# Written evidence from Tyndall Manchester

The Tyndall Centre for Climate Change Research is an internationally recognised climate-change research group, bringing together natural scientists, economists, engineers and social scientists to develop sustainable responses to climate change. Founded in 2000 as the first interdisciplinary research centre on climate change, Tyndall now includes researchers based in four UK universities, headquartered at the University of East Anglia.

This submission is by researchers at the University of Manchester (Tyndall Manchester). All the views expressed in this submission of evidence are attributed to the named authors and do not necessarily reflect those of researchers within the wider Tyndall Centre or the University of Manchester.

This submission is underpinned by over ten years of research activity on decarbonising shipping and aviation – including the ongoing UKERC low carbon aviation and shipping research project and the Supergen Bioenergy Hub.

Yours Faithfully,

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# Evidence submission:

# UK Parliament Environmental Audit Committee Inquiry on Net Zero Aviation and Shipping


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## Summary:

Climate change is a problem of cumulative emissions of greenhouse gases over time and reducing annual emissions is needed immediately for a pathway towards the Paris Agreement goal to pursue efforts to limit global warming to 1.5˚C [1]. The remaining global carbon budget (a measure of the total quantity of carbon dioxide we can release for an expected change in global temperature) for 1.5˚C is highly constrained, equivalent to around 11 years of emissions at current rates [1].

Our research on international shipping's implied share of this remaining budget and committed emissions from the sector shows that an urgent step change in action, including changes to operational practices and demand, as well as innovative technologies is needed. Implementing change across a highly globalised sector is challenging but the UK is particularly well placed to lead this transformation.

Likewise, our extensive analysis of the role of aviation in national and international carbon budgets evidences an urgent need to moderate and reduce emissions from this sector. Emerging Tyndall Manchester research on aviation biofuels and how operational practices can decarbonise air travel strongly point to a need for demand-side interventions in emissions management to keep aviation emissions within the bounds of carbon budgets for 1.5˚C.

**Key Points:**

- Both aviation and shipping need absolute emissions trajectory goals aligned with Paris Agreement goals. The IMO strategy refresh for 2023 is an opportunity for the UK to lobby for Paris aligned targets in shipping.
- Operational changes through slow-steaming, energy efficiency, shore-power and wind-propulsion with route optimisation can enable shipping to keep within Paris Agreement aligned carbon budgets if implemented urgently
- A detailed plan for demand management in aviation is needed for meeting the Paris Agreement 1.5˚C goal.
- Careful consideration of life cycle emissions, resource availability and prioritised use is needed as biofuels use in aviation and shipping increases.
- Port decarbonisation is an important component of local air quality and climate change goals. Support for shore-power is needed immediately.
- The UK should adopt recommendations of the IMO 4$^{th}$ Greenhouse Gas Report on voyage-based emissions allocation in defining its ownership of international shipping emissions.
- Important questions remain on the efficacy of carbon offsetting for meeting climate change goals. Where it is used, much will depend on the price setting process and implementation.

## 1. What contribution can operational efficiencies make to reduce emissions from aircraft / shipping vessels and over what timescale could these have an effect on emissions?

Shipping:

- In the long term the replacement of fossil fuels with new vessels propelled by low/zero emissions fuels is essential for shipping to play its part in achieving global climate change goals, but this on its own is insufficient if near term action is not also taken to reduce emissions from the existing fleet. The committed emissions of the existing fleet at expected turn-over with no policy interventions will exceed credible remaining carbon budgets for the sector [2].

- While low carbon fuels are currently either not technologically advanced enough or not affordable or deployed at scale [3] strong and rapid policy implementation can enable carbon savings from operational changes to shipping in the 2020's [2]. This would make a crucial contribution to bringing emissions from international shipping in line with the Paris Agreement.

- Operational changes through slow-steaming, energy efficiency, shore-power and wind-propulsion with route optimisation can enable shipping to keep within Paris Agreement aligned carbon budgets for international shipping [2].

- Wind propulsion, whilst not an 'operational efficiency' is an example of short-term retrofitting of ships that could provide very significant reductions in emissions in the short-term if combined with voyage optimisation and slow-steaming (both operational efficiencies). A recent Tyndall Manchester PhD study shows savings in emissions of as high as 40% for bulk carriers by ships being redirected towards beneficial winds, if there is some flexibility in arrival times [4]. This requires some slow-steaming, which has a cubed relationship between fuel consumed and speed, to provide the greatest benefits.

- Isolating operational efficiency from technical change and demand is unhelpful, as they are connected and have feedbacks.

Aviation:

- Aircraft differ in terms of their size (and hence weight) and typical journey length in a way that has important implications for the roll-out of alternative fuels. The larger the aircraft, the longer it will take for alternative fuels systems that can deliver near-zero carbon propulsion to be market ready at scale (see Q2). Near zero-carbon aircraft that can undertake transatlantic flights will unlikely be widely available until the 2040s. The timeframe will be a little shorter for typical aircraft types flying medium to short-haul distances (e.g. 1000km, 100 passengers). Technology development for electric aircraft is focused on small aircraft types that would not be used for medium or long-haul flight.

- Aircraft produce emissions other than $CO_2$ that contribute to rising global temperatures through their release of $NO_x$, soot and water vapour within the troposphere. Any alternative fuels will need to be assessed in relation to these other warming emissions in addition to the impact of reducing the release of $CO_2$.

- The long deployment time for alternative fuel systems for low to zero emission aircraft means the only way to significantly cut greenhouse gas emissions in the near term is either through technical and operational efficiency improvements and/or demand-management. As such if passenger-km travelled grows by 3% per year then technical and operational efficiency improvements of 3% per year are needed to maintain emissions at 2019 levels.

- Operational efficiencies in aviation (reducing congestion; better alignment air traffic control – e.g. one European Sky over Europe), could improve efficiency, but the savings will be 'one-off' and can in turn rebound to provide greater scope for increasing demand if runway use can be made to be more efficient as a result.

- In short, for aviation, technical and operational efficiencies would likely need to outstrip growth in activity by a very significant margin to align with Paris efforts to pursue 1.5˚C.

- Instead, a detailed plan for demand management is needed, including policies to ensure alternative modes of transport are used where available, a moratorium on airport expansion, measures to tackle frequent flying, and policies to drive virtual communications as a substitute to physical travel where appropriate.

- Demand management measures can, and must, be applied as a matter of urgency while the much needed technical and operational innovation is accelerated.

## 2. How close are zero carbon fuels to commercialisation for aviation / shipping? How effective will the Jet Zero Council be in catalysing zero emissions technologies? What role should transitional fuels such as alternative hydrocarbon fuels play?

Aviation:

- Sustainable aviation fuels (SAF) – i.e. biofuels will have a carbon footprint linked to lifecycle activities and processes of feedstock production and their synthesis into fuels [5], and when combusted at altitude, will continue to release emissions into sensitive parts of the Earth's atmosphere. In some cases, emissions in the production supply-chain will take place outside of the UK's territorial emissions boundary and the scope 1 emissions of the aviation sector, but they remain important. This should be considered when phrasing fuels as 'zero carbon' to ensure they aren't treated as 'zero impact'.

- Much of the technology and expertise to produce SAFs from biofuels that meet the many aviation fuel standards exists now [6], but the timeline to commercialisation will depend on reducing the cost of production, increasing efficiencies, as well as connecting components into a system that can operate effectively to deliver SAFs at scale. There is also need to develop sustainable biomass supply chains that can balance the potential demands for SAF production [7].

- The energy balance from the biomass resource used through to the fuel product is currently very poor. This refers to the energy input to grow, harvest, transport and process biomass into a biofuel for the energy value of the fuel produced. This has implications for cost of fuel, but also the climate and wider environmental impact (e.g. water use and biodiversity change) of fuel supply chains. More research is needed to optimise each stage of the biofuel process to ensure its commercial potential and to minimise environmental impacts. Too great a focus on decarbonisation, energy security and affordability in sourcing aviation biofuels can overlook implications for other national and international commitments such as on biodiversity [8].

Shipping:

- We recommend avoiding Liquefied Natural Gas (LNG) as a transitional fuel for shipping. Although it is sometimes cited as an appropriate option, this route will lock in further fossil fuel infrastructure at a time when the ambition for shipping decarbonisation needs to be significantly strengthened. Our research shows that to align with the 1.5˚C target international shipping needs to be reduced by 100% in the 2040s, rather than the current 50% by 2050 goal [2]. Given the asset lifetimes of ships can be around 25 years, there is insufficient time for this fuel infrastructure to be developed and then retired as a stranded asset.

- LNG is lower-carbon than heavy fuel oil, but it is not a low carbon fuel, and in addition releases methane, another greenhouse gas. Using LNG does not tackle other pollutants that need to be reduced at the same time - such as sulphur. As summarised in [10] switching to LNG could reduce $CO_2$ emissions from shipping by 7–15% , however with a growth in trade of ~4% per year our research finds that any relative emission savings would be undermined within about four to five years.

- Biofuel is another alternative fuel for shipping. As a result of the less onerous fuel characteristic requirements for shipping compared to aviation, producing shipping fuels from biomass is easier [11] and the issue of release in sensitive parts of the Earth's atmosphere is not the same as in aviation.

- Biomass is an abundant resource and may provide many opportunities for both the shipping and aviation sectors. There are also many studies that highlight that there are many underutilised biomass resources in the UK, particularly wastes, agri-residues, and opportunities to increased energy crop production [12]. However as many sectors are targeting the future use of biomass resource to provide heat, power, transport fuels and chemicals, decisions are required as to where the resource should be prioritised [8]. The types of biomass resource ideally used to produce both aviation and shipping fuels are not necessarily the same, meaning the biomass demands of these sectors may not be in competition for the same resource.

## 3. How should the Government's net zero aviation strategy support UK industry in the development and uptake of technologies, fuels and infrastructure to deliver net zero shipping and aviation?

- Need to also invest in biomass production/ mobilisation and supply chains, to ensure sufficient sustainable feedstock is available [7].

- Alternative fuels and electrification suffer from a competitive disadvantage because marine fuel oils are exempt globally from taxation and they do not pay for the external costs of the environmental damage they cause [13]. This market failure in not incorporating negative externalities and a disparity in taxation mean alternative fuels do not have a level playing field. This situation is likely to take many years to resolve via the International Maritime Organisation, so action at national level is warranted. The UK intends to incentivise maritime alternative fuels such as ammonia and hydrogen via the Renewable Transport Fuel Obligation (RTFO), however electricity has been placed out-of-scope.

- Shore-power is an infrastructure measure the UK could adopt to cut shipping greenhouse gas emissions and improving local air quality around UK ports. The Transport Decarbonisation Plan (TDP) announced there would be a consultation in Winter 2021 on the steps needed to support shore-power uptake. Recent analysis by Tyndall Manchester in [13] sets out the main barriers to shore power in the UK, and suggests a package of policies for how these could be overcome:
  - The use of electricity for powering ships in port as an alternative to marine fuel oil is at a disadvantage in the UK not only because untaxed marine fuel oil but also because of high industrial electricity prices. This makes the commercial case for shore-power in the UK worse than in countries such as Germany, France, Denmark and Sweden, which have exempted shore-power from electricity taxes. The UK can support the decarbonisation of shipping through exempting shore-power from electricity taxes.
  - All shore-power facilities worldwide have had government capital funding support, with extensive programmes of support in Germany, Norway and China. The UK has offered far lower support comparatively, although some funding has gone to ports via the recent Clean Maritime Demonstration Competition (CMDC).

- We recommend support for shore-power through; a) a funding pot is allocated for electricity charging infrastructure in ports (such as how the Government has done for local authorities and businesses in regard to road-transport electricity charging infrastructure); b) enacting regulation, such as a Zero-Emission berth standard for ships, to drive medium-term demand for shore-power; c) provision of an information service for port and ship operators, which could be hosted within the UK-SHORE unit flagged in the TDP.

- Wind assisted shipping shows great promise as a fuel saving and greenhouse gas reducing measure that can retrofit to existing vessels as well as tackle other pollutants at the same time (e.g. sulphur) [4]. Investment in ‘test’ technologies for wind-propulsion is needed however. Different ships require different decarbonisation technology. The shipping sector is risk adverse. There is a need for real-world wind-propulsion demonstration ships to gather data and provide a wider variety of ‘proof of concept’ designs.

## 4. How effective will the global offsetting scheme for international airlines (ICAO's CORSIA) and the UK and EU ETS be at stimulating technology improvement and/ or behaviour change to reduce emissions from aviation / shipping?

- As discussed in [14] offsetting schemes through emissions trading may have been effective at addressing emissions if implemented in 1990s. It is however questionable whether such an approach is capable of delivering the rapid and urgent reductions in greenhouse gas emissions now required to meet the Paris Agreement 1.5˚C target.

- There are long standing concerns about the effectiveness of offsetting and emissions trading schemes. The effectiveness of schemes such as the EU's Emissions Trading Scheme (EU ETS) to drive the rate of emissions change commensurate with targets such as the Paris Agreement have been debated [15], [16]. Whether carbon credits exchanged through the Clean Development Mechanism (CDM) are in fact equivalent to the emissions released have been queried [14]. The potential for offset credit mechanisms to enable high emissions technologies to remain relatively cheap and produce a rebound effect increasing global emissions have also been discussed [17]. Concerns about the equivalence of offset credits to emissions reduction measures and the possibility of a 'rebound effect' need to be taken seriously to ensure emissions do not increase as a result of the mechanism. A more detailed discussion of this can be found in [14].

- The effectiveness of CORSIA will depend on the 'getting the price right' i.e. the cost of carbon offsets. CORISA has approved projects from various geographies and the cost of the offset credits can vary depending on where they are based (e.g. O&M costs of a forestry project in North America is much higher than China). ICAO has an opportunity here to ensure that the offsetting cost for airline operators are at levels required to align with Paris Agreement goals. Overtime, the price of offsetting should converge with the cost of investment in low-carbon technologies, creating impetus for compliance entities to make a full transition needed to meet net zero emissions by 2050. This raises important questions for policy:
    - Will CORSIA eligible emission units have a standardised price?
    - What factors are being considered in determining the price of carbon offset credits?
    - Are there any planned cost-containment measures that will be put in place?

## 5. What further action is needed by the International Civil Aviation Organization and International Maritime Organization to drive emissions reductions? What can the UK Government do to drive international action on emissions?

- Both shipping and aviation should have international emissions targets for absolute emissions reduction trajectories that are aligned with the 1.5 degree goal of the Paris Agreement. An obligation similar to Nationally Determined Contributions (NDCs) for ICAO and IMO could be a framework through which solutions to emissions from these sources are driven.

- Analysis in [9] indicates that international shipping needs significantly stronger short and longer-term targets to be compatible with the Paris Agreement than those currently in place through the IMO. Deep emissions reductions in the 2020s are critical, as well as zero-emission dates around mid-century. There will be an opportunity to strengthen targets for international during the IMO 2023 strategy revision process and the UK Government should use this opportunity to push for targets in line with the Paris 1.5 degree goal.

- Greater impact over international aviation and shipping emissions may be achieved through the UK partnering with the EU to push for Europe-wide standards/targets for both aviation and shipping.

## 6. What is the most equitable way to reduce aircraft passenger numbers (e.g. reforming air passenger duty and taxes, frequent flyer levies, bans on domestic flights where trains are available, restrictions on airport capacity)? Are there any policy mechanisms that could reduce our reliance on shipping?

Aviation:

- The Committee on Climate Change's Balanced Pathway for sectors to meet the UK's Net Zero 2050 targets and proposed carbon budgets indicates a need to cap UK aviation emissions at around 2019 levels in absolute terms (i.e. not via offset credits) and reduce them by around 20% by 2030 [18]. This view of aviation emissions is also found in more stringent Paris Agreement aligned UK carbon budgets [19]. For targets over coming years and by 2030 to be met, our analysis indicates demand management will be necessary [14].

- Air travel and aviation emissions are largely skewed to a relatively small proportion of the population [20]. Frequent fliers in higher socio-economic groups may also be less sensitive to marginal cost increases. Blanket changes to duties and taxes may not achieve substantial change in emissions.

- Expanding net airport capacity in the UK is not consistent with the UK's existing climate change commitments or a UK carbon budget meeting the terms of the Paris Agreement . A growth in aviation emissions associated with greater airport passenger capacity would use up a significant proportion of the UK's remaining Paris aligned carbon budget [19].

Shipping:

- It's welcome that the TDP includes a commitment to "plotting a course to net zero for the UK domestic maritime sector", but given that international maritime emissions are now formally included in the UK's carbon budgets, this commitment should extend to all maritime emissions. The Clean Maritime Plan refresh in 2022 should include a pathway to net zero for all maritime emissions, with enabling policies to support this transition for ports and shipping operators. On this pathway, action to make substantial emissions reductions in this decade is a priority if the UK maritime sector is to play its part it in meeting the Paris 1.5 degree goal [2].

- If voyage distances increase on average due to changes to trade routes in response to the UK leaving the EU, then shipping related $CO_2$ emissions will also increase unless there are additional $CO_2$ mitigation measures implemented in tandem [21].

- Tyndall Manchester research has shown that a successful global transition way from fossil fuels has important implications for shipping demand and shipping emissions [21]. A large proportion of shipping is associated with the transportation of fossil fuel and moving away from fossil fuels, will reduce bulk transport needs. While there may be some substitution of transport of biomass, this is unlikely to be the same extent and therefore a potential reduction in energy product shipping if the Paris Agreement is met should be planned for [22].

- Wind assisted ships and voyage optimisation can reduce the energy demand of shipping without reducing tonnage of shipped goods [4].

## 7. How should the UK define its ownership of international aviation and shipping emissions (i.e. arrivals, departures or both) in order to include them in legislative targets?

Shipping:

- Previously, our research illustrated how bunker fuel sales were a particularly unhelpful way to allocate the UK's share of international shipping to the UK [23]. In that study, the UK's share of international shipping emissions were estimated to be 7 $MtCO_2$ per year under a bunker fuel reporting regime, but around 42 $MtCO_2$ when apportionment was based on a freight imported basis - partly due to the ease of bunkering at Rotterdam, which significantly skews the allocation [23]. The UK's Climate Change Committee say the new 4$^{th}$ GHG approach were adopted, this would approximately double the UK's international shipping emissions as currently estimated [24]. The likelihood of changes to emissions accounting means that UK strategy development on shipping decarbonisation should place a greater focus on international shipping emissions, compared with the current majority focus on domestic shipping emissions.

- There will likely be a move to the "voyage-based" approach internationally in coming years, the UK could adopt this early to better understand the scale of the challenge on shipping emissions under this regime.

Aviation

- The existing UNFCCC carbon accounting framework is complicated and imperfect in defining ownership of emissions, but for aviation emissions it may be a more suitable regime than is the case for shipping. Unlike with shipping, where vessels will deviate route more routinely to reduce refuelling costs, aircraft refuelling more closely reflects passenger/freight flows for the sector. As the disparity between ownership of emissions under different regimes is less significant the current UNFCCC framework is apt for defining ownership of emissions. There is also growing focus on assessing the performance and improving how the UNFCCC framework accounts emissions from the bioenergy sector where feedstocks are produced in different countries from which they are converted to energy [25].

## 8. Greater Action is needed on Port Decarbonisation and Air Quality

- Ship operations in ports are a significant contributor to local air pollution, as well as creating greenhouse gas emissions. Vessels run their engines in port to power on-board facilities and this combustion of marine fuel oil can be problematic from a public health as well as a climate change perspective.

- The Clean Air Strategy should be updated and integrated with the Clean Maritime Plan by requiring ports to set out a strategy for port decarbonisation and air quality improvement.

- Action on port decarbonisation and air quality should be guided by three principles: wide scope (include scope 3 emissions from ships); prioritising action on biggest sources of $CO_2$/air pollutions; prioritise action delivering in the short-term.

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