Title: Regulation to Implement the International Civil Aviation Organization (ICAO) Non-Volatile Particulate Matter (nvPM) Aircraft Engine Emission Standards **IA No: DfT00441** **RPC Reference No: RPC-DFT-5175(1)** **Lead department or agency:** Department for Transport **Other departments or agencies:** Civil Aviation Authority	**Impact Assessment (IA)** **Date: 13th May 2022** **Stage: Final** **Source of intervention:International** **Type of measure: Secondary Legislation** **Contact for enquiries:** impactassessments@dft.gov.uk

Summary: Intervention and Options

RPC Opinion: GREEN

Cost of Preferred (or more likely) Option (£m in 2019 prices)

Total Net Present Social Value	Business Net Present Value	Net cost to business per year	Business Impact Target Status
0.0	0.0	21.8	Non-qualifying provision

What is the problem under consideration? Why is government intervention necessary?

The international aviation sector provides considerable benefits to society and to the UK economy. There are however social costs or negative externalities from aviation that must be considered and mitigated where possible. The International Civil Aviation Organization (ICAO) sets international standards to regulate the certification of civil aeroplanes and engines based on their noise and emissions performance. In March 2020, the ICAO Council adopted a new set of certification standards to control emissions of non-volatile particulate matter (nvPM), also known as black carbon or soot. Due to the international nature of aviation, international coordination is needed to take action on these emissions. The government is best placed to introduce the new international standards to the UK through implementation in UK domestic legislation. The UK is an ICAO member state and is obligated to implement the new standards set by ICAO. These include standards for both particle mass and number, and different regulatory limits applicable to new aircraft designs and aircraft already in production. nvPM can have both short and long-term health and environmental impacts and has been linked to climate impacts by contributing to cloud formation. The emission of nvPM from aircraft engines is a negative externality and an example of market failure arising from the use of aircraft engines which requires government action.

What are the policy objectives and the intended effects?

The objective of the policy is to bring the UK in line with its obligations as an ICAO member state. These standards are aimed at reducing nvPM emissions from civil aeroplanes, particularly in the landing and take-off (LTO) cycle. They replace the previous 'smoke number' standards from the early 1980s based on plume visibility and for the first time introduce new scientific measurement techniques to quantify the mass and number of particles emitted. As with all ICAO environmental standards, the nvPM standards have been adopted to have an environmental benefit while being technically and financially feasible, and accounting for interdependencies with other pollutants.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

- **Option 0**: Do nothing - existing certification standards for nvPM will continue to apply to aircraft engines in UK law. Under this option it is assumed that any UK registered engine manufacturers will comply with the international obligation in order to continue to trade internationally.
- **Option 1**: Implement the new nvPM standards through secondary legislation.

Option 1 is preferred as it will bring the UK in line with its international obligations as an ICAO member state. Alternatives to regulation or market-based measures such as taxes or cap and trade schemes have not been considered due to the complex nature of implementation these would involve. A voluntary approach would not be sufficient to meet international obligations. Regulation is the best way to realise the standards which have been agreed by ICAO's Committee on Aviation Environmental Protection (CAEP) at its 11th formal meeting (CAEP/11) negotiations. The government is the only actor able to regulate domestically on the new nvPM standards.

Will the policy be reviewed? Yes. **If applicable, set review date:** Not expected by ICAO before 2028.

Is this measure likely to impact on international trade and investment?		Yes		
Are any of these organisations in scope?	**Micro** Yes	**Small** Yes	**Medium** Yes	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)		**Traded:** N/A	**Non-traded:** N/A	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits, and impact of the leading options.

Signed by the responsible: Robert Courts Date: 16 May 2022

Summary: Analysis & Evidence

Policy Option 1

Description: Implement the new nvPM standards through secondary legislation.

FULL ECONOMIC ASSESSMENT

Price Base Year 2019	PV Base Year 2023	Time Period Years 10	Net Benefit (Present Value (PV)) (£m)		
			Low: 0.0	High: 0.0	Best Estimate: 0.0

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	0.0	N/A	0.0	**0.0**
High	0.0		0.0	**0.0**
Best Estimate	0.0		0.0	**0.0**

Description and scale of key monetised costs by 'main affected groups'

We expect that the UK aviation sector would comply with the new international obligation under the Do Nothing scenario in order to continue to trade globally. Therefore, compared with the Do Nothing scenario the costs to business of the UK implementing the new standards domestically are 0. However, in order to illustrate the impact of the new international obligation on UK businesses for the purpose of Business Impact Target accounting we have constructed an alternative counterfactual where the UK alone implements the new standards and presented the direct costs to businesses. Under this constructed counterfactual businesses will incur a non-recurring cost to engine manufacturers of developing a technology response to meet the new standard, estimated at £102.5m. The ongoing cost to aircraft operators (AOs) of additional fuel, which is required as a result of lower fuel efficiency associated with the new engine technology necessary to comply with the nvPM standards, is estimated to be £42.8m. On top of this AOs will incur ongoing costs of £62.3m including lost revenue, spare engine costs and maintenance and build costs referred to in this impact assessment as 'other costs'. Lost profit is considered in appraisal as a way to measure impact to business, however for the purposes of this assessment lost revenue has been assumed to equate to lost profit and therefore is included in the EANDCB. See section 3.4.2.2 for a full explanation of this rationale. Lost revenue is caused by the reduction in revenue generating cargo as this is replaced by the additional weight of fuel required to cover the lower fuel efficiency associated with the new technology. This only applies where aircraft operate at maximum take-off mass. These costs are presented as discounted costs over the 2023 to 2033 appraisal period. These are only included in the Business Assessment, and not in the headline costs as we do not expect them to be incurred as a direct result of this policy option of matching the international standards, compared to doing nothing.

Other key non-monetised costs by 'main affected groups'

In the constructed counterfactual, increased fuel burn will lead to a potential increase in carbon costs for aircraft operators where flights are covered by carbon pricing schemes. This arises as a result of the additional emissions from aircraft operators as a result of the lower fuel efficiency associated with implementation of new aircraft engine technology, however this has not been monetised. While emissions as a result of the additional fuel burn are expected to increase in the aviation sector there will be no overall increase in emissions as these will be captured under the UK emissions trading scheme (UK ETS) cap and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Asset value loss has been considered but not included in the calculation of the EANDCB as this is considered to be an economic transfer.

We do not expect these costs to be incurred in reality compared to the do nothing, as we expect complete compliance with the international obligation regardless of UK Government matching those standards in domestic law.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0.0		0.0	**0.0**
High	0.0		0.0	**0.0**
Best Estimate	0.0		0.0	**0.0**

Description and scale of key monetised benefits by 'main affected groups'

No monetised benefits have been included in this impact assessment and in the EANDCB.

Other key non-monetised benefits by 'main affected groups'

The new standards are expected to result in emissions savings of approximately 12,300 tonnes of nvPM emissions globally. A proportion of these emissions savings would be attributed to the UK and the UK would benefit from reduced cost of environmental and health impacts arising from nvPM emissions. This benefit has not been monetised as there is no robust way to estimate benefits to the UK from a global reduction in nvPM emissions. Reduction in nvPM emissions will also result in reduction of the risk of climate warming effects from nvPM emissions in the atmosphere where these form contrails. This benefit has not been monetised as both the relationship between nvPM emissions and contrails, and the climate impacts of contrails, are subject to a high degree of uncertainty. We expect these benefits to be realised as a result of the adoption of the international standard, which also occurs in the Do Nothing scenario.
Reduction in capital costs has been assessed in the CAEP analysis, this is where operators in the business jet market choose not to respond to the new standard and switch to cheaper alternative aircraft and costs occurring from holding assets of a higher value such as depreciation costs and financing costs will reduce. This has been considered but not included in the EANDCB.

Key assumptions/sensitivities/risks	**Discount rate**	3.5

UK proportion of global fleet approximation used to apply CAEP/11 costs to UK context

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:						**Score for Business Impact Target (qualifying provisions only) £m:** N/A
Costs:	24.1	**Benefits:**	0.0	**Net:**	24.1	

1. Policy Rationale

1.1. Policy Background

1. The International Civil Aviation Organization (ICAO) sets international standards to regulate the certification of civil aeroplanes and engines based on their noise and emissions performance. In March 2020, the ICAO Council adopted a new set of certification standards to control emissions of non-volatile particulate matter (nvPM), also known as black carbon or soot. These standards were initially agreed at the eleventh meeting of ICAO's Committee on Aviation Environmental Protection (CAEP) so are often known as the CAEP/11 nvPM standards.

2. These standards are aimed at reducing nvPM emissions from civil aeroplanes, particularly in the landing and take-off (LTO) cycle, when they are on or close to the ground.

3. In the early 1980s, ICAO adopted a 'smoke number' standard, which sought to limit visible smoke from aircraft engines. In recent years, new measurement techniques have made it possible to scientifically measure both the mass and number of particles emitted by an aircraft engine. This led ICAO, in 2016, to agree a reporting standard for nvPM to gather data to allow it to set a scientifically based regulatory limit.

4. The CAEP/11 nvPM standards now replace the previous 'smoke number' standards with the first scientifically based certification standards for civil aeroplane nvPM emissions. They include standards for both particle mass and number and different regulatory limits applicable to new aircraft designs and aircraft already in production.

5. As with all ICAO environmental standards, the nvPM standards are intended to have an environmental benefit while being technically feasible, economically reasonable and accounting for interdependencies with other pollutants.

1.2. Problem under consideration

6. The UK is a member state of ICAO and is therefore treaty bound to implement standards set by ICAO into UK domestic law. At present the UK does not have the new nvPM standards in domestic legislation. Therefore, if these are not implemented the UK will be in breach of its obligations as an ICAO member state.

7. nvPM affects human health in two ways: by being toxic or by providing a surface for transporting toxic compounds to where they can do harm. It can have both short-term and long-term impacts health impacts.[1] nvPM can also have climate impacts by contributing to cloud formation and possibly warming effects in the atmosphere although the science of this is not conclusive.[2]

1.3. Rationale for intervention

8. The new standards aim to mitigate the environmental impacts of aviation specifically relating to nvPM emissions from aircraft engines. nvPM emissions from aircraft have been shown to have negative environmental externalities which are not currently accounted for in engine manufacturers' and aircraft owners' decision making, such as local air quality impacts and evidence of atmospheric warming impacts when released high in the atmosphere.

[1] COMEAP, 'Mortality effects of long-term exposure to particulate air pollution in the UK' (2010), [2] The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018, (2021), Lee et al. paragraph 4.5.
[2] The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018, (2021), Lee et al. paragraph 4.5.

9. Regulatory change is the most effective way to overcome the negative externality associated with nvPM emissions from aircraft engines and reduce the detrimental health and environmental consequences associated with emissions. The government is best placed to intervene via regulatory standards as there is a broad technical consensus regarding reducing nvPM emissions from civil aircraft, agreed by international experts in ICAO's CAEP. Furthermore, the UK is required to implement them to the extent that it is able to do so in order to meet international obligations (see paragraph 13). Therefore, setting regulatory standards in legislation is the best way to implement these in practice and achieve the policy objectives rather than leaving the free market to decide.

10. Implementing these regulations will provide regulatory certainty to the UK aerospace sector and provide confidence in UK aircraft and engines for global customers. Implementing these standards into domestic law will provide greater certainty for the UK regulator for the aviation sector, the Civil Aviation Authority (CAA), regarding its function as the UK's certifying authority for aircraft and engine designs.

11. If the UK does not implement these standards, it is highly likely that other certifying authorities around the world will still do so. The European Union has already adopted these standards and the United States are in the process of implementing these. [3] [4] This would result in a lack of harmonisation of standards globally. Differing standards could negatively impact the UK's aerospace and aviation sectors competitiveness as UK manufactured engines and airlines using these may be less attractive in the global market if there is uncertainty around whether these meet the standards. This is one potential outcome, although it is highly likely that the UK aerospace sector will adopt these standards voluntarily and in full and would seek certification outside the UK in order to avoid this issue and continue to trade internationally.

12. The UK is a signatory to the Convention on International Civil Aviation (the "Chicago Convention") and is therefore under an obligation to implement new standards as agreed by ICAO to the extent that it is able to. The UK has been actively involved in negotiating the nvPM standards over many years and has provided significant resources in the form of expert time and emissions testing to inform the standard setting process. Not implementing these amendments would therefore cause reputational damage to the UK.

13. As these are international standards, there is no other way to meet this obligation other than through regulation. Alternatives to regulation or market-based measures such as taxes or cap and trade schemes have not been considered due to the complex nature of implementation these would involve. A voluntary approach would not be sufficient to meet international obligations.

1.4. Policy objective

14. The aim of this regulation is to bring UK secondary legislation in line with international standards and maintain international competitiveness of UK industry by providing regulatory certainty. The international standard aims to deliver environmental (health and climate) benefits.

15. In practice, it is likely that engine and aircraft manufacturers intending to certify their products in the UK will aim to meet ICAO standards regardless of whether they are written into UK regulations, due to the inherently international nature of the sector. If the UK took no further action, an engine manufacturer (and subsequently an aircraft manufacturer) could manufacture engines that did not meet these new standards, but it could then not be sold outside of the UK. Additionally, not doing so could lead to reputational damage for the UK and its industry through breaking international convention and treaties we are signed up to.

[3] Implementation of the Latest CAEP amendments to ICAO Annex 16 Volumes I, II and III, Explanatory Note to Decision 2021/011/R, European Union Aviation Safety Agency, 2020

[4] Regulations for Emissions from Aircraft Engines, US EPA

16. These standards are the first scientifically based international certification standards for aircraft nvPM emissions. While modelling of the environmental benefits in terms of emissions reductions to be expected has been undertaken, it is possible that these benefits may not be realised. Additionally, and particularly as engine designs react to these standards, additional environmental benefit may become technically and economically feasible. ICAO will therefore keep these standards under review. Certification data from authorities such as the UK having implemented and applied the standards, will help to contribute to the evidence base for any such review.

1.5. Options considered

1.5.1. Option 0 – Do Nothing

17. Under the 'do nothing' option only the existing aircraft engine certification standards will apply in the UK. The new international standards will not be implemented in the UK and as a result UK engine manufacturers will not be legally required to meet these standards. However, in this scenario their UK certified engines could not be sold outside of the UK. This would put the UK out of step with global standards that we have negotiated for over many years.

18. However, it is assumed that the rest of the world will implement the new standards regardless of whether the UK does. Therefore, under this option UK businesses are assumed to comply with the international standards in order to continue to trade in the global market.

1.5.2. Option 1 – Implement the New International Standards

19. The Government's preferred option is to implement the new CAEP/11 nvPM standards. This will bring UK secondary legislation in line with international standards, leading to health and environmental benefits, while maintaining the international competitiveness of UK industry by providing certainty in regulation of the aviation sector.

20. Regulatory change will provide consistent standards to be applied across the aviation sector. The CAEP/11 nvPM standards have been set through the negotiation process and with significant scientific expert input. These standards have been agreed by ICAO to be the best option accounting for costs to businesses and possible trade-offs with other pollutants. Government is the only actor able to adopt the new standards in domestic legislation as the regulator. As the new standards have been agreed using international technical expertise, regulation is the most efficient way to implement these standards over potential market-based measures that may achieve differing levels of efficiency.

21. No other options have been considered or monetised in this impact assessment. The international consensus, to which the UK subscribes, is to take a regulatory rather than market-based approach to aircraft engine nvPM emission certification.

2. Analytical Approach

2.1. Counterfactual

22. In order to present the most accurate picture of costs imposed on businesses as a result of the UK implementation of the new international standards, and therefore to best inform the decision to be taken, two counterfactuals are presented to consider how businesses would act in the absence of

the preferred option. This approach is in line with Regulatory Policy Committee guidance on accounting for the impacts on business for the Business Impact Target, alongside presenting the public and Parliament with the evidence base used to make their decision.[5]

2.1.1. Counterfactual A: Rest of World Implements, UK takes no further action

23. Under this counterfactual the UK does not implement new standards, but the rest of the world does, and as such UK engine manufacturers comply with new standards in order to allow them to continue to trade internationally. Under this counterfactual UK businesses will continue to meet the international regulatory requirements in the absence of domestic legislation.

24. If the UK took no further action, engine manufacturers could continue to certify their engines for sale only within the UK. We do not think this is likely as the majority of civil aviation aircraft manufacturers are American or European and both countries are adopting these international standards. As such, UK engine manufacturers will be producing new engines in line with this standard to continue international trading, even if the UK takes no further action.

25. Using this counterfactual, the policy option, adopting the international standards in UK law, would incur no additional costs or benefits. We believe this is the most accurate reflection of what will happen in the absence of regulation, however using this counterfactual would fail to identify the impact of the new international obligations on UK business. This counterfactual is used for the calculation of the Net Present Value.

2.1.2. Counterfactual B: International Obligation Does Not Exist, Only UK Implements

26. An alternative counterfactual has been constructed under which the new international obligation does not exist and therefore no country implements this. Using this counterfactual, the policy option will be that the UK implements the new international obligation while the rest of the world does not. This counterfactual is used in order to produce meaningful analysis of the impact on UK business of the new international obligation, rather than assume there will be no impact as businesses will comply regardless of domestic regulation. This alternative counterfactual is used for the calculation of equivalised annual net direct costs to business (EANDCB) to assess direct costs to business as a result of the new international standards in line with the Better Regulation Framework Guidance.

27. While an alternative counterfactual has been constructed in order to assess direct costs to business under this counterfactual, we assume that UK businesses will face costs equal to those they would face if there was a global obligation and therefore a global technology response. This means that technology would be developed in order to meet global demand and available for UK business use even under the alternative counterfactual.

2.2. Number of Businesses Affected

28. This regulation will directly affect manufacturers of aircraft engines within scope of the international standards (all engines greater than 26.7 kilonewtons (kN) rated thrust) whose design authority is the CAA. This is currently zero, although at least one large engine manufacturer whose state of design is outside the UK is a significant contributor to the UK economy. In addition to this it is expected that there may be other engine manufacturers with significant supply chain operations in the UK.

29. This regulation will affect suppliers and customers of engine manufacturers (i.e. manufacturers of parts and aircraft) whose design authority is the UK. As above this is technically expected to be zero but at least one large civil aircraft manufacturer whose state of design is outside the UK is a

[5] RPC Case Histories September 2020, pages 8-9

significant contributor to the UK economy. Therefore, we have considered costs to engine manufacturers in our analysis. The costs to engine manufacturers considered are included in the technology response costs in Section 3.4.1.1.

30. We estimate there are around 6 aircraft manufacturers in the UK with engine products over 26.7kN thrust and therefore in scope of the new standards, that are customers of the large engine manufacturer referred to in paragraph 29. UK aircraft operators and airlines will also be affected by the new standards, the most recently published CAA data[6] estimates there are 32 UK airlines where a UK airline is defined as an airline that holds a UK aircraft operators' certificate.[7]

31. UK businesses may also be affected to the extent that they are a constituent part or supplier of a manufacturer whose country of design (where the engine is certified) is implementing this regulation. However, this is out of the scope of this impact assessment.

2.3. CAEP/11 Analysis

32. The analysis undertaken by the International Civil Aviation Organisation (ICAO) Committee on Aviation Environment Protection (CAEP) included an impact assessment which provides international cost estimates for implementation of the new nvPM standards.[8] These cost estimates represent the best available evidence we have for estimating the impact of the new standards and these have been adapted to a UK context. The CAEP/11 analysis does not monetise the benefits of nvPM emissions reduction as it is ICAO practice to conduct cost effectiveness analysis rather than to monetise environmental benefits.

33. This is the most robust and proportionate approach to assessing the impact of new standards in time frame available for implementation of the standards due to the expectation that UK businesses would adopt the standards anyway and therefore the net present value of domestic implementation is 0. The resource required to gather additional information and modelling tools necessary for an independent assessment has been considered to be significant. As a number of large and interacting models have been used to produce the CAEP analysis it is not possible to reproduce this analysis using characteristics of the UK fleet. In addition to this we do not have access to these models, or the detailed information required to provide inputs for the UK only. The CAEP analysis uses commercially sensitive information that the UK cannot unilaterally release as part of the implications of our CAEP membership.

34. With these factors taken into consideration adapting existing analysis, which the UK along with a multitude of countries around the world have already contributed to as an ICAO member state, is the most proportionate approach for this purpose. We have adapted the final results of the CAEP analysis using an approximation for the UK fleet, this is detailed in section 2.4.

35. There are significant sources of uncertainty in our analysis. Where these are present the potential impacts of these uncertainties have been discussed and caveats to our analysis have been included. In particular the CAEP analysis was conducted using inputs and assumptions relevant to an international context and approximating this to a UK context is likely to reduce the overall accuracy of results. The aim of this impact assessment is to give an indication of where the scale of costs to businesses may lie using the best information available to us. In addition to this the domestic implementation of the new standards is not expected to have any real world impacts and impacts identified for Business Impact Target (BIT) purposes are excluded from the BIT score due to this being an international obligation. Therefore, approximating the CAEP analysis as set out in

[6] UK airline data December 2021, Table 8.2, Civil Aviation Authority (caa.co.uk)
[7] Air operator certificates, Civil Aviation Authority (caa.co.uk)
[8] EASA Impact assessment Containing CAEP/11 Regulatory Impact Assessment, EASA, 2020

section 2.4 has been judged to be the most proportionate and feasible approach to estimating the direct cost to UK business.

36. The analysis produced by CAEP uses a number of international economic models from sources including the European Union Aviation Safety Agency (EASA), the US Department of Transportation, and academia. This analysis was undertaken for 12 stringency options, in order to facilitate agreement by CAEP on a single stringency level. A stringency options refer to different options for the regulatory level at which emissions standards are set.

37. The analysis for the CAEP/11 nvPM mass and number standards included modelling of the global fleet in two ways, these were referred to as 'Path A' and 'Path B'. The difference in these options arose from differences in the modelling of wide body passenger aircraft, however differences in results mainly impacted stringency options SO7-12. Stringency option 5 is used here as the closest approximation of the chosen nvPM mass and number standards, therefore the impact of the two paths modelling is small. We have assumed Path B results throughout this analysis, this is done as Path B results were marginally higher than Path A for 'Fuel Cost' and 'Other Costs.' This therefore may be a slight overestimation of costs rather than an underestimation, which we have chosen in order to be conservative in our analysis.

38. ICAO CAEP standard setting and stringency analysis processes rely on having access to commercially sensitive data that is not in the public domain to ensure the best possible data is available to inform standard setting. The UK participates in CAEP on the basis of an agreement that it will not unilaterally release this data and therefore this impact assessment only includes data that has been published by ICAO. To do otherwise could impact the UK's international relations through ICAO and impair CAEP's ability to use such data in future.

2.4. UK Approximation

39. The CAEP/11 analysis presents costs over an appraisal period of 2025 to 2042. This is due to the fact that the planned date of implementation at the time the analysis was undertaken was 2025. The end date of the appraisal period of 2042 was used by CAEP as this was the date that CAEP demand scenarios were projected out to. As the negotiations have now concluded, CAEP's decision has been to implement at an earlier date of 2023. 2023 is therefore the first year of appraisal used in our analysis.

40. We have used a standard appraisal period for impact assessments of 10 years, meaning impacts have been appraised from 2023 to 2032 inclusive. We have assumed that ongoing costs and benefits are constant across each year in the appraisal period and have taken the costs from original appraisal period and applied these to the appraisal period used in this impact assessment.

41. The CAEP analysis costs are presented in USD dollars in 2012 prices. This has been converted to 2019 prices using the Gross Domestic Product deflators published by the Office for National Statistics[9] and converted to GBP sterling using an exchange rate[10] in order to assess impact to the UK.

42. In order to apply the results of the CAEP analysis to a UK context, we have used an approximation using UK international aircraft and airline data in order to determine the proportion of costs that may

[9] GDP deflators at market prices, and money GDP December 2021 (Quarterly National Accounts)
[10] Exchange rate correct as of 23rd February 2022

fall on the UK economy. It should be noted that this is a rough approximation used to give an idea of the potential magnitude of costs to the UK.

43. The extent of costs to businesses as a result of the new standards will depend on a number of factors. These include aspects such as size of the UK fleet, age and condition of existing aircraft, number of aircraft in production as well as those already certified that would already meet the new standard. These factors will likely differ significantly between aircraft manufacturers and aircraft operators meaning that the distribution of costs may differ between different firms, and hence the UK fleet may differ from the global average. In addition to cost of materials and labour, availability of technology and ability to change production processes where necessary will affect costs of meeting the standards. We acknowledge the high level of uncertainty in this approximation however this is the most reasonable and proportionate approach of impacts to the UK we can provide.

44. As detailed information about the UK fleet is not available and costs cannot be applied to aircraft individually, measures including number of aircraft registered in the UK and UK registered airlines have been used to determine an appropriate proxy.

45. Using the data available a number of options for approximation were considered and used to construct a low, central, and high assumption. These have been estimated using number of aircraft data and comparing this to global fleet data from a number of sources. The UK number of aircraft is estimated from CAA data which gives a figure for aircraft in service at the end of the last quarter.[11] This is then compared to global fleet data which was originally drawn from ICAO data in order to estimate the proportion of the global fleet represented by UK aircraft.[12] [13] Data over three years from 2019 to 2021 has been used to estimate a low, central, and high estimation for proportion of UK aircraft compared to the global fleet.

46. The central estimate of the proportion of global fleet that are registered in the UK is estimated using an three year average of aircraft data for the UK estimate and the global estimate, the UK figure of 951 aircraft is then divided by the global figure of 25,833 aircraft to give an estimate of 3.68% for the UK proportion. A low estimate of 3.24% is produced using the lowest UK aircraft figure over 2019 to 2021 and dividing this by the highest figure for global aircraft over the same period. The same is done for the high estimate of 4.25% using the highest UK figure and the lowest global figure.

Table 1: Approximation Estimates Applied to CAEP/11 Analysis

	Low	Central	High
UK Aircraft	903	951	1009
Global Aircraft	27,884	25,833	23,715
UK Proportion of Global Fleet	3.24%	3.68%	4.25%

47. Flight or air traffic movements (ATMs) data is not considered to be a suitable measure of how the UK aviation sector will be affected by the new nvPM standards as these only consider aviation activity regardless of whether this is by a UK registered airline or a foreign business. Therefore, data on UK airlines and aircraft is a more appropriate measure. In addition to this the majority of the costs assessed, other than the technology response costs, will fall on aircraft operators. UK airline and aircraft data is therefore the best available measure of the scale of these costs.

[11] Aircraft Type and Utilisation Individual Airlines, November 2021, Table 08.2, CAA
[12] Size of aircraft fleets worldwide 2019-2040, Statista, originally from ICAO.
[13] Aircraft fleet - number of airplanes in service 2020, Statista, originally from ICAO.

3. Costs and Benefits

3.1. Option 0 – Do Nothing

48. Under the ‘Do Nothing’ option only the existing aircraft engine emission standards will apply in the UK. The new international standards will not be implemented in the UK and as a result UK engine manufacturers will not be legally required to meet these standards. However, it is assumed that the rest of the world will implement the new standards regardless of whether the UK does. Therefore, under this option and using counterfactual A, UK businesses are assumed to comply with the international standards in order to continue to trade in the global market. Using this counterfactual in the ‘do nothing’ option UK business will therefore voluntarily incur the costs of meeting the new nvPM mass and number standards.

49. An alternative counterfactual is considered in order to present meaningful analysis of the impact on UK business of the new international obligation. Under this alternative counterfactual the ‘Do Nothing’ option is that the new international obligation does not exist and therefore no country, including the UK, implements it. There will be no additional costs or benefits to UK business and the UK economy in this ‘Do Nothing’ option.

3.2. Option 1 – The UK Implement the Standards into Domestic Law

50. Under this Option the UK implements the new environmental standards into UK domestic law. This means UK engine manufacturers will be required to adopt these new standards in order for engines to pass certification requirements and be sold on the market.

51. Under Option 1 using the central counterfactual, counterfactual A as set out in paragraph 23, there are no new costs imposed on business by the UK government. This is due to the fact that business will already comply with international standards in the absence of new legislation implementing these into UK domestic law. Therefore, there is no additional cost or benefit associated with the new regulation using this counterfactual. This approach informs the estimation of Net Social Present Value for the preferred option.

52. The costs of complying with the new international standards using the alternative counterfactual, under which the UK applies the new standards and the rest of the world does not, are presented in Table 2. This is done in order to estimate direct costs incurred by UK business by the new international standards and used for the calculation of the EANDCB.

3.3. Summary of Costs and Benefits

53. A list of the costs and benefits that have been included in this impact assessment have been detailed below. Where costs or benefits were not been monetised the reasoning for this has been explained in the corresponding section. Table 2 presents costs and benefits included in the EANDCB, discounted over 2023 to 2032 and presented in 2019 prices.

3.3.1. Monetised Costs and Benefits Included in EANDCB

Transition Costs

- Cost of technology response required to meet the new standard – 'Non-recurring Costs' (direct)

Ongoing Costs

- Spare engine costs (direct) – included in 'Other Costs'
- Lost revenue (direct) – included in 'Other Costs'
- Fuel cost (direct)
- Incremental build and maintenance costs (direct*)* – included in 'Other Costs'

3.3.2. Not included in EANDCB:

Unmonetised Costs

- Cost of asset value loss (transfer)
- Increase in Carbon Costs as a result of additional fuel burn (direct)

Unmonetised Benefits

- Reduction in nvPM Engine Emissions (indirect)
- Reduction in potential climate warming effects (indirect)
- Reduction in capital costs (direct)

54. While the new standards apply directly to engine manufacturers when they are certifying aircraft, costs to aircraft operators (spare engine costs; lost revenue; fuel cost; incremental build and maintenance cost) are included as direct costs and therefore considered in the EANDCB. Impacts on aircraft operators are considered to be direct costs due to the fact that impacts as a result of the new standards are immediate and are largely unavoidable for UK. Furthermore these impacts take place in the aviation sector which is the same market being regulated in this instance and increase the cost of business activity in this market While the new regulations apply directly to engine manufacturers, aircraft operators are sensitive to these impacts as a result of the new standards and closely linked to engine manufacturers in the supply chain. For these reasons, these costs have been assumed to be direct in accordance with RPC guidance on direct and indirect costs[14].

Table 2: Discounted Costs and Benefits 2023 to 2032, £m in 2019 prices

Monetised Costs	Low	Central	High
Transition Costs			
Non-Recurring Cost	90.16	102.53	118.46
Ongoing Costs			
Fuel Cost	37.66	42.83	49.48
Other Costs	54.80	62.32	72.00

3.4. Costs

3.4.1. Transition Costs

[14] RPC case histories - other BIT methodology issues, March 2019 - GOV.UK (www.gov.uk)

3.4.1.1. Technology Response Costs

55. The CAEP analysis produces a number of technology responses which predict the way current technology in use will need to be adapted to meet the new nvPM stringency requirements. These costs may fall on engine manufacturers in the UK. Detailed information on each of these technology responses is included in the CAEP working group papers however this is not published and therefore not included in this assessment. The CAEP analysis states that engine technology responses were chosen based on input from manufacturers and expert sources. The descriptors used in the published CAEP/11 analysis and in our impact assessment are as follows, where NI represents 'nvPM improvement'. Table 3 lists the technology responses chosen by CAEP and the corresponding non-recurring cost for an engine family.[15] This information is used as input data in the CAEP analysis to produce the aggregate costs used in the UK approximation in this assessment.

56. In the CAEP/11 analysis the cost of developing a technology response to the new emissions standards is referred to as the 'non-recurring cost'. This captures the cost of developing a technology response to pass the new standard but does not include recurring costs such as labour and raw materials which may be associated with implementing the new technology.

Table 3: Non-Recurring Costs by Technology Response, 2019 prices

Reference	Description of Technology Response	Cost (£m)
NI1	nvPM improvement, minor changes	13
NI2#[16]	nvPM number improvement, scaled proven technology	126
NI2m	nvPM mass improvement, scaled proven technology	210
NI3	nvPM number improvement, new technology	419

3.4.2. Ongoing Costs

3.4.2.1. Spare Engine Costs

57. Spare engines are required by AOs for regular maintenance and unscheduled engine removals, having ready-to-fly spare engines means that operators can keep their aircraft in service with minimum disruption while the removed engine is sent for servicing. The introduction of a new standard would cause a loss of fleet commonality between pre-standard assets and new compliant fleet assets. This means there will be additional costs to maintain spare engines for the pre-standard compliant fleet and a separate set of spare engines needed for the new compliant fleet aircraft.

[15] An 'engine family' refers to how engine manufacturers group or classify engines based on similar characteristics, this is done for certification and compliance purposes.
[16] There are two different technology response costs listed in the CAEP/11 analysis for NI2 as these differ depending on whether an nvPM mass or number stringency option is applied

58. A complication in modelling this cost has been identified by the CAEP analysis as the rise in engine leasing by AOs who previously purchased their own engines. As this may change how assets are managed this is considered in the analysis. The business jet market is presented as an example as AOs in this market rely more on engine manufacturers and maintenance repair operations (MROs) to invest in a pool of engines and make them available on a rental basis to support unscheduled maintenance and inspections. Despite this different asset management behaviour, the business jet market is assumed to be the same as the commercial jet market in the analysis. This is due to the fact that engine manufacturers and MROs act like a large fleet in terms of spare asset management.

59. The analysis applies an assumed 'commonality factor' for new engines, which represents the level of similarity to pre-standard compliant engines. A commonality factor of 50% is applied where 50% of engines are assumed to require a NI3 technology response and require new technology. The remaining 50% of new engines were assumed to be able to be mixed with the engines they replaced and did not require spare engines to be acquired.

60. Table 4 presents estimated spare engine prices for the aircraft types considered in the analysis. This information is used as input data in the CAEP analysis to produce the aggregate costs used in the UK approximation in this assessment.

Table 4: Spare Engine Price by Type of Aircraft, 2019 prices

Aircraft Type	Aircraft Retirement Code	Spare Engine Price (£m)
Wide body passenger	B_WB_PAX	9.48
Narrow body freight	G_NB_FRT	5.45
Wide body freight	H_WB_FRT	4.44
Narrow body passenger	A_NB_PAX	4.28
Business jet	F_BJ	2.85

61. Total costs associated with spare engines for each stringency are not presented separately in the CAEP/11 analysis. Instead, these are included in 'Other Costs' alongside lost revenue and maintenance and incremental build costs.

3.4.2.2. Lost Revenue

62. The cost of lost revenue is estimated where engines receive a technology response to the new nvPM standards that requires a new technology to be introduced. Under this technology response the introduction of new technology causes a 0 to 0.5% fuel burn penalty. Due to this fuel burn penalty additional fuel will need to be loaded to complete the same journey. Therefore, a certain volume of load carried by the aircraft will need to be removed to still operate at a take-off mass that does not exceed the maximum take-off mass (MTOM) of the aircraft.

63. The cost of lost revenue only applies to long distance flights and where aircraft are operated at maximum take-off mass. The CAEP analysis identifies that wide body segment aircraft[17] that receive a NI3 technology response will be impacted by the fuel burn penalty. Where this occurs, operators will choose to restrict cargo over passengers due to the additional revenue passengers produce.

64. Using the 0 to 0.5% estimated fuel penalty the average required cargo off-loaded is calculated at 0.17 tonnes. This is monetised using a cargo yield of $0.28 per revenue tonne kilometre (RTK). A

[17] Specifically, the CAEP analysis finds aircraft models impacted are 787, A330neo, A350 and A380.

revenue tonne kilometre is generated where a metric tonne of revenue load is carried 1 kilometre and is measure of airline volume. This figure was taken from the CAEP/8[18] report which calculated a RTK of $0.26 in 2009, this was then inflated to 2012 prices to give a figure of $0.28/RTK. In 2019 prices and in GBP sterling this is equivalent to £0.23/RTK.

65. Using this cargo yield the CAEP analysis estimates lost revenue for each year. Where data was missing between years this was estimated using interpolation using available data points. This calculation was undertaken with global fleet information to aggregate this figure to estimate total lost revenue.

66. The following calculation was used to estimate lost revenue per year where 'C-Bin Distance' refers to distance travelled by a certain classification of aircraft or a 'Competition Bin,' these competition bins are used to split aircraft by type, for example wide body passenger aircraft with a certain number of seats.

Lost Revenue per Year = Off-loaded Payload x C-Bin Distance x Cargo Yield x No. Operations at MTOM

67. The CAEP/11 analysis does not present separate lost revenue figures for different stringency options that were assessed in the analysis. Instead, this is included in the 'Other Costs' figure.

68. Appraisal of impacts to business of regulation considers lost profit as a result of change in legislation, however for the purpose of this impact assessment lost revenue is considered to be a suitable proxy for lost profit. These reasons for this are set below.

69. In this assessment lost revenue is assumed to equate to lost profit for the purposes of the calculation of the EANDCB. This is due to the fact that the change in costs associated with a reduction in volume of transported cargo is negligible. The costs of carrying cargo will largely consist of the cost of fuel as a result of the additional weight of the aircraft, and the overall weight of the aircraft is assumed to be largely the same as a result of the substitution from cargo to fuel.

70. Other costs that may be associated with additional cargo include the costs of transporting cargo in the airport or airfield that are covered by the airline and any labour costs associated with these. We expect these costs to be negligible relative to the costs considered in the impact assessment.

3.4.2.3. Fuel Costs

71. For technology response NI3 there will be a fuel burn penalty trade off of 0 to 0.5% as explained above in the lost revenue section. Due to this fuel burn penalty, additional fuel will be burnt in order to conduct the same journeys. As a result of this, aircraft owners and operators using aircraft that is subject to this fuel penalty will face increased fuel costs for their journeys.

72. The published CAEP/11 analysis does not disclose how fuel costs have been calculated and the assumptions used for the estimation of these costs. Importantly the price of jet fuel used is a source of significant uncertainty as fuel prices are volatile.

[18] CAEP/8 NOX STRINGENCY COST-BENEFIT ANALYSIS DEMONSTRATION USING APMT-IMPACTS, CAEP/8-IP/30, 2010

3.4.2.4. Other Costs

73. Other costs represent the largest cost category for stringency option 5 (as a proxy for the CAEP-agreed stringency), according to the CAEP analysis. 'Other Costs' includes recurring costs of lost revenue, spare engine costs and incremental build and maintenance. As the impact of lost revenue and spare engine costs is explained and quantified above the remaining part of this cost is incremental build and maintenance costs. These costs may arise due to the increased complexity of new engine technology used to meet the nvPM emissions standard.

74. The proportion that each cost makes up of the overall 'Other Costs' figure has not been included in the published CAEP analysis. However, it is assumed all these costs will fall on aircraft owners and operators and will be recurring each year of the appraisal period.

3.5. Not Included In EANDCB

3.5.1. Unmonetised Costs

3.5.1.1. Asset Value Loss

75. Asset value loss (AVL) is estimated by CAEP based on the principle that the introduction of a new nvPM standard would reduce the market value of existing aircraft that do not meet the standard even if the standard does not apply to the in-service fleet. It also accounts for the fact that the introduction of a new standards would cause a loss of fleet commonality between pre-standards assets and new compliant fleet assets.

76. An 'impairment charge' is applied in the CAEP modelling which acts as a proxy for the actual loss in market value that would occur when the aircraft is sold before the end of its economic life and is sold at a lower cost than was estimated when the aircraft was purchased. Asset values as projected through depreciation rates were assumed to be an appropriate proxy for market resale values.

77. Table 5 presents estimated AVL per engine for each potential technology response required to remain in the market. Where 'No Response' is the given technology response this indicates that the aircraft does not meet the new standards and therefore goes out of production. Under this technology response the highest cost technology response, the cost associated with NI3 is assumed.

Table 5: Asset Value Loss per Engine by Technology Response Required, 2019 prices

Technology Response	AVL per engine (£m)
NI1 (minor changes)	0
NI2 (scaled proven technology)	0.22
NI3 (new technology)	0.45
No Response	0.45

78. AVL would be included in a business' financial statements however AVL has been considered to be an economic transfer between different owners and operators of aircraft and aircraft engines in our impact assessment. This means that there is no overall net cost or net benefit as a result of the change. This is due to the fact that the reduction in value of aircraft when this is sold would be gained elsewhere by another operator who would be able to acquire this aircraft at a lower price than before the implementation of the international standards. While it is possible to monetise an approximation of AVL for the UK, the CAEP analysis highlights that CAEP has not confirmed whether costs of AVL should be included in estimation of total costs. Therefore, AVL is not included in the EANDCB calculation.

3.5.1.2. Increase in Carbon Costs from Additional Fuel Burn

79. As detailed in section 2.4.2.3. on fuel costs, the nature of technologies to address nvPM emissions means that some additional fuel will be required in order for aircraft owners and operators to complete the same journeys with the same cargo and passengers, i.e. the same mass of aircraft. Assuming that aircraft owners and operators will continue to make the same journeys as before the introduction of the new nvPM standards, there will be additional greenhouse gas emissions in the aviation sector from the burning of additional aircraft fuel required to cover the lower fuel efficiency.

80. Carbon emissions from aviation fuel burn on domestic flights and flights departing the UK to the European Economic Area (EEA) are captured under the UK's Emissions Trading Scheme, a cap and trading scheme which requires the aviation sector to acquire allowances in order to emit carbon. In addition to this UK participates in ICAO's global Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) which requires aircraft operators to purchase offsets on international flights.

81. Although there will be an increase in emissions for the aviation sector, for domestic flights and flights from the UK to the EEA these emissions will come under the UK ETS emissions cap and represent no additional carbon emissions for the UK as a whole. International flights outside the UK ETS scope, which includes flights from the UK to non-EEA countries, are covered by CORSIA and therefore emissions from these flights will be offset. It should be noted however that as CORSIA requires offsetting where emissions are above a 2019 baseline, offsetting obligations are expected to be zero or very low in the short-term until global aviation activity rises above the 2019 baseline.

82. While emissions are not expected to increase for the UK as a whole, due to the increase in emissions in the aviation sector aircraft operators may see an increase in their carbon costs where flights are covered by carbon pricing schemes. This is because they will need to purchase additional UK ETS allowances or CORSIA offsets to cover their emissions. This cost has not been monetised due to the uncertainty around the increase in carbon emissions and the proportion of flights covered by the UK ETS and CORSIA flown by UK airlines. We expect the impact of this to be low relative to the scale of monetised impacts for the UK aviation sector.

3.5.1.3. Trade off with NOx Emissions

83. Alongside the potential trade off with CO_2 emissions there is a risk that changes to engine design to reduce nvPM emissions could lead to increased emissions of nitrous oxides (NOx). As we do not have information available to assess the scale of these impacts this trade-off has not been

monetised in our analysis. This trade-off is discussed in more detail in the Risks and Unintended Consequences section.

3.5.1.4. Familiarisation Cost

84. As a new regulation is being introduced in the form of a new environmental standard there may be a familiarisation cost associated with the new regulation. However, we have not included familiarisation costs in our analysis. The reason for this is that familiarisation costs would fall on engine manufacturers who would be directly subject to this regulation and there are no engine manufacturers registered in the UK. A familiarisation cost would arise for engine manufacturers who would need to understand the new regulations and update guidance and training processes in order to bring this in line with the new requirements.

85. While there are engine manufacturers that contribute significantly to the UK economy and therefore considered in our analysis, we assume that any familiarisation costs would be included in the technology response costs and passed through to aircraft manufacturers and airlines.

3.5.2. Unmonetised Benefits

3.5.2.1. Reduction in nvPM Aircraft Engine Emissions

86. The objective of the new international standards is to reduce nvPM emissions from aircraft engines during landing and take-off and while in flight. nvPM emissions that occur during landing and take-off have a negative impact on local air quality in the vicinity of airports and aerospace. This can impact human health and the environment nearby to these sites. The reduction in nvPM emissions by mass from the CAEP analysis is estimated at approximately 12,300 tonnes globally. A reduction in nvPM emissions globally will benefit the UK from reduced damage to health and the environment.

87. Particulate matter (PM) emissions have been linked to health impacts such as chronic mortality, respiratory and cardiovascular illness, cancer, asthma, and strokes.[19] Negative environmental impacts such as blackening on the exterior of buildings can be caused by PM. Estimating the cost of damage associated with emissions may therefore include increased cleaning costs and reduced amenity of buildings as a result of this. As well as valuing damage caused to human health and the environment, estimated damage costs may account for the impact on productivity from absenteeism and workdays lost for employees, volunteers, and carers due to the health impacts of exposure to emissions.

88. In order to assess human health and environmental costs of air pollutants, ‘damage costs’ have been calculated by the Department of Environment, Food and Rural Affairs. Damage costs are a set of values for a tonne of emissions that capture the external costs associated with a change in pollutant emissions.[20] Damage costs are not available for nvPM emissions therefore we have not monetised the avoided cost of damage caused by nvPM.

[19] From Air Quality Damage Costs Updates, Defra, 2020
[20] From Air Quality Damage Costs Updates, Defra, 2020

89. While damage costs have been published for other types of particulate matter emissions such as PM2.5 aircraft emissions there is a strong evidence base linking exposure to PM2.5 emissions to severe health and environmental impacts. As an equivalent evidence base does not exist for nvPM emissions, approximating the avoided cost of a reduction in nvPM emissions using PM2.5 aircraft emissions (the most comparable pollutant for which damage costs have been produced) could be potentially unacceptably inaccurate. The high degree of uncertainty associated with estimating specific damage costs, coupled with the uncertainty around the approximation of the UK share of global nvPM emissions, make monetisation of this benefit unviable.

90. It should be noted that damage costs published by Defra are applicable to a UK context only. This is due to the fact that these damage costs are derived using UK specific values for value of a life year (VOLY) and quality adjusted life years (QALYs).[21] Applying these damage costs to global emissions estimate would therefore lead to inaccuracy in the global avoided costs of reduction in nvPM aircraft emissions.

3.5.2.2. Reduction in Risk of Climate Warming Effects

91. Particulate matter from aircraft engines also known as soot has been linked to contrail formation. Contrails are vapour trails produced by aircraft engines typically at high altitudes. Formation of contrails and clouds have been linked to warming effects in the atmosphere. While the science is still uncertain on the overall net impact of soot and other aerosols from aircraft engines, reduction in emissions of nvPM will help to reduce the risk of warming effects in the atmosphere. Uncertainties regarding the overall warming effect of non-CO_2 emissions are acknowledged in a number of published reports.[22] [23] The reduced risk to the climate is therefore included as an environmental benefit in this assessment but cannot be easily monetised.

3.5.2.3. Reduction in Capital Cost

92. Capital costs are defined in the CAEP analysis as costs resulting from depreciation of assets and finance costs. This reduction in costs occurs when an engine does not meet the new standard and rather than implementing new technology an engine family chooses to not respond to the new standard, a 'no response.' With this response the aircraft will go out of production as the engine will no longer meet the standards required to continue to trade and participate in the market. For some aircraft, the CAEP analysis suggests that aircraft operators may switch to cheaper alternative aircraft that meet the new standards or cheaper existing aircraft that were certified pre-standard. Another source of reduction in capital costs could be that as an asset is no longer in use by the company, this will likely be sold. Therefore, there will no longer be depreciation costs from holding an asset and a reduction in finance costs required.

3.6. Business Impact Target Calculations

93. As the new nvPM standards regulation is an international obligation it is a non-qualifying provision for the Business Impact Target. The equivalent annual direct impact on business has been

[21] Air quality appraisal: impact pathways approach,GOV.UK, 2020
[22] Updated analysis of the non-CO2 climate impacts of aviation and potential policy measures pursuant to EU Emissions Trading System Directive Article 30(4), European Commission, 2020
[23] The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018, Lee et al., 2020

calculated in 2019 prices with costs and benefits discounted to a 2023 base year. This is equal to £24.1 million in costs.

94. In scope of the EANDCB calculation are the non-recurring costs, fuel costs, and other costs, these are summarised in Table 2. Asset value loss is out of the scope of the EANDCB as this is a transfer. The increase in carbon costs and environmental benefits of reduction in nvPM emissions have not been monetised and therefore are not included in the EANDCB.

3.7. Net Present Social Value Calculations

95. The calculation of the NPV (Net Present Value) reflects the assumption that in order to continue trading in the international market UK engine manufacturers and aircraft operators will voluntarily comply with the new standards in the absence of domestic legislation. Therefore, under counterfactual A the net present social value of the policy is 0.

3.8. Indirect Costs and Benefits

96. We expect there to be possible indirect costs to businesses as a result of the implementation of the new engine emission standards. Technology response costs may be passed through from engine manufacturers to aircraft manufacturers and aircraft operators. This may also impact ticket price or higher costs for freight services. For the purpose of the calculation of the EANDCB for the BIT we account for costs only where these are incurred in line with RPC guidance. Therefore, these costs are accounted for with the engine manufacturer.

97. In addition to possible cost pass through impacts there may be competition impacts of higher production costs. These are likely to vary between actors affected as some engine manufacturers may already meet the new standards while others may require significant investment in order to meet the requirements. The cost of meeting the new standards may therefore have negative competition impacts for some businesses due to the additional costs of meeting the new standards. There may also be a positive impact of the UK implementing these standards domestically as this will provide harmonisation of standards internationally.

98. We do not have the detailed information available to undertake a full commercial assessment, therefore this has not been included in the main analysis. We think it unlikely that the additional costs imposed by the new international obligation will cause engine manufacturers and aircraft operators in the UK exiting the market, however this has not been tested.

99. It should be noted that the indirect costs and benefits discussed in this section will occur in the Do Nothing option where the UK does not implement the new standards into domestic law.

4. Risks and unintended consequences

100. As the new nvPM emissions standards have been negotiated and developed over a number of years by CAEP, the new standards regulation is not considered to be controversial or unexpected. No legal challenges are expected.

101. In addition to this, as the standards specify a regulatory limit for emissions and new and in-production, engines that do not meet the new standard will not be able to pass certification and therefore will not be available in the market. Therefore, the risk of this is low.

102. As the new standard applies to certification of new and in production engines enforcement should not present any additional difficulties for the regulator. This is due to the fact that aircraft engines are already required to be certified in order to enter service. In the event an engine manufacturer changed its state of design to the UK additional resources may be required to perform certification work however as this is an international certification standard the UK implementing this domestically is not expected to influence engine manufacturers' choice of state of design.

4.1. Trade Off with NOx Emissions

103. There is a known trade off when reducing nvPM emissions in engine design with emissions of NOx for the current engine technology available. This trade-off is acknowledged in the CAEP analysis. There are new technologies available for aircraft engines however these are limited by the fact these are not in widespread use by all manufacturers and are more difficult to scale down to smaller engines.

5. Wider impacts

5.1 Innovation Test

104. The impacts of the new nvPM standards on innovation are expected to be positive. ICAO environmental standards are designed not to favour a particular technology over another, encouraging innovation to improve performance against the regulatory limits. As this regulation is outcomes focused this should allow for innovation in technology or methods used.

105. The new nvPM standards are expected to encourage the development of low nvPM combustor technologies. Previously, engines were not designed with control of nvPM as an objective. Rather, low nvPM was a secondary effect of measures to control nitrogen oxides (NO_x), another air pollutant where past advancements in engine technology enabled reduction in emissions of both pollutants. Different NO_x reduction technologies can vary significantly in their nvPM performance, and so these new standards will encourage manufacturers to design engines with both pollutants in mind.

5.2 Small and Micro Business Assessment

106. As the new standards are underpinned by international obligations it is not possible for the UK to unilaterally exempt small and micro businesses from the new regulations.

107. The nvPM standards apply to engines rated 26.7kN thrust or higher, therefore smaller aircraft with engines below this size are exempt from the new regulations. It is likely that aircraft above this size would require significant numbers of employees and resources in order to operate.

108. There are no micro businesses operating in the aviation sector that will be impacted by the new nvPM standards. We expect there to be very few if any small businesses that will be impacted by the new nvPM standards. Information from the CAA's air operator certificate register suggests there may be around 4 businesses holding air operator's certificates that would fall into the small business categories in the business and general aviation[24] sector that operate aircraft in scope of

[24] General aviation activities are defined by ICAO as non-commercial business flights, aerial work, instructional and pleasure flying and other flying. From ICAO Glossary

the new standard with engines rated higher than 26.7kN thrust. This information is commercially sensitive and therefore is not publicly available. There are no small or micro businesses in the commercial aviation sector.[25]

109. It is therefore very unlikely that small and micro businesses will be disproportionately impacted by the UK implementation of the new nvPM emissions standards.

5.2. Equalities Impact Assessment

110. This measure is not expected to impact equalities.

5.3. Justice Impact Test

111. This measure is not expected to have an impact on the justice system, this is because no new offences are being created. If an aircraft engine does not meet the new standards, it will not be certified.

5.4. Trade Impact

112. This measure is expected to have a positive impact on trade as it implements international obligations and harmonisation of aircraft engine standards globally. This is a key objective of international standard setting such as this. Implementing these standards will improve confidence in UK produced aircraft engines for customers on the global market so will help to enable exporting of UK produced goods.

5.5. Family Test

113. This measure is not expected to impact family life.

5.6. Health Impact Assessment

114. This measure is expected to have a positive impact on health. This is due to the reduction in nvPM emissions which has a positive local air quality impact. In particular this is expected to benefit those living or working in the vicinity of airports and airfields.

115. This impact has not been monetised but is described qualitatively in the benefits section of the impact assessment.

5.7. Human Rights Impact

116. This measure is not expected to impact human rights.

5.8. Rural Proofing

117. This measure is not expected to impact those in a rural setting unfairly.

[25] Commercial aviation is defined by ICAO as commercial operators or use of aircraft for the general public for the transportation of passengers, mail and/or freight for remuneration. From ICAO Glossary

5.9. Sustainable Development

118. These standards have been set by CAEP with the objective to have a positive impact on sustainable development, in particular the development of a sustainable global aviation system.

5.10. Competition Assessment

119. We do not believe the impact on competition will be significant, this is due to the fact that the new nvPM emissions standards will be applied globally. There may be positive competitive impacts from the harmonisation of global standards. The UK implementing these standards will also help to reduce the risk that engines that do not meet the new standard are rejected on the market and cause additional costs to UK business.

5.11. Greenhouse Gases Impact Test/Wider Environmental

120. The environmental impact, including impact on greenhouse gas emissions is included in the central cost benefits analysis therefore it is not repeated here.

6. Post implementation review

1. **Review status:** Please classify with an 'x' and provide any explanations below.

	Sunset clause		Other review clause		Political commitment		Other reason	X	No plan to review

2. **Expected review date** (month and year):

		/			Five years from when the Regulations come into force

3. **Rationale for PIR approach:**

Rationale for not conducting a PIR:

As an internationally agreed standard, the UK is not able to unilaterally review this regulation. However, it may request such a review by ICAO CAEP, where evidence and resources are brought to support the exercise.

As engine manufacturers are still working to understanding nvPM formation and are in the early stages of responding to the CAEP/11 nvPM standards, there is no expectation that the standard would be updated before 2028.

If a review is conducted by ICAO, it would be expected to take at least three years. The UK would bring any relevant technical expertise and data it had at its disposal to support the review.

A future review by ICAO could be expected to consider, inter alia:

- progress of technology, including manufacturers' responses to the existing standards.
- environmental need, e.g. new scientific evidence about the impacts of nvPM; and
- certification data, including any emerging margin to the existing standards. Number of engines certified to the new standards could be used to establish a baseline for any review of the standards.

Metrics for success considered by ICAO could include the below:

- number of aircraft engines certified to the new standard
- performance of certified aircraft engines relative to the standard (known as 'margin')
- global nvPM emissions data
- global data on other pollutants such as NOx and CO_2

It should be noted that ICAO's approach to a review could differ from the above as a proposed approach has not been set out yet. As there is no intention to complete a PIR, risks, and uncertainties the approach to the PIR does not relate to risks and uncertainties in the analysis.

Circle the level of evidence and resourcing that will be adopted for this PIR (see Guidance for Conducting PIRs):

Key Objectives, Research Questions and Evidence collection plans			
Key objectives of the regulation(s)	**Key research questions to measure success of objective**	**Existing evidence/data**	**Any plans to collect primary data to answer questions?**
	To be determined by ICAO (see explanation in box 3 above)		