduce the uncertainties associated with aviation's non-CO_2 impacts, whilst also supporting efforts to build international consensus and develop non-CO_2 mitigation measures in the UK. Monitoring non-CO_2 impacts should also help to mitigate non-CO_2 impacts from aviation and support ongoing efforts to understand the potential trade-offs associated with the impacts of non-CO_2 mitigation options on carbon emissions.
- **Implementing non-CO_2 mitigation strategies**. This is likely to include activities to plan and deliver contrail avoidance trials in the UK and to analyse the impact of new fuels (SAF and hydrogen) on aviation's non-CO_2 emissions. These activities would further improve the knowledge

[11] D.S. Lee et al (2020) The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018 (published in volume 244 of Atmospheric Environment). Available at: https://www.sciencedirect.com/science/article/pii/S1352231020305689

base for aviation's non-CO_2 impacts and may influence how non-CO_2 impacts could be effectively monitored and mitigated in the UK (including the feasibility of including non-CO_2 impacts into the UK ETS and/or CORSIA). Requirements such as these would also incentivise the aviation industry to design and deploy new technologies and solutions to reduce non-CO_2 impacts, providing opportunities for economic benefits from UK industry leading on the development of technologies to reduce non-CO_2 impacts.

Figure 3.6 Addressing non-CO2: Theory of change

3.6.1 Addressing non-CO_2: Priority monitoring indicators

A shortlist of five priority monitoring indicators has been identified for the addressing non-CO_2 policy measure (Table 3.6). This covers two of the outputs and three of the outcomes from the above ToC. The output indicators should be relatively straightforward to monitor using DfT's management information and monitoring activities are likely to focus on the short-term. The outcome indicators are slightly more complex and uncertain (i.e. it is not yet known whether non-CO_2 impacts will be included in either the UK ETS or CORSIA) and will require more effort to gather data from DfT and external datasets.

Table 3.6 Priority indicators: Addressing non-CO_2

Output/ Outcome	ToC box no.	Output/outcome description	Indicator description	Data source			Timing				
				DfT MI	DfT dataset	Other dataset	2025-29	2030-34	2035-39	2040-44	2045-50
Output	Non:10	Collaborate with UK and international industry, regulators and academia on non-CO_2 impacts, measurement and regulation	• Formation of non-CO_2 working groups in the UK (e.g. task and finish groups) • UK and international agreements relating to non-CO_2 impacts and mitigation	Y	Y	Y	Y	Y	Y	Y	Y
Output	Non:12	Deliver contrail avoidance trials	• Plans developed for contrail avoidance trials in the UK • Delivery of contrail avoidance trials in the UK	Y			Y				
Outcome	Non:13	Increased understanding of non-CO_2 impacts and how to measure them	• Development of methodologies for measuring non-CO_2 impacts	Y			Y	Y			
Outcome	Non:19	Potential inclusion of non-CO_2 impacts in UK ETS and/or CORSIA	• Decision made on whether to include non-CO_2 impacts in UK ETS and/or CORSIA • *(Potential)* Implementation of decision to include non-CO_2 impacts in UK ETS and/or CORSIA	Y			TBC				
Outcome	Non:28	Potential trade-offs / impacts (positive or negative) of non-CO2 interventions for carbon emissions	• Estimated carbon emissions (MtCO2e) – current and projected, from UK measures to address non-CO_2 impacts • Projected contribution to total carbon emissions by 2050		Y	Y	Y	Y	Y	Y	Y

Note: A full list of output and outcome indicators is provided in Annex 1. Indicators for reduced non-CO_2 impacts (Non:27 in the ToC) should be added to the list of high priority indicators in the future but will firstly require an increased understanding of non-CO_2 impacts, how they should be measured and potential data sources.

There will also be requirements for additional research to inform the addressing non-CO2 measures. This is likely to include research with industry and academia covering the costs, investments and impacts associated with aviation decarbonisation activities and research to explore stakeholder perceptions of delivery processes and impacts of non-CO2 activities. However, there is also likely to be some more targeted research into approaches and action to collect, measure, report and verify data on non-CO2 impacts, and the extent to which other countries are implementing and complying with any international guidance, standards or regulations.

3.6.2 Addressing non-CO_2: Evaluation questions

Potential areas of focus for evaluation questions relating to the addressing non-CO_2 policy measures include:

Process evaluation – Questions about: the rationale for different policy measures; their effectiveness in incorporating non-CO_2 mitigation within other policy areas; the extent to which R&D funding and activities has been targeted effectively to improve understanding and fill gaps in the evidence base; the appropriateness and timeliness of measures and delivery processes; and any lessons learned that could improve delivery.

Impact evaluation – Questions about: the impacts of non-CO_2 policy measures for understanding the scale and nature of non-CO_2 impacts of aviation activities, the measurement and reporting of non-CO_2 impacts, and the development of mitigation policies; impacts for the overall level of non-CO_2 impacts; any trade-offs for carbon savings or any wider economic and environmental impacts; progress towards individual targets for non-CO_2 measures and their expected / actual contribution to overall aviation decarbonisation objectives; the extent to which impacts can be attributed to the addressing non-CO_2 measures; and considerations of any unintended consequences or impacts.

Value for money evaluation – Questions about: the scale of resources used to deliver the non-CO_2 measures; their costs and benefits; comparisons of the value for money delivered by different activities, and any lessons learned that could help to improve value for money in the future.

4 Recommendations and next steps

This M&E framework provides a series of tools that DfT can use to:

- Initiate a comprehensive programme of monitoring to track the progress and performance of aviation decarbonisation measures in the UK.
- Inform decisions around the development and implementation of interventions, requirements for additional research, and the planning and delivery of evaluation activities.

Some of these actions are things that DfT can already start to deliver, including monitoring activities and the use of monitoring data to inform the development of interventions. Others, such as the design and delivery of evaluations, will need to take place when there is sufficient understanding of potential interventions across all policy areas. The recommended next steps for DfT are set out below and cover activities associated with monitoring, additional research and evaluation.

Monitoring activities can commence immediately to prepare and start collecting, analysing and reporting relevant data for the priority indicators. The key tasks associated with monitoring include:

- Consolidating existing data sources, identifying potential new sources and/or making improvements to existing sources (particularly DfT's internal datasets and MI) to provide evidence for the priority indicators.
- Developing tools and allocating roles and responsibilities for the collection, analysis and reporting of monitoring data for the priority indicators. This should consider whether monitoring activities are managed centrally or for individual policy areas, whether data are presented using dashboards, spreadsheets and/or written documents and the frequency of data collection, analysis and reporting. Timings will depend on DfT's own requirements for MI as well as the availability and frequency of updates to datasets, some of which can be updated on a monthly or quarterly basis, while others will need to be updated annually.
- Using monitoring indicators to analyse the progress and performance of different activities and policy areas and identify needs and opportunities for new interventions and/or changes to existing interventions to best meet the overall aviation decarbonisation objectives.
- Undertaking periodic reviews of the high and low priority indicators to establish if there is a need (and sufficient resource) to track additional indicators, if any changes need to be made to the prioritisation of indicators over time, and if there are any new indicators that should be added to the list in Annex 1.

Additional research activities are also required to gather evidence for some monitoring indicators that are not available from existing datasets and to inform evaluation activities. These research activities will require additional resources and will therefore be dependent on available budgets. The main tasks for DfT are to consider the costs and benefits of additional research and the ability to target efforts to ensure any research activities are cost-effective. This will include:

- Reviewing the indicators listed in Annex 1 and the extent to which additional research will add value to the data available from existing datasets.
- Identifying opportunities for delivering cost-effective research activities that can target multiple indicators, can be shared with other government departments and/or combined with other research activities.
- Consider how additional research activities can be used to inform evaluation activities and included within the evaluation methodologies specified in implementation plans (described below).

Evaluation activities should be designed and delivered when more is known about the delivery of interventions across the different policy areas. The above monitoring and research activities should provide important information that can be used to inform the development and implementation of interventions to support aviation decarbonisation. When more is known about these interventions, this M&E framework can support DfT in designing and delivering evaluation activities through the following tasks:

- Reviewing and revising the ToCs over time to ensure they capture all relevant activities/interventions, outputs and intended outcomes for each policy area. The ToCs should be treated as living/dynamic tools that are edited and updated over time to reflect changes and the addition of new activities and interventions within each policy area. There may also be requirements for additional ToCs covering new policy areas, such as those aimed at influencing consumers and direct demand management measures.
- Review the need for additional monitoring indicators for any outputs and outcomes associated with new or revised activities and interventions.
- When there is greater understanding of the interventions that will support the achievement of aviation decarbonisation objectives, a detailed implementation plan should be developed that:
  - Prioritises different policy measures for evaluation using the assessment tool provided in Annex 3;
  - Considers how the monitoring indicators and data can be used to inform baselines against which the progress and impacts of future interventions can be evaluated;
  - Refines the evaluation questions presented in Annex 4 to develop a list of questions that are specific to the intervention(s) being evaluated;
  - Uses the review of potential evaluation methodologies presented in Annex 5 to develop specific approaches and methodologies for evaluating specific interventions; and
  - Considers how to best deliver evaluation activities using a combination of DfT and external resources, depending on the nature of the tasks and the available budget.

DfT should consider the recommendations and next steps set out in this report for the monitoring and evaluation of aviation decarbonisation activities in the UK and globally.

ANNEXES

Annex 1 Full list of monitoring indicators

The high priority indicators listed in Section 3 are included in **bold text** in this table.

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
System efficiencies	Output	SE:31	Increased number and % of aircraft meeting ICAO emissions standards	• Number (and %) of UK aircraft meeting ICAO emissions standards
	Output	SE:32	Increased investment in developing efficient aircraft technologies	• Investment (£) in efficient aircraft technologies in the UK (public / private / total)
	Output	SE:33	Increased workforce skills / numbers of skilled jobs and apprenticeships	• Number of skilled jobs in the UK relating to new aircraft designs & technologies • Number of UK apprenticeships / training programmes / FE/HE programmes relating to new aircraft designs & technologies • Take-up of relevant apprenticeships / training programmes / FE/HE programmes in the UK
	Output	SE:34	Increased use of more efficient aircraft	• Total carbon emissions per passenger km across the UK aircraft fleet
	Output	SE:35	Reduction in average weights of aircraft (by type)	• Average weights of the UK aircraft fleet (by type)
	Output	SE:36	Reduction in amount of fuel tankered	• *(Potential)* implementation of a mechanism in the UK to restrict tankering • (Actual or estimated) reduction in amount of fuel tankered due to the mechanism
	Output	SE:37	Increased utilisation of airline capacity	• Average flight loads for flights departing the UK (utilisation % of capacity)
	Output	SE:38	Increased % of flights and airlines implementing more efficient flight plans and aircraft movements	• % of UK flights and airlines implementing more efficient flight plans and aircraft movements • Estimated carbon savings resulting from more efficient flight plans and aircraft movements in the UK
	Output	SE:39	Airports deploying low carbon and zero emission technologies	• Number of UK airports deploying low / zero emission technologies: - Low carbon heat and power systems - Zero / low emissions ground vehicles - Provision of clean power & PCA systems at aircraft stands
	Output	**SE:40**	**Airports with net zero and/or zero emission targets**	• **Number of UK airports with net zero targets** • **Number of UK airports with zero emission targets**
	Output	SE:41	Implementation of improvements to terminal airspace, operations and other smaller-scale opportunities	• Number of proposals developed / implemented in the UK
	Output	**SE:42**	**Development of airspace change proposals**	• **Development of airspace change proposals in the UK**
	Output	**SE:43**	**Expansion of Free Route Airspace (>25,000ft)**	• **Implementation of Free Route Airspace across UK regions (i.e. North of England by Autumn 2025 and London and the South East by Autumn 2026)**
	Outcome	**SE:44**	**Increased use of new / modified aircraft that have higher fuel efficiency**	• **Number of new / modified aircraft in use in the UK (and % of total)** • **Distance travelled by new / modified aircraft (and % of total)**
	Outcome	**SE:45**	**Airports' progress towards net zero / zero emission targets**	• **Estimated carbon emissions / savings of UK airports (MtCO2e)** • **Airports' reports of progress towards net zero / zero emission targets**
	Outcome	**SE:46**	**Increased efficiency of UK airspace**	• **Estimated efficiency of UK airspace (NATS 3Di metric)**
	Outcome	**SE:47**	**Implementation of airspace change proposals**	• **Implementation of the Future Airspace Strategy Implementation (FASI) element of the Airspace Modernisation Strategy and other airspace change proposals**

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
System efficiencies	Outcome	SE:48	Airlines able to select their own routes between defined entry and exit points (in free route airspace)	• Take-up of ability to select own routes through UK airspace (number and & of airlines / flights making changes to routes, due to the implementation of Free Route Airspace)
	Outcome	**SE:49**	**Support growth of UK manufacturing in ultra-efficient aircraft technologies**	• **UK jobs (FTE) and GVA (£) in aviation sub-sectors (and supply chains) relating to ultra-efficient aircraft technologies**
	Outcome	**SE:50**	**Increased efficiency from using existing / conventional aircraft**	• **Average flight loads for flights departing the UK (% of total passenger and freight capacity)** • **Estimated carbon emissions / savings per passenger or metric ton of freight for flights departing the UK**
	Outcome	SE:51	Quicker journeys with reduced emissions and noise impacts	• Average flight times (mins) and distances (km) for different routes using UK airspace • Airport noise contours and associated areas / decibels in the UK • Estimated carbon emissions / savings associated with more efficient journeys in UK airspace (MtCO2e) • Estimated non-CO_2 emissions / savings in the UK (tbc - informed by current research activities) • Estimated UK emissions of other air pollutants (NOx, particulate matter, SO_2, CO, etc.)
	Outcome	SE:52	Potential to increase capacity and improve resilience through more efficient use of airspace	• Number of flights and routes using UK airspace • Stakeholder perceptions of the extent to which more efficient use of UK airspace has increased capacity and improved resilience
	Outcome	SE:53	Potential reduction of non-CO_2 impacts	• Estimated non-CO_2 emissions / savings in the UK
	Outcome	SE:54	Potential for growth in flights, passengers and freight	• Number of UK flights / passengers (domestic & international) • Volume and value of air freight (domestic & international)
	Outcome	**SE:55**	**Carbon savings**	• **Estimated carbon emissions / savings (MtCO2e) - current and projected from system efficiencies measures** • **Projected contribution to total carbon savings by 2050**
	Outcome	SE:56	Other environmental benefits (e.g. reduction in noise, local air pollutants and non-CO_2 impact)	• Airport noise contours and associated areas / decibels in the UK • Estimated UK emissions of air pollutants (NOx, particulate matter, SO_2, CO, etc.) • Estimated non-CO_2 emissions / savings in the UK
	Outcome	SE:57	Economic benefits (e.g. increased jobs, GVA and share of global market in efficient technologies)	• UK jobs (FTE) and GVA (£) in aviation sub-sectors (and supply chains) relating to efficient technologies • UK share (%) of global market in aviation sub-sectors relating to efficient technologies
SAF	**Output**	**SAF:11**	**Increased investment in SAF plants in the UK**	• **Investment (£) in SAF plants in the UK (public / private / total)**
	Output	**SAF:12**	**Supply of feedstocks for SAF through UK production and imports**	• **UK production (volume & value) of feedstocks (in total and for SAF/aviation use)** • **UK imports (volume & value) of feedstocks (in total and for SAF/aviation use)**
	Output	SAF:13	Increased potential to use SAF for aircraft	• Number of aircraft able to use SAF in the UK (and % of total) • Distance travelled in UK airspace by aircraft using SAF (and % of total) • Public awareness and perceptions of SAF
	Output	**SAF:14**	**Development and operation of early stage aviation fuel testing in the UK**	• **Number of testing facilities associated with SAF testing in the UK**
	Output	**SAF:15**	**Ongoing assessment of the SAF Mandate to support SAF production and use**	• **SAF supplied and rewarded through the SAF Mandate (volume)**

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
SAF	Output	SAF:16	Fuel suppliers obliged to reduce emissions of aviation fuel	• Volume of SAF supplied in the UK (absolute volume and % of all aviation fuel)
	Output	**SAF:17**	**Decreasing cost of SAF relative to jet fuel**	• **Average costs (£) of SAF and conventional jet fuel in the UK (including taxes and carbon prices)**
	Output	SAF:18	ICAO adoption of SAF sustainability standards	• Adoption of global SAF sustainability standards
	Outcome	**SAF:19**	**Development of commercial scale SAF plants in the UK**	• **Number of SAF plants under construction in the UK** • **Number of SAF plants in operation in the UK**
	Outcome	SAF:20	Reduced risks / barriers to invest in SAF production in the UK	• Stakeholder and investor perceptions of risks and barriers to investment in SAF production in the UK (and effects of SAF policy measures)
	Outcome	SAF:21	Increased certainty increases investor confidence	• Stakeholder and investor perceptions of confidence to invest in SAF production in the UK (and effects of Jet Zero policy measures)
	Outcome	SAF:22	Accelerated testing and development of new SAF fuels	• Number of new fuels tested / approved in the UK • Outputs of SAF fuel testing in the UK (volume and value)
	Outcome	SAF:23	Increased confidence in future levels of demand and supply of SAF	• Stakeholder perceptions of future demand and supply of SAF (UK and global)
	Outcome	**SAF:24**	**Financial incentives to SAF producers**	• **Funding / incentives (£) provided to SAF producers in the UK**
	Outcome	SAF:25	Increased demand for SAF from fuel suppliers	• SAF consumption by aviation fuel suppliers in the UK (volume and value)
	Outcome	SAF:26	Increased SAF production capacity in other countries	• Number of countries developing SAF production capacity • Volume and value of SAF production in other countries
	Outcome	SAF:27	International quality standards for SAF	• Development of international quality standards for SAF • Number of countries adopting international quality standards for SAF
	Outcome	**SAF:28**	**Increased demand for SAF from suppliers and airlines**	• **SAF consumption by airlines departing the UK (volume and value)**
	Outcome	**SAF:29**	**Increased SAF production in the UK (delivering mandate targets)**	• **UK SAF production (volume and value)** • **Progress against SAF mandate targets**
	Outcome	SAF:30	Increased innovation in UK SAF production	• R&D investments (£) in UK SAF production • Number of patents (applications and patents issued) relating to SAF production in the UK • Stakeholder perceptions of innovation in UK SAF production
	Outcome	SAF:31	More efficient production processes / lower costs of SAF production	• Costs (£) of SAF production in the UK • Average price of SAF produced in the UK (nominal and real prices)
	Outcome	SAF:32	Increased investment in UK SAF industry	• Total investment (£) in UK SAF industry (public / private / total)
	Outcome	SAF:33	Additional capital unlocked for the UK SAF industry	• Private investment (£) in UK SAF industry unlocked by SAF policy measures
	Outcome	SAF:34	Development of SAF supply chain in the UK	• Number of businesses, jobs and revenues / output (£) involved in supplying the UK SAF industry
	Outcome	SAF:35	Increased global demand (and supply) of SAF	• Total global production of SAF (volume and value) • Total global consumption of SAF (volume and value)
	Outcome	**SAF:36**	**Increased global demand for UK SAF**	• **Total global consumption of SAF produced in the UK (volume and value)**
	Outcome	SAF:37	Increased use of SAF	• Number (and %) of airlines and flights departing the UK and using SAF • Distance (km and % of total) of flights departing the UK and using SAF

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
SAF	Outcome	SAF:38	Increased capacity and capability of UK SAF production	• UK SAF production (volume and value) • Number of businesses, jobs and plants involved in UK SAF production, testing and distribution • Stakeholder perceptions of SAF production capacity and capabilities in the UK
	Outcome	SAF:39	Increase in domestic sales of UK SAF	• UK SAF consumption (volume and value)
	Outcome	SAF:40	Creation of green jobs in the UK	• UK jobs (FTE) in sectors relating to the production, distribution and use of SAF (incl. supply chains and spillover effects for other 'green' sectors)
	Outcome	SAF:41	Increase in competitiveness of UK as a SAF hub	• UK share of global SAF market (volume and value) • Stakeholder perceptions of UK competitiveness in the SAF market
	Outcome	**SAF:42**	**Increase in UK exports of SAF**	• **UK SAF exports (volume and value)**
	Outcome	**SAF:43**	**Carbon savings**	• **Estimated carbon emissions / savings (MtCO2e) - current and projected from use of SAF on flights departing the UK** • **Projected contribution to total carbon savings by 2050**
	Outcome	SAF:44	Other environmental benefits (e.g. reduction of non-CO_2 impact)	• Estimated UK emissions of air pollutants (NOx, particulate matter, SO_2, CO, etc.) • Estimated non-CO_2 emissions / savings
	Outcome	SAF:45	Increased fuel security for the UK & reduced reliance on imports	• UK imports & exports of SAF (volume and value) • UK imports & exports of all aviation fuels (volume and value) • Stakeholder and industry perceptions of fuel security for the UK (and impacts of SAF policy measures)
	Outcome	SAF:46	Economic benefits (e.g. increased jobs, GVA, exports and share of global SAF market)	• UK jobs (FTE) and GVA (£) in sectors relating to the production, distribution and use of SAF (incl. supply chains) • UK exports of SAF and SAF-related products / services (volume and value) • UK share (%) of global SAF market
ZEF	**Output**	**ZEF:12**	**Increased number and value of ZEF R&D projects in the UK**	• **Number of ZEF R&D projects in the UK** • **Funding provided for ZEF R&D projects in the UK** • **Investment in ZEF R&D projects in the UK (public / private / total)**
	Output	ZEF:13	Increased knowledge, skills and relationships / networks associated with ZEF R&D	• Number of collaborative working groups / networks created to support ZEF R&D in the UK • Number of organisations engaging with collaborative groups / networks relating to ZEF R&D in the UK
	Output	**ZEF:14**	**Increased education and training provision relating to ZEF technologies**	• **Number of UK apprenticeships / training programmes / FE/HE programmes relating to ZEF technologies**
	Output	**ZEF:15**	**Increased take-up of relevant apprenticeships, training and FE/HE programmes**	• **Take-up of relevant apprenticeships / training programmes / FE/HE programmes in the UK**
	Output	**ZEF:16**	**Development of regulations to ensure safety and support ZEF activities and ambitions**	• **Regulations developed to ensure safety and support ZEF activities and ambitions**
	Output	**ZEF:17**	**Improved understanding and specification of requirements to support zero emission aircraft technologies**	• **Number of UK projects researching requirements for supporting zero emission aircraft technologies** • **Investment (£) in UK projects to improve understanding of requirements (public / private / total)**
	Output	**ZEF:18**	**Investment in production and supply of ZEF technologies**	• **Investment (£) in the production of zero emission technologies in the UK (public / private / total)**
	Output	ZEF:19	Increased demand for ZEF technologies and aircraft	• Number and value of orders for ZEF technologies and aircraft from UK and international airlines

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
ZEF	Output	ZEF:20	Increased demonstration and supply of low carbon hydrogen	• Investment in hydrogen demonstration projects in the UK (public / private / total) • Delivery of hydrogen demonstration activities in the UK • Volume of low carbon hydrogen produced in the UK
	Outcome	ZEF:21	Increased knowledge and understanding of the feasibility and benefits of developing zero emission aircraft	• Stakeholder and industry perceptions and understanding of the feasibility of developing zero emission aircraft and the expected benefits (and the extent to which this has been supported by ZEF policy measures in the UK) • Public awareness and understanding of zero emission (hydrogen) aircraft in the UK
	Outcome	ZEF:22	Determine which ZEF technologies (hydrogen, hydrogen fuel cell, or electric) are best for different routes and aircraft types	• Stakeholder and industry perceptions of the available evidence and understanding of which ZEF technologies are best for different routes and aircraft types (and the extent to which this has been supported by ZEF policy measures)
	Outcome	ZEF:23	Accelerated testing and demonstration of zero emission technologies	• Number of projects, businesses, jobs and facilities associated with the testing and demonstration of zero emission technologies in the UK
	Outcome	**ZEF:24**	**Projects developing from R&D to pilot testing and initial stage small scale commercialisation**	• **Number of zero emission R&D projects progressing to pilot testing / small scale commercialisation stages in the UK** • **Investment (£) in UK projects progressing to pilot testing / small scale commercialisation stages (public / private / total)**
	Outcome	ZEF:25	Reduced risks / barriers to invest in development of zero emission technologies	• Stakeholder and investor perceptions of risks and barriers to investment in development of zero emission technologies in the UK (and effects of ZEF policy measures)
	Outcome	ZEF:26	Increased support & certainty increases investor confidence	• Stakeholder and investor perceptions of confidence to invest in zero emission aircraft in the UK (and effects of ZEF policy measures)
	Outcome	ZEF:27	Development of skills required to develop and produce zero emission aircraft	• Number of people developing skills relating to zero emission aircraft in the UK • Number of training courses delivered relating to the design and production of zero emission aircraft in the UK (by level of qualification) • Number of people attending these training courses (by level of qualification)
	Outcome	ZEF:28	Implementation of UK and international legislation / regulations to support industry	• Regulations / legislation introduced to support the development of zero emission aircraft (UK and international)
	Outcome	ZEF:29	Increased development and installation of ground infrastructure to support zero emission aircraft	• Stakeholder and industry perceptions of understanding of ground infrastructure support requirements and the feasibility of delivering in the UK • Number (and %) of UK airports developing ground infrastructure to support zero emission aircraft
	Outcome	ZEF:30	Opportunities for demonstration and deployment of zero emission aircraft	• Number (and %) of routes deploying zero emission aircraft (domestic, international and PSO routes) • Number (and %) of zero emission aircraft deployed in the general aviation sector in the UK
	Outcome	**ZEF:31**	**Increased demonstration and development of low carbon hydrogen production**	• **Number and value of UK project(s) demonstrating the use of low carbon hydrogen for aviation**
	Outcome	ZEF:32	Increased investment in development of hydrogen / zero emission aircraft	• Total investment (£) in the development of low carbon hydrogen and zero emission aircraft in the UK
	Outcome	ZEF:33	Increased innovation in development of hydrogen / zero emission aircraft	• Number of patents (applications and patents issued) relating to the development of low carbon hydrogen and zero emission aircraft in the UK • Stakeholder perceptions of the extent of innovation in the development of low carbon hydrogen and zero emission aircraft in the UK (and effects of ZEF policy measures)

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
ZEF	Outcome	ZEF:34	Increased capacity and capability for production of low carbon hydrogen	• Number of businesses, jobs and facilities involved in UK production, testing and distribution of low carbon hydrogen • Stakeholder perceptions of UK capacity and capabilities in the production of low carbon hydrogen (and effects of ZEF policy measures)
	Outcome	ZEF:35	Increased capacity and capability for production of zero emission aircraft	• Number of businesses, jobs and facilities involved in UK production, testing and distribution of zero emission aircraft • Stakeholder perceptions of UK capacity and capabilities in the production of zero emission aircraft (and effects of ZEF policy measures)
	Outcome	ZEF:36	Development of UK supply chain for zero emission aircraft	• Number of UK businesses, jobs and revenues / output (£) involved in the supply chain for zero emission aircraft
	Outcome	ZEF:37	ZEF technologies and aircraft purchased by UK and international airlines	• Number of ZEF aircraft purchased by UK and international airlines • Value of ZEF technologies and aircraft purchased by UK and international airlines
	Outcome	ZEF:38	Reduced carbon emissions per flight	• Estimated carbon emissions / savings per flight (CO_2e)
	Outcome	**ZEF:39**	**Increased deployment of zero emission aircraft**	• **Number of zero emission aircraft in operation (and % of total number of operational aircraft) by UK and international airlines** • **Number (and %) of flights** departing the UK **using zero emission aircraft (domestic and international)** • **Distance (and % of total) of flights** departing the UK **using zero emission aircraft (domestic and international)**
	Outcome	ZEF:40	Potential reduction of non-CO_2 impacts	• Estimated non-CO_2 emissions / savings in the UK
	Outcome	**ZEF:41**	**Increased UK production of low carbon hydrogen**	• **UK production of low carbon hydrogen (volume and value)**
	Outcome	**ZEF:42**	**Creation of green jobs in the UK**	• **UK jobs (FTE) in sectors relating to the production, distribution and use of zero emission aircraft (incl. supply chains)**
	Outcome	ZEF:43	Increased UK production of zero emission aircraft	• UK production of zero emission aircraft, components and technologies (volume and value)
	Outcome	ZEF:44	Increase in UK exports of zero emission aircraft technologies	• UK exports of zero emission aircraft, components and technologies (volume and value)
	Outcome	**ZEF:45**	**Carbon savings**	• **Estimated carbon emissions / savings (MtCO2e) - current and projected from flights departing the UK using zero emission aircraft** • **Projected contribution to total carbon savings by 2050**
	Outcome	ZEF:46	Other environmental benefits (e.g. reduction of non-CO_2 impact)	• Airport noise contours and associated areas / decibels • Estimated UK emissions of air pollutants (NOx, particulate matter, SO_2, CO, etc.) • Estimated non-CO_2 emissions / savings in the UK
	Outcome	ZEF:47	Increased fuel security for the UK and reduced reliance on imports	• UK imports & exports of low carbon hydrogen (volume and value) • UK imports & exports of all aviation fuels (volume and value) • Stakeholder and industry perceptions of fuel security for the UK (and impacts of ZEF policy measures)
	Outcome	ZEF:48	Economic benefits (e.g. increased jobs, GVA, exports and share of global aerospace manufacturing)	• UK jobs (FTE) and GVA (£) in aerospace manufacturing and zero emission fuel sectors (incl. supply chains) • UK exports of zero emission aircraft, low carbon hydrogen and related products/services (volume and value) • UK share (%) of global aerospace manufacturing market and zero emission fuels market

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
Markets & removals	**Output**	**M&R:16**	**CORSIA fully implemented and enforced in UK**	• **Implementation of CORSIA legislation in UK**
	Output	M&R:17	Increased coverage and effective implementation of CORSIA (in other countries)	• Number of countries implementing CORSIA legislation
	Output	**M&R:18**	**Relationships established between carbon markets**	• **Implementation of decisions regarding interactions between CORSIA and UK ETS**
	Output	**M&R:19**	**Implementation of UK ETS cap consistent with net zero and phase out aviation free allocation policy**	• **Implementation of net-zero consistent UK ETS cap** • **Implementation of decision to phase out the aviation free allocation policy**
	Output	**M&R:20**	**Implementation of decisions on how the UK ETS should treat SAF and non-CO_2**	• **Implementation of decisions regarding treatment of SAF and non-CO_2 in UK ETS**
	Output	**M&R:21**	**Develop business models / markets to support GGRs**	• **Implementation of decisions regarding interactions between GGRs and UK ETS / CORSIA** • **Development of UK business models to support GGRs**
	Output	M&R:22	Increased investment in GGR technology	• Investment (£) in GGR technology in the UK (public / private / total) • Number of CCUS clusters developed in the UK
	Outcome	M&R:23	UK aviation obliged to comply with CORSIA	• Implementation of CORSIA legislation in the UK • Industry estimates of the costs to UK aviation of complying with CORSIA
	Outcome	M&R:24	Increased harmonisation of international standards (competitiveness impacts on UK aviation minimised)	• Stakeholder and industry perceptions of harmonisation of international standards and impacts for competitiveness of UK aviation (and effects of M&R policy measures)
	Outcome	M&R:25	Increased costs for aviation sector	• Costs (£) to UK aviation businesses of complying with markets and removals policies
	Outcome	M&R:26	Increased effectiveness of UK ETS to support decarbonisation	• Stakeholder and industry perceptions of the effectiveness of UK ETS in supporting decarbonisation • Estimated emission savings delivered by the UK ETS (covering carbon - MtCO2e - and potentially non-CO_2 emission savings)
	Outcome	**M&R:27**	**Increased incentives for UK aviation to reduce international emissions**	• Stakeholder and industry perceptions of extent to which M&R measures and mechanisms have incentivised actions to reduce international emissions • **Price (£) of UK ETS allowances / CORSIA emission units**
	Outcome	**M&R:28**	**Increased demand for and purchases of CORSIA / UK ETS credits (from UK aviation)**	• **Number of CORSIA / UK ETS credits purchased by the UK aviation industry** • **Estimated carbon emissions / savings relating to international flights to and from the UK (MtCO2e)**
	Outcome	M&R:29	Increased prices for aviation consumers and lower demand growth	• Average fares for UK passengers per flight / per km (nominal and real prices) • Number of UK flights / passengers (domestic & international) • Volume and value of air freight (domestic & international)
	Outcome	M&R:30	Increased incentives for aviation industry to invest in decarbonisation of UK aviation	• Airline investments (£) in decarbonisation of UK aviation • Number (and %) of UK flights and airlines that have reduced their carbon emissions • Scale of reduction in carbon emissions of flights departing the UK (absolute and %)
	Outcome	**M&R:31**	**Increased incentives for aviation to invest in GGRs**	• **Aviation investments (£) in GGRs in the UK**
	Outcome	**M&R:32**	**Increased capacity and capability of GGR technologies**	• **Total capacity of GGR facilities in the UK (MtCO2e)** • Stakeholder and industry perceptions of current and potential capacity and capabilities of GGR technologies in the UK (and effects of M&R policy measures)
	Outcome	M&R:33	Increased investment in decarbonisation of the aviation sector	• Investment (£) in aviation decarbonisation in the UK

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
Markets & removals	Outcome	M&R:34	Increased effectiveness of carbon markets and increased removals	• Stakeholder and industry perceptions of the effectiveness of carbon markets and the extent to which M&R measures have incentivised the decarbonisation of UK aviation and other sectors
	Outcome	M&R:35	Increased GGRs	• Estimated GGRs associated with UK aviation (tonnes of CO_2 removed)
	Outcome	M&R:36	Direct carbon emissions reductions in the aviation sector	• Estimated carbon emissions / savings in the UK aviation industry (MtCO2e)
	Outcome	M&R:37	Emissions reductions in other sectors (net emissions benefit)	• Estimated carbon emissions / savings in other sectors, resulting from UK aviation purchasing CORSIA / UK ETS credits (MtCO2e)
	Outcome	M&R:38	Increased compensation for residual carbon emissions by 2050	• Estimates of residual carbon emissions for UK aviation (MtCO2e)
	Outcome	**M&R:39**	**Carbon savings**	• **Estimated carbon emissions / savings (MtCO2e) - current and projected from M&R measures in the UK** • **Projected contribution to total carbon savings by 2050**
	Outcome	M&R:40	Economic benefits (e.g. increased jobs, GVA)	• UK jobs (FTE) and GVA (£) supported by UK aviation contributions to decarbonisation through carbon markets and removals (incl. jobs/GVA supported in delivering the markets and removals activities and mechanisms)
	Outcome	M&R:41	Enhanced reputation of UK as a leader in establishing and developing carbon markets	• Stakeholder perceptions of UK's reputation as a global leader in carbon markets (and effects of M&R policy measures)
Addressing non-CO_2	Output	Non:9	Research projects and publications to fill gaps in evidence base and reduce uncertainties relating to non-CO_2 impacts	• Funding (£) provided for UK research of non-CO_2 impacts • Number of UK research projects / papers / publications relating to non-CO_2 impacts (and addressing evidence gaps)
	Output	**Non:10**	**Collaborate with UK and international industry, regulators and academia on non-CO_2 impacts, measurement and regulation**	• **Formation of non-CO_2 working groups in the UK (e.g. task and finish groups)** • **Number of UK and international agreements relating to non-CO_2 impacts and mitigation**
	Output	Non:11	Commence monitoring of non-CO_2 impacts	• Methodology developed to monitor non-CO_2 impacts • Ongoing monitoring of non-CO_2 impacts in the UK
	Output	**Non:12**	**Deliver contrail avoidance trials**	• **Plans developed for contrail avoidance trials in the UK** • **Delivery of contrail avoidance trials in the UK**
	Outcome	**Non:13**	**Increased understanding of non-CO_2 impacts and how to measure them**	• Stakeholder perceptions of the extent to which there is understanding of non-CO_2 impacts (and effects of non-CO_2 policy measures) • **Development of methodologies for measuring non-CO_2 impacts**
	Outcome	Non:14	Build UK and international consensus on non-CO_2 impacts, measurement, regulation and best practice	• Number of international agreements relating to non-CO_2 impacts and mitigation
	Outcome	Non:15	Increased collection of industry data on non-CO_2 impacts	• Number (and %) of UK airlines / flights collecting data on non-CO_2 impacts
	Outcome	Non:16	Increased understanding of how to mitigate non-CO_2 impacts	• Stakeholder and industry perceptions of the extent to which there is understanding of how to mitigate non-CO_2 impacts (and effects of non-CO_2 policy measures)
	Outcome	Non:17	Increased ability for UK to take a leading role in driving / influencing international regulations	• Stakeholder and industry perceptions of the UK's role and ability to be a global leader in driving / influencing international regulations relating to non-CO_2 • Development of UK-led proposals for influencing international regulations relating to non-CO_2
	Outcome	Non:18	Non-CO_2 included in other international standards, regulation & actions	• *(Potential)* Inclusion of non-CO_2 in other international standards, regulations and actions • Number (and %) of countries implementing / complying with international standards, regulations and actions relating to non-CO_2

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
Addressing non-CO_2	**Outcome**	**Non:19**	**Potential inclusion of non-CO_2 impacts in UK ETS and/or CORSIA**	• **Decisions made on whether to include non-CO_2 impacts in UK ETS and/or CORSIA** • ***(Potential)* Implementation of decisions to include non-CO_2 impacts in UK ETS and/or CORSIA**
	Outcome	Non:20	Measurement, reporting, verification (MRV) systems introduced for non-CO_2	• Introduction of MRV systems for non-CO_2 emissions • Number (and %) of UK airlines adopting MRV systems for non-CO_2 emissions • Number (and %) of UK flights for which MRV systems are used to monitor non-CO_2 emissions
	Outcome	Non:21	Collaboration between government, academia and industry to develop non-CO_2 policies and mitigation plans	• Stakeholder, academia and industry perceptions of the level of collaboration relating to the development of non-CO_2 policies and mitigation plans in the UK (and effects of non-CO_2 policy measures) • Development and implementation of non-CO_2 policies • Industry reports of the extent to which they have developed / implemented non-CO_2 mitigation plans
	Outcome	Non:22	Consistency between UK and international measures and regulation (UK not disadvantaged)	• Stakeholder and industry perceptions of the extent to which UK and international measures and regulation (relating to non-CO_2) are consistent • Stakeholder and industry perceptions of whether (and the extent to which) the UK is disadvantaged by inconsistencies between UK and international measures and regulations relating to non-CO_2
	Outcome	Non:23	Increased funding / credit for reduced emissions in other sectors	• Number of credits purchased by the UK aviation industry for reduced non-CO_2 emissions in other sectors • Average price (£) of credits purchased by the UK aviation industry for reduced non-CO_2 emissions
	Outcome	Non:24	Aviation industry incentivised to deploy technology and solutions to reduce non-CO_2 impacts	• Aviation investments (£) in UK solutions to reduce non-CO_2 impacts • Stakeholder and industry perceptions of extent to which non-CO_2 policy measures have incentivised investments to reduce non-CO_2 impacts
	Outcome	Non:25	Increased action to reduce non-CO_2 impacts	• Investment (£) in UK actions to reduce non-CO_2 impacts (public / private / total) • Stakeholder and industry perceptions of levels of action aimed at reducing non-CO_2 impacts
	Outcome	Non:26	Opportunities for UK industry to develop solutions to mitigate non-CO_2 impacts	• Industry investments (£) in developing UK solutions to mitigate non-CO_2 impacts • Stakeholder and industry perceptions of opportunities for the UK to develop solutions to mitigate non-CO_2 impacts and become a global leader in developing such solutions (and effects of non-CO_2 policy measures)
	Outcome	Non:27	Reduced non-CO_2 impacts	• Estimated non-CO_2 emissions / savings from UK measures to address non-CO_2 impacts
	Outcome	**Non:28**	**Potential trade-offs / impacts (positive or negative) of non-CO_2 interventions for carbon emissions**	• **Estimated carbon emissions (MtCO2e) - current and projected from UK measures to address non-CO_2 impacts** • **Projected contribution to total carbon emissions by 2050**
	Outcome	Non:29	Economic benefits for UK aerospace and aviation (jobs, GVA, international competitiveness, global market share)	• UK jobs (FTE) and GVA (£) in aerospace and aviation sub-sectors associated with products/services to address non-CO_2 emissions • UK exports of aerospace and aviation products/services that address non-CO_2 emissions (volume and value) • UK share (%) of global aerospace and aviation markets (if possible, focusing on markets associated with products/services to address non-CO_2 emissions)

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
Total aviation decarb-onisation	Output	TOT:11	A coherent set of initiatives delivering a range of solutions to meet carbon budget commitments and achieve economy-wide net zero	• Agreement of a set of initiatives capable of delivering net zero in the UK
	Output	TOT:12	Increased international collaboration and consensus on net zero standards	• Agreement of international objectives and standards for net zero emissions from aviation • Number of countries committing to net zero objectives / standards for aviation
	Output	TOT:13	Increased coordination and collaboration across industry, government and academia	• Number of organisations / departments engaged in aviation decarbonisation delivery partnerships in the UK • Number of initiatives / projects delivered by aviation decarbonisation delivery partnerships in the UK
	Output	TOT:14	Increased incentives and information to influence consumer and industry behaviour	• *Included above for individual policy measures*
	Output	TOT:15	Increased funding and reduced barriers to investment	• *Included above for individual policy measures*
	Output	TOT:16	Research outputs help to define initiatives and explore potential contributions to Jet Zero	• *Included above for individual policy measures*
	Output	**TOT:17**	**Updated evidence and projections of future carbon emissions / savings**	• **Annual monitoring and reporting of CO_2 emissions in the UK** • ***(Potential future)* annual monitoring and reporting of non-CO_2 emissions in the UK**
	Output	TOT:18	Ongoing monitoring of progress of individual initiatives	• Ongoing monitoring of aviation decarbonisation initiatives in the UK
	Output	TOT:19	Evaluation evidence on processes, impact and value for money	• Ongoing evaluation of aviation decarbonisation initiatives in the UK (covering process, impact and value for money evaluation)
	Outcome	**TOT:20**	**Consolidation and coordination of initiatives relating to aviation decarbonisation**	• **Number of aviation decarbonisation initiatives in the UK** • Stakeholder and industry perceptions of synergy between the UK's aviation decarbonisation commitments and their coherence in delivering net zero objectives
	Outcome	TOT:21	A more favourable international landscape for UK aviation and decarbonisation efforts	• Stakeholder and industry perceptions of the extent to which the international landscape has changed to provide a more favourable landscape for aviation decarbonisation in the UK (and the impacts of aviation decarbonisation policy measures)
	Outcome	TOT:22	Industry commitment to delivering change with support from academia and government	• Stakeholder and industry perceptions of the extent to which the UK aviation industry is committed to delivering change, with support from academia and government (and the impacts of aviation decarbonisation policy measures) • Stakeholder, industry and academia perceptions of the strength of coordination and collaboration between UK industry, academia and government (and the impacts of aviation decarbonisation policy measures)
	Outcome	TOT:23	Changes in industry and consumer behaviour	• Stakeholder, industry and consumer perceptions of the extent to which the UK's aviation decarbonisation measures have delivered changes in industry and consumer behaviour
	Outcome	TOT:24	Increased investment, innovation, R&D and TRLs	• Total investment (£) relating to aviation decarbonisation in the UK • Number of UK patents (applications and patents issued) relating to aviation decarbonisation • Total R&D expenditures relating to aviation decarbonisation in the UK • TRLs relating to the development of new aviation decarbonisation technologies in the UK • Stakeholder and industry perceptions of the extent to which the UK's aviation decarbonisation policy measures have influenced investment, innovation, R&D and TRLs

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
Total aviation decarb-onisation	Outcome	TOT:25	Industry informing government where policy and R&D can be most effectively deployed	• Stakeholder and industry perceptions of the extent to which the UK aviation industry is informing government where policy and R&D can be most effectively deployed (and the impacts of aviation decarbonisation policy measures)
	Outcome	TOT:26	Increased understanding of expected impacts of individual initiatives and potential to support and deliver net zero	• Stakeholder and industry perceptions of the extent to which individual initiatives are expected to deliver impacts and support net zero in the UK
	Outcome	TOT:27	Evidence used to inform strategic decisions regarding direction, priorities, risks and mitigation	• Stakeholder perceptions of the extent to which evidence is being / has been used to inform strategic decisions regarding the direction, priorities, risks and mitigation actions of aviation decarbonisation policy measures in the UK
	Outcome	TOT:28	Critical mass of initiatives secures required commitment and action from industry	• Stakeholder and industry perceptions of the extent to which aviation decarbonisation provides a critical mass of initiatives, capable of securing the required commitment and action from the UK aviation industry
	Outcome	TOT:29	Delivery of total outcomes 'greater than the sum of the parts' of individual initiatives	• Stakeholder and industry perceptions of the extent to which aviation decarbonisation supports the achievement of outcomes that are greater than those of individual initiatives (had they been delivered in isolation)
	Outcome	TOT:30	Ensure UK aviation is not disadvantaged by investment / commitment to decarbonisation	• International comparisons of investment (£) in / commitments towards aviation decarbonisation (UK vs other countries) • Stakeholder and industry perceptions of the level of investment and commitment to achieving net zero in aviation in the UK relative to other countries • Stakeholder and industry perceptions of whether (and the extent to which) the UK is disadvantaged by its aviation decarbonisation investments and commitments
	Outcome	TOT:31	Increased efficiency of airspace, aircraft and airports	• Estimated carbon emissions / savings associated with more efficient journeys through UK airspace (MtCO2e) • Estimated carbon emissions / savings associated with more efficient aircraft designs (MtCO2e) • Estimated carbon emissions / savings of UK airports (MtCO2e)
	Outcome	TOT:32	Development and commercialisation of new aviation fuels and technologies	• Investment (£) in the development and commercialisation of new aviation fuels and technologies in the UK (public / private / total) • TRLs of new aviation fuels and technologies in the UK • UK production of new aviation fuels and technologies (volume and value) • Stakeholder and industry feedback on progress in developing and commercialising new aviation fuels and technologies in the UK (and the impact of aviation decarbonisation policy measures)
	Outcome	**TOT:33**	**Increased effectiveness of carbon markets and increased removals**	• **Number of CORSIA / UK ETS credits purchased by the UK aviation industry** • **Average price (£) of CORSIA / UK ETS credits purchased by the UK aviation industry** • **Purchases / investments (£) of offsets and removals by the UK aviation industry**
	Outcome	TOT:34	Allocate R&D funding to best meet objectives	• R&D funding by aviation decarbonisation policy measure • Stakeholder and industry perceptions of the appropriateness of R&D funding allocations to best meet the UK's aviation decarbonisation objectives
	Outcome	**TOT:35**	**Adjust the mix of initiatives, mechanisms and levers to achieve the best portfolio objectives**	• **Changes made to aviation decarbonisation measures, initiatives, mechanisms and levers in the UK** • Stakeholder and industry perceptions of the appropriateness of the UK's aviation decarbonisation measures, initiatives, mechanisms and levers in maximising progress towards portfolio objectives

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
Total aviation decarb-onisation	Outcome	TOT:36	Accelerated system transformation	• Stakeholder and industry perceptions of the extent to which aviation decarbonisation policy measures have delivered / accelerated system transformation for UK aviation
	Outcome	**TOT:37**	**(Cost effective) Increases in carbon savings / contributions to net zero**	• **Estimated / modelled carbon emissions / savings by aviation decarbonisation policy measure (MtCO2e)** • **Costs (£) of delivering aviation decarbonisation policy measures in the UK** • **Assessment of cost effectiveness of the UK's aviation decarbonisation policy measures (£ per MtCO2e)**
	Outcome	TOT:38	Reduced barriers and accelerated progress to net zero objectives	• Stakeholder and industry perceptions of barriers to net zero objectives and progress in reducing barriers (and impacts of the UK's aviation decarbonisation policy measures)
	Outcome	TOT:39	Increased international collaboration to sustainable goals	• Stakeholder and industry perceptions of levels of international collaboration (and impacts of the UK's aviation decarbonisation policy measures)
	Outcome	**TOT:40**	**Approach to mitigating non-CO_2 impacts developed**	• **Approaches developed in the UK to mitigate non-CO_2 impacts**
	Outcome	TOT:41	Creation of new jobs, skills, export opportunities in the development of new technologies and fuels	• UK jobs (FTE) involved in developing new aviation technologies and fuels (by occupation, high / low skilled) • Stakeholder and industry perceptions of skills developed, and skilled jobs created, in developing new aviation technologies and fuels in the UK (and impacts of aviation decarbonisation policy measures) • UK exports (volume and value) of new aviation technologies and fuels
	Outcome	TOT:42	Effective regulatory environment encourages innovation	• Stakeholder and industry perceptions of the effectiveness of the UK and international regulatory environment in encouraging innovation (and impacts of aviation decarbonisation policy measures)
	Outcome	TOT:43	New UK industries provide opportunities across UK regions	• Regional distribution of investment (£) and economic growth (jobs & GVA) in the UK aviation industry • Stakeholder and industry perceptions of extent to which aviation decarbonisation policy measures are providing opportunities across the UK regions
	Outcome	TOT:44	Minimised impacts that increase costs for passengers and restrict demand for air travel for trade, travel and tourism	• Average fares for UK passengers per flight / per km (nominal and real prices) • Number of UK flights / passengers (domestic & international) • Volume and value of UK air freight (domestic & international)
	Outcome	TOT:45	Increased fuel security through UK based SAF / hydrogen production	• UK production & consumption of SAF, hydrogen and other aviation fuels (volume and value) • UK imports & exports of SAF, hydrogen and other aviation fuels (volume and value) • Stakeholder and industry perceptions of fuel security for the UK (and impacts of aviation decarbonisation policy measures)
	Outcome	**TOT:46**	**Carbon savings**	• **Estimated carbon emissions / savings (MtCO2e) - current and projected from the UK's aviation decarbonisation measures** • **Projected contribution to total carbon savings by 2050**
	Outcome	TOT:47	Other environmental benefits (e.g. reduction of non-CO_2 impacts)	• Airport noise contours and associated areas / decibels in the UK • Estimated UK emissions of air pollutants (NOx, particulate matter, SO_2, CO, etc.) • Estimated non-CO_2 emissions / savings in the UK

Policy measure	Output/ Outcome	ToC box no.	Output/outcome description	Indicator
Total aviation decarb-onisation	**Outcome**	**TOT:48**	**Economic benefits (e.g. increased jobs, GVA, exports and thriving aviation sector)**	• **UK jobs (FTE) and GVA (£) in aviation, aerospace and related sub-sectors (incl. supply chains)** • **UK exports of aviation, aerospace and related products and services (volume and value)** • **UK share (%) of global aviation, aerospace and related markets**
	Outcome	**TOT:49**	**Increased resilience, security of supply**	• **UK imports & exports of SAF, low carbon hydrogen and other aviation fuels (volume and value)** • Stakeholder and industry perceptions of the UK's resilience and security of supply (and impacts of aviation decarbonisation policy measures)

Annex 2 Development of monitoring indicators

This Annex describes the development and prioritisation of monitoring indicators for tracking progress with aviation decarbonisation activities.

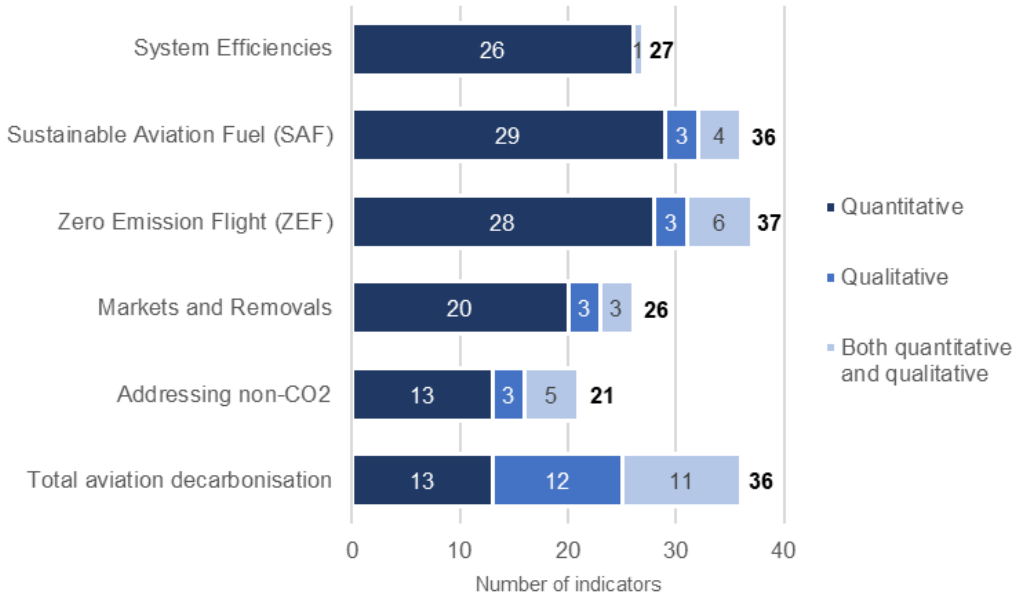
A2.1 Full list of monitoring indicators

The table in Annex 1 provides the full list of potential indicators for monitoring all outputs (i.e. direct results of activities) and intended outcomes (i.e. the resulting consequences and impacts) from the ToCs and for informing future evaluation activities. This long list aims to ensure comprehensive coverage of all outputs and outcomes associated with aviation decarbonisation and the individual policy areas.

The indicators have been designed to have a clear and explicit relationship with the underpinning ToCs. They are directly linked to the numbered boxes in the ToCs presented in Section 3. They have also been selected to provide a mixture of quantitative and qualitative indicators to enable a detailed assessment of progress, the achievement of targets, and to provide a comprehensive understanding of changes in outcomes. They cover a combination of existing data sources such as DfT's tracking and management information (MI) for aviation decarbonisation activities, other DfT datasets (e.g. DfT's Technology Tracker survey, workforce statistics), and external datasets (e.g. data published by the CAA, UK airports, and other Government Departments).

The ToCs presented in Section 3 specify 186 different outputs and outcomes that are expected to be generated across aviation decarbonisation and the five individual policy measures. Indicators and potential data sources by which indicators can be populated have been analysed for all outputs and outcomes. Three of the outputs in the overarching ToC for aviation decarbonisation are duplicates of outputs in the ToCs for individual policy areas, so have been excluded from the following analysis, which focuses on monitoring indicators for the remaining 183 outputs and outcomes. The number of monitoring indicators varies across the different policy measures (Figure A2.1), from 21 indicators for the 'Addressing non-CO_2' policy measure, to 37 indicators for the ZEF policy measure.

Figure A2.1 Distribution of 183 indicators by type of indicator and policy area

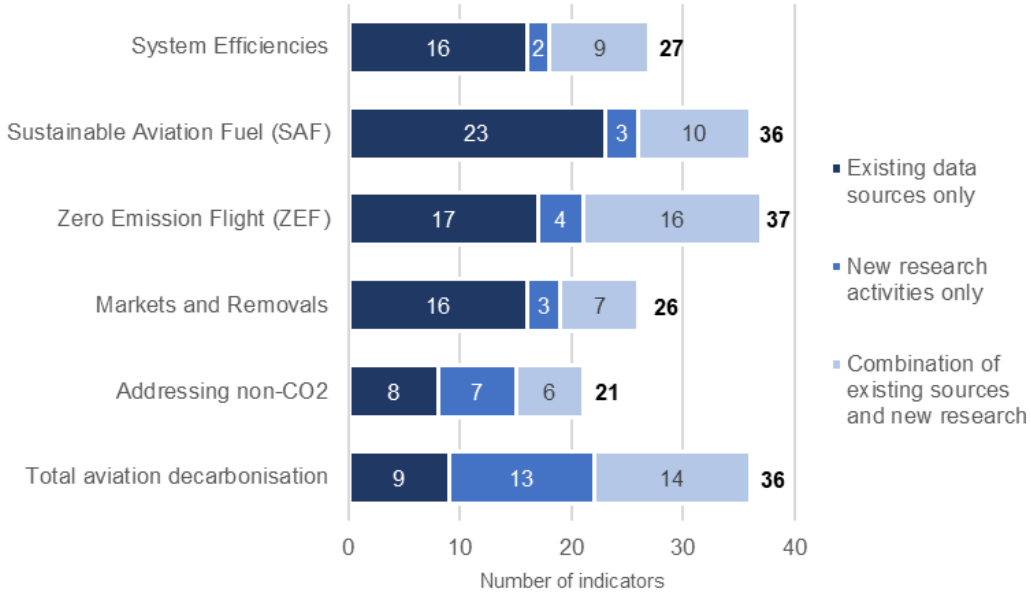


The progress of most outputs and outcomes can be tracked using purely quantitative indicators (71%), or a combination of quantitative and qualitative indicators (16%), while the remaining 13% are qualitative in nature. There is also a clear distinction between the individual policy measures, which include a greater proportion of quantitative indicators, and the portfolio-level outputs and outcomes, which would need to be monitored using a more even balance of quantitative and qualitative indicators.

Figure A2.2 describes the type of data sources that are expected to provide evidence for the indicators. It shows the type of evidence that is required for each of the 183 monitoring indicators:

- 89 indicators (49%) are expected to require data from existing sources only (including aviation decarbonisation management information, other DfT datasets, and other external datasets);
- 32 indicators (17%) are unlikely to be covered by existing datasets and are expected to generate requirements for new research and evaluation activities; and
- 62 indicators (34%) are expected to require a combination of existing data sources and new research activities.

Figure A2.2 Distribution of 183 indicators by type of data source and policy area



The data sources and requirements vary between policy areas. Figure A2.2 suggests that existing datasets are most likely to be able to provide evidence for monitoring indicators for the system efficiencies, SAF and markets and removals policy areas. This is likely to reflect the more established activities in these policy areas, compared to the more novel approaches and activities in the ZEF and non-CO_2 policy areas, which are likely to be more dependent upon evidence from new research activities. The portfolio-level indicators are also expected to generate requirements for new research activities to provide evidence of the more complex influences of the overarching aviation decarbonisation activities at the portfolio-level.

A2.2 Indicators requiring additional research activities

The above analysis suggests that 94 indicators are likely to generate demands for additional research activities to provide the required evidence (either in isolation or in combination with existing datasets). Nearly all of these indicators (84) are associated with aviation decarbonisation outcomes, while the remaining ten are indicators of outputs. This reflects the relatively strong evidence base for output indicators, provided by DfT's management information and existing datasets, while there are more significant gaps in the evidence base for outcomes.

The 94 indicators requiring additional research have been analysed to ascertain whether these research activities can be delivered in a way that it is feasible and proportionate to minimise demands on DfT resources and budgets. Table A2.1 provides a summary of the different types of research that are required to provide evidence for the monitoring indicators. It suggests that the additional research requirements typically fall into two broad categories with a third smaller-scale research category:

1. Research with the UK aviation industry. This can be further disaggregated into: research of the costs, investments and projects that can be attributed to aviation decarbonisation measures and/or are associated with the delivery of aviation decarbonisation objectives; research to explore the economic and environmental impacts of aviation decarbonisation measures and resulting changes in industry behaviours; and other bespoke pieces of research that are specific to individual policy measures (e.g. the extent to which airlines make changes to their flight routes after the implementation of Free Route Airspace).
2. Research with industry and other stakeholders (e.g. government, academia) to explore their perceptions and experiences of the delivery of aviation decarbonisation measures and the resulting impacts.
3. Research with aviation consumers and the general public, although this is expected to be smaller in scale and focused on public awareness and perceptions of the risks and benefits of SAF and ZEF solutions.

Table A2.1 Indicators requiring additional research by policy area and type of research

Policy measure	Industry specific research			Stakeholder perceptions of delivery processes / impacts	Public / consumer research	Total indicators requiring additional research
	Costs, investments & projects	Economic and environmental impacts	Other / bespoke industry research			
System Efficiencies	1	7	2	1	-	**11**
SAF	3	5	-	7	1	**13**
ZEF	8	8	-	9	1	**20**
Markets and Removals	3	3	-	6	-	**10**
Addressing non-CO_2	3	2	3	8	-	**13**
Total aviation decarbonisation	5	5	1	22	-	**27**
Total	**23**	**30**	**6**	**53**	**2**	**94**

Note: The sum of columns is greater than the total because some indicators cover multiple types of research.

There are likely to be opportunities for consolidation such that each research activity can collect data to inform multiple indicators. There are 23 cells in Table A2.1 containing indicators and each is likely to represent a single research activity (e.g. a survey of consumers or interviews with industry representatives and/or wider stakeholders) that can cover the indicators included within that cell. There are also likely to be opportunities for further consolidation across policy measures or the different types of research activity. For example, there are likely to be opportunities:

- to combine research activities relating to aircraft technologies under both the system efficiencies and ZEF policy measures.
- to combine research activities with industry to cover multiple themes such as industry costs and investments, as well as the impacts of aviation decarbonisation measures.
- for research with stakeholders to cover multiple policy measures.
- for the public / consumer research to include questions about different themes within aviation decarbonisation.

It is therefore estimated that around 12-20 research activities will be required to cover the 94 indicators listed in Table A2.1. This is likely to include:

- approximately six research activities with industry covering costs, investments, projects and impacts associated with aviation decarbonisation activities (i.e. one for each policy area and one for aviation decarbonisation as a whole).
- between three and six bespoke research activities with industry (depending on the extent to which these can be grouped by policy measure).
- between two and six research activities with stakeholders (depending on the extent to which these can be grouped by policy measure and type of stakeholder).
- at least one piece of research with consumers.

It should also be noted that other Government departments are responsible for delivering the initiatives that are associated with many of these indicators. An analysis suggests that 34 of the 94 indicators requiring additional research (36%) are associated with aviation decarbonisation initiatives that overlap with:

- the Department for Business and Trade (DBT) – for indicators relating to ZEF and aircraft efficiencies.
- the Department for Energy Security and Net Zero (DESNZ) – for some indicators relating to SAF, low-carbon hydrogen, fuel security and carbon markets and removals.
- the Department for the Environment, Food and Rural Affairs (Defra) – for some indicators relating to air pollution, noise and other potential non-CO_2 impacts.

This suggests there are likely to be opportunities to share research and evaluation activities with these other departments.

A2.3 Prioritising monitoring indicators using existing datasets

It is necessary to prioritise some of the indicators that are expected to be able to use existing datasets to have a monitoring plan that is feasible and proportionate, but which provides

sufficient visibility of progress across all aviation decarbonisation policy areas. This section presents the suggested priorities for monitoring and describes how these were selected.

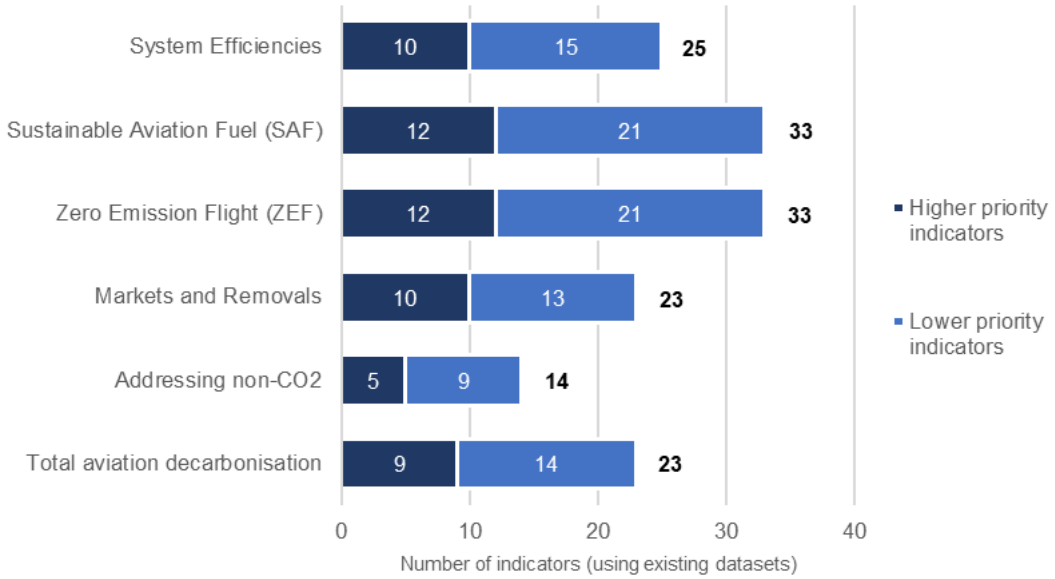
The analysis in section A2.1 suggests that most indicators of outputs and outcomes should be possible to monitor using existing datasets[12]. These indicators have been assessed to prioritise the indicators that are most feasible, robust and meaningful to monitor through existing datasets produced by DfT or other external datasets. The assessment has prioritised indicators that:

- represent activities that are likely to have strategic importance for aviation decarbonisation and its initiatives.
- appear to have clear and measurable options for targets that should provide a simple and robust means of monitoring progress over time.
- have relatively low resource requirements to collate and analyse relevant data (due to the availability, timeliness and quality of data).

Each indicator was scored against these criteria, using a three-point scale to allocate a high (1), medium (0.5) or low (0) score. However, it was decided to apply a double-weighting to the criterion relating to resource requirements, given the importance of prioritising indicators for which data are more readily available and easier to access and analyse. This meant that each indicator received a score from zero to four and the results are summarised in Figure A2.3 for the different policy measures[13]. The scores have been combined to create two groups: lower priority indicators with scores of up to 2.5 out of 4; and higher priority indicators with scores of 3 or more out of 4.

Given the need for a feasible and proportionate monitoring plan, it is suggested that monitoring activities should focus on the 58 higher priority indicators. While it is suggested that lower priority indicators are not included in ongoing monitoring activities at this stage, they may still help to inform the plans and methodologies for future evaluation activities.

Figure A2.3 Number of indicators by level of priority and policy measure

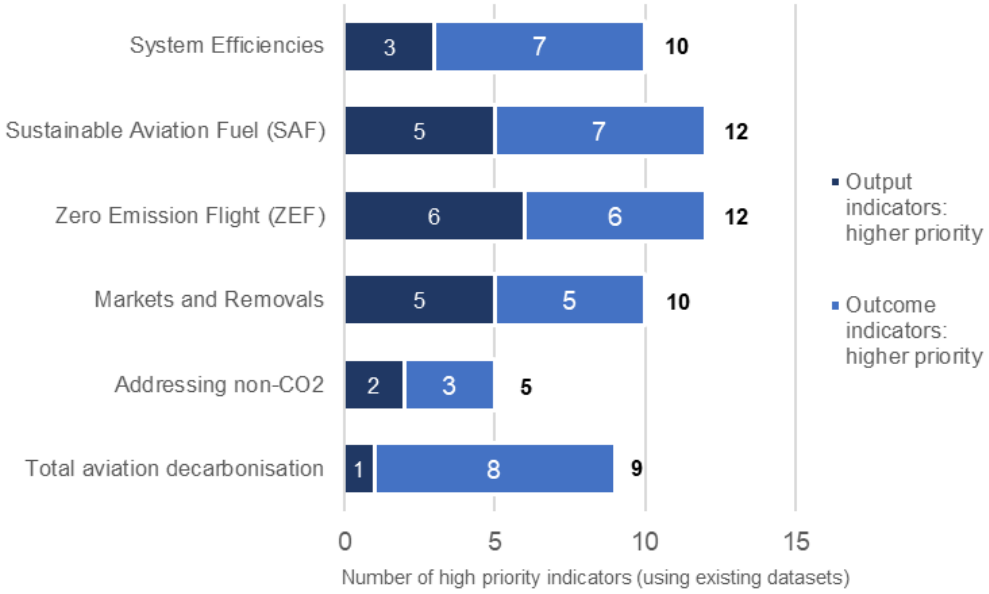


[12] The analysis suggests that 151 of the 183 indicators can be evidenced using existing datasets including 89 that can be solely evidenced using existing data and 62 that combine existing datasets and new research activities.

[13] For example, the outcome indicator for the 'increased efficiency of UK airspace' (SE:46) was identified as a high priority indicator with a total score of 3 out of 4, based on medium scores of 0.5 for both strategic importance and the ability to develop clear and measurable targets, and a high 'double-weighted' score of 2 for the availability of data and relatively low resource requirements in gathering and analysing data from the NATS 3Di dataset.

Figure A2.4 shows how the 58 high priority indicators provide coverage of all policy areas and include 22 output indicators and 36 outcome indicators. The 58 high priority indicators are listed in tables in Section 3, which provide details of the indicators for each policy measure including a summary of data sources and timings for data collection and analysis.

Figure A2.4 Number of priority indicators of outputs and outcomes by policy measure



Annex 3 Prioritisation of policy measures for evaluation

Table A3.1 Assessment of policy measures against prioritisation criteria

Policy measure	System efficiencies				SAF			ZEF			Markets & removals			Addressing non-CO_2			Total aviation decarbo-nisation
Sub-measure / Prioritisation criterion	Aircraft efficiency	Airline efficiency	Airport efficiency	Airspace efficiency	Increased production	Supporting measures	Commercialisation & use	ZEF R&D	Production & commercialisation	Increased use	Implementation of CORSIA	Implementation of UK ETS	Availability of GGRs	Improved understanding	Improved monitoring	Mitigation strategies	
Potential contribution to net zero objectives																	
Do the activities have the potential to deliver significant carbon savings?																	
Investments and expenditures																	
Have high levels of investment and expenditure been committed/planned to deliver the activities?																	
Total costs/burdens																	
Are there high social costs associated with delivering the activities (private costs/investment and public expenditure)?																	
Evidence base																	
Would evaluation fill gaps in the evidence base, after taking account of other planned evaluation activities?																	
Learning																	
Are there opportunities for evaluation to be targeted at innovative activities with high potential for learning?																	

Policy measure / Sub-measure / Prioritisation criterion	System efficiencies				SAF			ZEF			Markets & removals			Addressing non-CO_2			Total aviation decarbo-nisation
	Aircraft efficiency	Airline efficiency	Airport efficiency	Airspace efficiency	Increased production	Supporting measures	Commercialisation & use	ZEF R&D	Production & commercialisation	Increased use	Implementation of CORSIA	Implementation of UK ETS	Availability of GGRs	Improved understanding	Improved monitoring	Mitigation strategies	
Uncertainty and risk																	
Is there a high level of uncertainty whether activities will be delivered and target outcomes achieved/?																	
Is there a high level of risk of potentially negative outcomes and/or consequences of activities?																	
Timeliness																	
Is there value in undertaking evaluation activities in the short-term (e.g. within the next 3-5 years)?																	
Feasibility																	
Is it feasible to conduct an evaluation (taking account of resources, proportionality)?																	
Is it possible to evaluate the activity with available evidence?																	
TOTAL SCORE (Key: Y=1; y=0.5)																	

Table legend

Y	Yes, definitely
y	Yes, but to a lesser extent
	No / unlikely

Annex 4 Potential evaluation questions by policy area

Table A4.1 Evaluation questions: Aviation decarbonisation

Process evaluation	Impact evaluation	Value for money evaluation
• To what extent, if at all, are the objectives and rationale for aviation decarbonisation clear, appropriate and understood and shared by all partners and stakeholders? • How effective (or ineffective) was the process for identifying and developing the required policy measures and was there anything that could have been improved? • To what extent, if at all, have the aviation decarbonisation policy measures provided clarity to the industry on the most appropriate way to cut emissions and achieve net zero by 2050? • How effective are the processes for managing and implementing aviation decarbonisation measures and is there anything that could be improved? • To what extent, if at all, have the policy measures provided the right support at the right time to achieve aviation decarbonisation objectives? • What changes, if any, has DfT made to the basket of aviation decarbonisation levers and initiatives and the level of focus on each? • To what extent, if at all, have aviation decarbonisation policy measures been able to adapt to ensure they make best use of available levers and measures to deliver their objectives? • Should DfT have focused on specific policy areas/levers, rather than taking a broader approach? If so, which ones? • To what extent, if at all, have the required partnerships been supported to help deliver aviation decarbonisation objectives? • To what extent, if at all, were M&E processes appropriate, timely and effective? • What lessons, if any, have been learned that could improve the delivery of aviation decarbonisation strategies and initiatives in future?	• What impacts, if any, have the policy measures delivered for the decarbonisation of UK aviation? • To what extent, if at all, have the policy measures delivered strategic vision and intent for aviation decarbonisation? • How impactful, if at all, are the different government levers and initiatives? • To what extent, if at all, have the aviation decarbonisation policy measures helped to encourage and support a more favourable international landscape to maximise benefits and ensure UK aviation is not disadvantaged? • To what extent, if at all, has UK industry been supported and enabled to maximise the opportunities and economic benefits arising from aviation decarbonisation? • To what extent, if at all, has aviation decarbonisation helped to accelerate system transformation in the UK aviation industry? • To what extent, if at all, has aviation decarbonisation achieved its net zero objectives, delivered other environmental and economic benefits and supported increased resilience and security of supply for UK aviation? • To what extent, if at all, can these environmental, economic and resilience impacts be attributed to the aviation decarbonisation policy measures? • Have there been any unintended consequences or unexpected impacts of aviation decarbonisation and its policy measures?	• What resources were used to deliver aviation decarbonisation? • What benefits, if any, has aviation decarbonisation delivered (or is expected to deliver) and how do these compare to its costs? • Is there evidence that some types of activities deliver better value for money than others? • Could better value for money have been delivered and, if so, how? • Have lessons been learned that could improve value for money (of aviation decarbonisation or other initiatives) in the future?

Table A4.2 Evaluation questions: System efficiencies

Process evaluation	Impact evaluation	Value for money evaluation
• To what extent, if at all, are the objectives and rationale for the system efficiencies policy area clear, appropriate and understood and shared by all partners and stakeholders? • To what extent, if at all, has aviation decarbonisation provided the right support at the right time to achieve the objectives of the system efficiencies policy measure? • How effective have the policy measures been in coordinating the partners and tasks required to support the development of more efficient aircraft technologies, enhance and accelerate carbon savings across airline and airport activities, and redesign UK airspace? • To what extent, if at all, was funding for R&D activities targeted at the projects most likely to maximise impacts and value for money? • To what extent, if at all, were M&E processes appropriate, timely and effective? • What lessons, if any, have been learned that could improve the delivery of similar policy measures in future?	• What contribution have the system efficiencies measures made / are expected to make to overall aviation decarbonisation objectives and targets? • What impacts, if any, have the system efficiencies measures had for generating carbon savings through the increased efficiency of UK aircraft, airlines, airports and airspace? • What impacts, if any, have the system efficiencies measures had for non-CO_2 emissions? • What impacts, if any, have the system efficiencies measures had for the development of efficient aircraft technologies in the UK? • What impacts, if any, have the system efficiencies measures had on adoption of low / zero emissions targets across UK airports? • What has been the impact of system efficiencies measures, if any, for the redesign and increased efficiency of UK airspace? • What other improvements, if any, have been supported by the system efficiencies measures and what impacts have they delivered? • What economic impacts, if any, have been delivered by the system efficiencies measures? • To what extent, if at all, can environmental, economic and social impacts be attributed to the system efficiencies measures? • Have there been any unintended consequences or unexpected impacts of the system efficiencies policy measure?	• What resources were used to deliver the system efficiencies measures? • What benefits, if any, have these measures delivered (or are expected to deliver) and how do these compare to their costs? • Is there evidence that some types of activities deliver better value for money than others? • Could better value for money have been delivered and, if so, how? • Have lessons been learned that could improve value for money (of the system efficiencies measures or other initiatives) in the future?

Table A4.3 Evaluation questions: SAF

Process evaluation	Impact evaluation	Value for money evaluation
• To what extent, if at all, are the objectives and rationale for the SAF policy area clear, appropriate and understood and shared by all partners and stakeholders? • To what extent, if at all, have the SAF measures been effective at collaborating with UK and international partners to ensure alignment of policies and support delivery of initiatives? • To what extent, if at all, has aviation decarbonisation provided the right support at the right time to support UK demand and supply of SAF and achieve the objectives of the SAF policy measure? • To what extent, if at all, were M&E processes appropriate, timely and effective? • What lessons, if any, have been learned that could improve the delivery of similar policy measures in future?	• What contribution have the SAF policy measures made / are expected to make to overall aviation decarbonisation objectives and targets? • What impacts, if any, have SAF policy measures had on the demand and supply of SAF in the UK? • What impacts, if any, have SAF policy measures had for the demonstration of SAF and confidence amongst investors and industry in the use of SAF in the UK? • What impacts, if any, have SAF policy measures had for stimulating demand for SAF in the aviation industry? • What impacts, if any, have SAF policy measures had for the development, commercialisation and production of SAF in the UK? • To what extent, if at all, has this increased resilience and fuel security in the UK? • What impacts, if any, have SAF policy measures had for supporting international ambition, standards, production and demand for SAF? • What economic impacts, if any, have been generated in the UK SAF industry? • To what extent, if at all, can environmental, economic, social and resilience impacts be attributed to SAF policy measures? • Have there been any unintended consequences or unexpected impacts of the SAF policy measure?	• What resources were used to deliver the SAF measures? • What benefits, if any, have these measures delivered (or are expected to deliver) and how do these compare to their costs? • Is there evidence that some types of activities deliver better value for money than others? • Could better value for money have been delivered and, if so, how? • Have lessons been learned that could improve value for money (of the SAF measures or other initiatives) in the future?

Table A4.4 Evaluation questions: ZEF

Process evaluation	Impact evaluation	Value for money evaluation
• To what extent, if at all, are the objectives and rationale for the ZEF policy measures clear, appropriate and understood and shared by all partners and stakeholders? • To what extent, if at all, has aviation decarbonisation provided the right support at the right time to achieve the objectives of the ZEF policy measure? • To what extent, if at all, has it been possible to combine and utilise funding from the UK Government and Horizon Europe to deliver ZEF activities and objectives? • To what extent, if at all, has R&D funding been targeted to maximise impacts for the development of ZEF technologies? • How effective have the ZEF measures been in engaging partners to deliver appropriate skills development solutions and demonstration activities to support the wider deployment of ZEF technologies? • To what extent, if at all, were M&E processes appropriate, timely and effective? • What lessons, if any, have been learned that could improve the delivery of similar policy measures in future?	• What contribution have the ZEF policy measures made / are expected to make to overall aviation decarbonisation objectives and targets? • What impacts, if any, have ZEF policy measures had on the development and deployment of zero emission technologies and aircraft? • What impact, if any, have the ZEF policy measures had for skills development to support the design, development and production of zero emission aircraft and technologies in the UK? • What impact, if any, have the ZEF policy measures had for the development and production of low carbon hydrogen in the UK? • To what extent, if at all, has this supported increased resilience and fuel security in the UK? • What impacts, if any, have the ZEF policy measures had for the demonstration and deployment of zero emission aircraft in the UK (including through domestic routes, PSO routes and general aviation sector)? • What impacts, if any, have ZEF policy measures had for supporting international ambition, standards and collaboration in relation to ZEF? • What economic impacts, if any, have been generated by the development and production of zero emission technologies, aircraft and fuels in the UK? • To what extent, if at all, can environmental, economic and social impacts be attributed to the ZEF policy measures? • Have there been any unintended consequences or unexpected impacts of the ZEF policy measures?	• What resources were used to deliver the ZEF measures? • What benefits, if any, have these measures delivered (or are expected to deliver) and how do these compare to their costs? • Is there evidence that some types of activities deliver better value for money than others? • Could better value for money have been delivered and, if so, how? • Have lessons been learned that could improve value for money (of the ZEF measures or other initiatives) in the future?

Table A4.5 Evaluation questions: Markets and removals

Process evaluation	Impact evaluation	Value for money evaluation
• To what extent, if at all, are the objectives and rationale for the markets and removals policy area clear, appropriate and understood and shared by all partners and stakeholders? • To what extent, if at all, has aviation decarbonisation provided the right support at the right time to achieve the objectives of the markets and removals policy measure? • To what extent, if at all, has the delivery of markets and removals measures been aligned with what is happening, in the industry? • To what extent, if at all, have the measures incentivised decarbonisation, as opposed to the industry electing to pay the carbon price? • To what extent, if at all, were M&E processes appropriate, timely and effective? • What lessons, if any, have been learned that could improve the delivery of similar policy measures in future?	• What contribution have the markets and removals measures made / are expected to make to overall aviation decarbonisation objectives and targets? • To what extent, if at all, have the markets and removals policy measures supported the other aviation decarbonisation initiatives to reduce carbon emissions? • What impacts, if any, have the UK ETS and CORSIA had for incentivising decarbonisation of UK aviation activities (for domestic and international flights)? • What impacts, if any, have market and removals policy measures had on the harmonisation of international standards and uptake of CORSIA? • What impacts, if any, have the markets and removals policy measures had on GGR capacity and capabilities in the UK? • To what extent, if at all, have the markets and removals policy measures stimulated greater connections between the aviation and GGR sectors? • What economic impacts, if any, can be attributed to the markets and removals policy measures (e.g. through increased investments in decarbonisation in the aviation industry)? • Have there been any unintended consequences or unexpected impacts of the markets and removals policy measures (including impacts on connectivity of the UK and UK regions)?	• What resources were used to deliver the markets and removals measures? • What benefits, if any, have these measures delivered (or are expected to deliver) and how do these compare to their costs? • Is there evidence that some types of activities deliver better value for money than others? • Could better value for money have been delivered and, if so, how? • Have lessons been learned that could improve value for money (of the markets and removals measures or other initiatives) in the future?

Table A4.6 Evaluation questions: Addressing non-CO_2

Process evaluation	Impact evaluation	Value for money evaluation
• To what extent, if at all, are the objectives and rationale for the addressing non-CO_2 policy area clear, appropriate and understood and shared by all partners and stakeholders? • How effective has aviation decarbonisation been in terms of delivering the right support at the right time to help understand, measure and mitigate non-CO_2 impacts? • To what extent, if at all, has R&D funding been targeted effectively to fill gaps in the evidence base and improve understanding of non-CO_2 impacts? • How effective have processes been for incorporating non-CO_2 mitigation within other aviation decarbonisation policy measures? • To what extent, if at all, were M&E processes appropriate, timely and effective? • What lessons, if any, have been learned that could improve the delivery of similar policy measures in future?	• What contribution have the non-CO_2 policy measures made / are expected to make to overall aviation decarbonisation? • What impacts, if any, have the non-CO_2 policy measures had on the understanding of non-CO_2 impacts and the scale of non-CO_2 emissions from aviation activities? • What impacts, if any, have the non-CO_2 policy measures had on the measurement and reporting of non-CO_2 emissions in the aviation industry? • What impact, if any, have the non-CO_2 measures had for the development of policies to mitigate non-CO_2 impacts? • What impact, if any, have the non-CO_2 policy measures had for reducing the non-CO_2 impacts of aviation? • To what extent, if at all, have non-CO_2 mitigation activities have any adverse or complementary effects for carbon savings in other aviation decarbonisation policy areas? • What economic impacts, if any, have been generated by the development of non-CO_2 solutions in the UK? • To what extent, if at all, can environmental and economic impacts be attributed to the non-CO_2 policy measures? • Have there been any unintended consequences or unexpected impacts of the addressing non-CO_2 policy measures?	• What resources were used to deliver the addressing non-CO2 measures? • What benefits, if any, have these measures delivered (or are expected to deliver) and how do these compare to their costs? • Is there evidence that some types of activities deliver better value for money than others? • Could better value for money have been delivered and, if so, how? • Have lessons been learned that could improve value for money (of the addressing non-CO_2 measures or other initiatives) in the future?

Annex 5 Potential evaluation methodologies

This Annex sets out some high-level options for potential approaches to the evaluation of aviation decarbonisation measures.

A5.1 Key challenges for the design of impact evaluations

Whilst the intention is that future evaluations will cover process, impact and economic / value for money aspects, the focus here is on the challenges associated with the impact evaluation element and how these can potentially be addressed. This reflects two considerations:

- Much of the process evaluation element should be relatively straightforward. It will require the assessment of different aspects of the processes associated with aviation decarbonisation, drawing on the National Audit Office's 'three/four Es' principles[14] to address the evaluation questions. The most potentially challenging aspect may be the assessment of the UK's involvement in securing international cooperation and agreements.
- The economic evaluation will largely be reliant on the findings of the impact evaluation. A full economic evaluation, which will only be possible in the longer-term, would ideally be based upon a cost-benefit approach, or more limited cost-effectiveness or 'three/four Es' approaches if this proves not to be feasible.

A variety of aspects of aviation decarbonisation present challenges for the design of impact evaluations:

- The large number of activities that could be involved in aviation decarbonisation means significant prioritisation will be needed. However, this means that there could be significant gaps in the evidence which is available to assess the totality of the impacts of aviation decarbonisation.
- Some interventions will have very long timescales before their key impacts can be expected to feed through.
- Initial evaluation activities will need to focus on the extent to which the outputs and outcomes identified in the ToCs are being achieved. There could therefore be issues assessing the extent to which progress is likely to be sufficient to meet the long term objectives of aviation decarbonisation.
- There are a variety of potential confounding factors – such as energy prices, economic growth or its absence, decisions by other countries and organisations and public environmental concerns – which will also influence the extent to which the intended outcomes are achieved and create challenges in assessing the attribution of outcomes to the interventions involved.
- The nature of aviation decarbonisation and its constituent measures and the evolving international context will impose limitations on the extent to which it will be possible to establish suitable comparison groups which could be used to

[14] Economy – for example in the procurement of inputs, Efficiency – in terms of the relationship between the resources deployed and the outputs and impacts delivered and Effectiveness in terms of achieving objectives, with the fourth being Equity to the extent this is relevant in context.

provide counterfactuals for the development of the sector in the absence of aviation decarbonisation measures.

- The potential interactions between interventions could create issues for any attempt to estimate the overall impacts of aviation decarbonisation by aggregating the effects of individual interventions, with risks of possible double-counting and/or of missing potential causal links.
- Interventions may create wider beneficial impacts on global greenhouse gas emissions through mechanisms which cannot be easily identified and traced, such as the impacts of demonstration activities.
- Alternatively, it may be that one effect of interventions will be to displace some emissions to other, less tightly regulated, jurisdictions. Similarly, some interventions may intensify competition for allocations or scarce resources, between aviation and other energy intensive users, creating a risk that emission savings in one sector may be displaced to other sectors or countries.

The latter points argue that a comprehensive evaluation of aviation decarbonisation would need to look beyond its impacts on UK aviation and its linked sectors.

A5.2 Potential Approaches to the Impact Evaluation

This section makes some preliminary suggestions of potential evaluation approaches and methods that could be applied and identifies some areas of aviation decarbonisation where there may be scope to apply counterfactual impact or other quantitative methodologies – though it should be stressed that, at this stage, these are presented as possibilities for potential investigation.

A5.2.1 Overview

The general methodology for evaluating complex multi-faceted programmes and interventions, such as aviation decarbonisation, typically seeks to utilise a combination of:

i) **A *Top-Down* approach** – involving an assessment of the extent to which the key aviation decarbonisation outcomes have been achieved, and an assessment of how far these outcomes should be attributed to the aviation decarbonisation policy measures as opposed to other confounding factors.

Where, as here, there will be significant issues in assessing attribution, a common approach is to utilise some form of Contribution Analysis (CA), *"an approach to assessing the performance of policies and programmes towards an outcome or outcomes…where designing an experiment is impractical…by focusing on questions of 'contribution'… [providing] an alternative way of thinking about the problem of attribution to the traditional positivist approach of proving causality via a counterfactual. By developing a Theory of Change showing the links between the activities, outcomes and contexts …and collecting evidence…a credible 'contribution story' can demonstrate whether policies and programmes were indeed an important influencing factor in driving change, perhaps along with other factors."*[15].

[15] Scottish Government Guide 6 Contribution Analysis

A key limitation of CA alone is that it cannot 'prove' whether an intervention is responsible for an observed outcome or for a particular proportion of the outcome. Rather it is *"designed to reduce uncertainty about the contribution the intervention is making to the observed results through an increased understanding of why the observed results have occurred and the roles played by the intervention and other internal and external factors"*[16].

The strength of the inferences which can be drawn from CA can be increased by its combination with a Process Tracing (PT) approach[17], *"a qualitative analysis methodology [the main purpose of which is] to establish whether, and how, a programme or specific intervention causes a particular outcome or set of outcomes. This is done by applying formal tests to examine the strength of evidence linking potential causes to the changes [and] testing alternative ideas about how changes may have come about."*[18].

In summary, the traditional types of test which are used to assess whether the hypothesis that a programme was responsible for particular observed outcomes is likely to be true comprise:

- '*Straw-in-the-Wind*' tests – which, if passed, lend support for the hypothesis.
- '*Hoop tests*' – for which failure to pass would effectively refute the hypothesis.
- '*Smoking Gun*' tests - which would tend to confirm that the hypothesis is true, although failure to pass which would not necessarily disprove it.
- Where possible, one or more '*Double Decisive*' tests – which, if passed, would essentially be both necessary and sufficient to prove the hypothesis.

Further tests added more recently[19] include *'Consistent Chronology'* – whether the outcome follows the relevant intervention with a lag which makes it plausible that the intervention was responsible for bringing it about – and *'Convergent Triangulation'* – whether evidence from independent sources with potentially conflicting interests points to similar conclusions.

Clearly the specifics of a PT approach and the details of tests which might be required at different stages and their associated evidence requirements would require significant development work. In the longer term there could also be scope for utilising Bayesian inferencing methods[20] in which initial assessments of the probability that the interventions were responsible for particular developments would be progressively refined as additional evidence accrues. The feasibility of this approach and how it might be operationalised would need to be assessed further when there is more information about the interventions, although this approach may be more useful for assessing the impacts of specific measures than for a portfolio-level impact evaluation.

[16] Better Evaluation Contribution Analysis, Updated 2021

[17] See, for example, Befani B and Mayne J (2014) Process Tracing and Contribution Analysis: A Combined Approach to Generative Causal Inference for Impact Evaluation, IDS Bulletin 45

[18] Intrac for civil society (2017) Process Tracing

[19] See, for example, Delahais T and Toulemonde J (2017) Making rigorous causal claims in a real life context: Has research contributed to sustainable forest management? Evaluation Vol 23(4). SAGE

[20] See Befani and Mayne above

ii) **A *Bottom-Up approach*** considering the impacts of individual measures. The assumption is that this would comprise a mixed methods approach involving:

- *Counterfactual Impact Evaluation (CIE)* and other statistical methods wherever these are likely to be feasible and proportionate. A discussion of the measures where there appears to be at least some potential to apply such approaches is included below.
- *Theory Based / Qualitative* methods. It is likely that most of the aviation decarbonisation measures will fall into this category, including initiatives relating to demonstration activities, low / zero carbon targets for airports and initiatives to secure international agreements and influence international regulations. In these cases, it should be possible to assess the extent to which outcomes have been achieved from existing evidence or primary research. There are, however, likely to be greater challenges in disentangling the role of aviation decarbonisation measures in bringing about the outcomes. These characteristics make them particularly suited to an evaluation methodology based upon CA supported by aspects of PT to tease out and test the significance of key potential causal links.

A5.2.2 Potential Counterfactual Impact Evaluation (CIE) and other Quantitative Designs

The Scientific Maryland Scale (SMS) is a commonly accepted measure of robustness, based on a (from most to least robust) ranking[21] of evaluation designs as summarised in simplified form below. UK Central Government evaluations are now expected to achieve at least SMS Level 3 wherever practicable.

Scientific Maryland Scale

Level 5: a random control trial in which subjects are randomly assigned between the treatment and comparison groups.

Level 4 (quasi-random): establishment of a comparison group such that the difference between the treatment and comparison groups can reasonably be considered to be random, typically through exploiting some form of discontinuity in eligibility for treatment. An example would be a comparison between a group of firms which just passed the 'score' which needed to be achieved to secure a grant with a group which just failed to achieve the pass mark.

Level 3 (quasi-experimental): selection of a comparison group which is thought to bear reasonable similarities to the treatment group (for example, all failed applicants for a particular grant), typically with a statistical matching process designed to reduce residual differences between the two groups.

Level 2: involving, for example, use of statistical methods which seek to control for differences between a treated and untreated group or for external factors which are likely to influence outcomes between the two groups.

Level 1: involving, for example, simple before and after comparison of outcomes for a treated group.

[21] See, for example, What works centre for local economic growth (2015) for a more detailed treatment.

It is considered unlikely to be realistic to apply any form of CIE design to the evaluation of the impacts of aviation decarbonisation measures on the UK aviation sector as a whole. There are no obvious UK sectors from which a counterfactual might be drawn and the assumption is that it will not be practicable to identify satisfactory potential international comparators which are not likely to be influenced by some of the same regulatory influences – including aspects which may also be influenced by some of the aviation decarbonisation measures themselves. However, there is likely to be significant potential value in considering how the performance of the UK aviation sector in improving its emissions compares with that of the same sector in other developed countries and the respective roles of aviation decarbonisation and similar interventions in other countries.

There are also likely to be specific aviation decarbonisation measures where CIE or other econometric approaches could potentially be applied, most notably:

- **Markets and Removals measures**. The design of the UK ETS and CORSIA schemes and the potential changes in their coverage could create a variety of discontinuities whose impacts might potentially be explored through a Level 3 or perhaps higher SMS econometric approach, or through an approach such as interrupted time series analysis. For example, if extensions of the schemes' coverage led to changes in the treatment for different operators or routes, it might be possible to assess impacts for the treatment group using a difference-in-differences econometric modelling approach.
- **Potential competitions**. Competitions are particularly suited to a CIE type approach because they potentially create a pool of unsuccessful applicants which may be sufficiently similar to the successful bidders – including in largely unobservable characteristics such as motivation – thereby providing a potentially suitable comparison group. If the numbers of successful and unsuccessful applicants and observations of their post-treatment performance are sufficiently large, a combination of statistical matching of treated and untreated subjects[22] and econometric analysis could potentially be used to produce an SMS Level 3 – or even Level 4[23] – assessment of the economic impacts on successful applicants of receiving funding.

[22] Typically through some form of Propensity Score Matching.

[23] If it is possible to compare the applicants which just met the cut-off for funding with those that just missed out.