

Institution: The University of Manchester		
Unit of Assessment: 12 (Engineering)		
Title of case study: Reducing climate change caused by shipping and aviation		
Period when the underpinning research was undertaken: 2003–2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Alice Larkin (prev. Bows)	PDRA (2003–8), Lecturer (2008–2011), Senior Lecturer (2011–2013), Reader (2013–2016), Professor (2016–present)	2003–present
Kevin Anderson	Senior Research Fellow (2003–11), Professor (2011–present)	2003–present
Sarah Mander	PDRA (2003–8), Research Fellow (2008–10), Senior Research Fellow (2015–present)	2003–present
Ruth Wood	PDRA (2008–10), Lecturer (2011–2016), Senior Lecturer (2016–present)	2008–present
John Broderick	Knowledge Exchange Fellow (2011–2015), Lecturer (2017–2020)	2011–2015, 2017–2020
Conor Walsh	PDRA	2012–2017
Paul Gilbert	PDRA (2010–12), Lecturer (2013–2015), Senior Lecturer (2015–18)	2010–2018
Michael Traut	PDRA	2014–2017
Period when the claimed impact occurred: 2014–2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact		
<p>Research from the University of Manchester (UoM)'s Tyndall Centre for Climate Change Research (Tyndall-Manchester) identified the failure of greenhouse gas emissions mitigation policies in the shipping and aviation sectors to align with the Paris Agreement climate targets. The research characterised the impact of this failure, and published decarbonisation pathways that have engaged international, national and local policy and industry stakeholders and influenced debate at multiple scales.</p> <p>Global CO₂ targets have now been set by the International Maritime Organisation (IMO), through the adoption of resolution MEPC.304(72) as a direct result of Tyndall-Manchester research. In the aviation sector, Tyndall-Manchester research quantified the extent of technical improvement possible, noting the contradiction between expected aviation emissions growth with the Paris Agreement targets. The Heathrow third runway expansion policy passed by the UK Government was rejected at judicial review because of this inconsistency. The Manchester Climate Change Framework has adopted aviation climate policies because of Tyndall-Manchester input. This has reduced investment and policy risk for business and local government by recognising this source of emissions in subsequent spatial and economic planning, avoiding the need for late, costly, reactive responses.</p>		
2. Underpinning research		
<p>The research on the shipping and aviation sectors generated three key findings that underpin the impact.</p> <p>Paper [1] identified that omitting international aviation and shipping from the UN's climate change target framework is a major risk to the 2 °C goal because of the significant climate impact of these emissions. Paper [2] provided specific insights into the structure and capabilities of the shipping sector, and showed that there are many technical options for decarbonising shipping. For instance, hull and propeller redesign, in combination with speed changes, fuel switching to bioenergy or hydrogen, and wind assistance. It also showed that setting an ambitious target for the shipping industry is not as high risk as it is for aviation. Paper [3] then quantified the implications of the Paris Agreement mitigation targets for international shipping by relating the IPCC AR5 Synthesis report cumulative emissions budget findings with fleet efficiency trajectories from the reference</p>		

scenarios of the Third IMO GHG [Greenhouse Gas] Study (2014), demonstrating the necessity of urgent CO₂ targets.

Finding 1: *The shipping sector has a similar greenhouse gas emissions reduction challenge as aviation, but with greater potential for technical solutions. It is feasible and necessary to set ambitious CO₂ targets as a matter of urgency.*

A sequence of EPSRC funded interdisciplinary projects, conducted by the Tyndall-Manchester team, explored the challenge of decarbonising international transport. They calculated the expected future emission from the aviation sector following workshops and interviews with industry to assess technical mitigation potential [4]. The finding of expected rates of emissions increase indicated that demand management and emissions trading deserved greater research and policy attention. The research considered voluntary carbon trading and concluded that this was unlikely to address the matter either. The “tonnes of carbon” included in these trading systems were found not to be physical tonnes of material, and so carbon trading for emissions growth would likely increase the extent of climate change. The research quantified the risk to UK climate change targets if airport expansion continues and demonstrated that as for shipping, leaving aviation outside of the UN’s climate change target framework is a major risk to the 2 °C goal [1, 4].

Finding 2: *The aviation sector currently produces 10% of UK CO₂ emissions, and this is likely to increase to levels incompatible with UK and global CO₂ mitigation targets. Technical mitigation potential to cut CO₂ is less than the necessary rate of reduction.*

Research funded by the North West Regional Development Agency explored the UK regional distribution of aviation emissions, developing the first methodology for sub-national apportionment for international aviation emissions [5]. Further funded work identified the implications of current UK government aviation emissions projections for national carbon budgets and the constraints they place on other sectors [6]. Unachievable emission reduction rates, greater than 20% *per annum*, were found to be required from the rest of the economy if aviation grows at the rate forecast by the UK’s Department for Transport (DfT) and if national climate policy is aligned with the UN Paris Agreement.

Finding 3: *If the aviation sector takes a disproportionate share of future emissions, then the pressure on other sectors may inhibit regional development or jeopardise the overall climate objective.*

3. References to the research

The underpinning research papers have all been published in first or second quartile journals (SCR). Researchers from UoM are highlighted in bold text.

- [1] **Bows-Larkin, A.**, (2014), All adrift: aviation, shipping and climate change policy, *Climate Policy*, 1-22. DOI: [10.1080/14693062.2014.965125](https://doi.org/10.1080/14693062.2014.965125)
- [2] **Bows-Larkin, A., Anderson, K., Mander, S., Traut, M., & Walsh, C.** (2015), Shipping charts a high carbon course, *Nature Climate Change*, 5, 293-295. DOI: [10.1038/nclimate2532](https://doi.org/10.1038/nclimate2532)
- [3] **Traut, M., Larkin, A., Anderson, K., McGlade, C., Sharmina, M., & Smith, T.** (2018), CO₂ abatement goals for international shipping, *Climate Policy*, 18(8), 1066-1075. DOI: [10.1080/14693062.2018.1461059](https://doi.org/10.1080/14693062.2018.1461059)
- [4] **Bows, A., & Anderson K.**, (2007), Policy clash: Can projected aviation growth be reconciled with the UK Government’s 60% carbon reduction target? *Transport Policy*, 14 (2), 103-110. DOI: [10.1016/j.tranpol.2006.10.002](https://doi.org/10.1016/j.tranpol.2006.10.002)
- [5] **Wood, F. R.** (2011), Who’s flying? The spatial distribution of aviation emissions in Great Britain, *Carbon Management*, 2(1), 85-98. DOI: [10.4155/cmt.10.42](https://doi.org/10.4155/cmt.10.42)
- [6] **Anderson, K., Broderick, J. F., & Stoddard, I.** (2020), A factor of two: how the mitigation plans of ‘climate progressive’ nations fall far short of Paris-compliant pathways, *Climate Policy*, 1-15. DOI: [10.1080/14693062.2020.1728209](https://doi.org/10.1080/14693062.2020.1728209)

Grants contributing to the above research are:

Tyndall Centre for Climate Change Research Phases 1 and 2, EP/D508037/1, EPSRC, NERC and ESRC (total GBP17,000,000), 2000–2010.

The High Seas project, EP/H02011X/1, awarded to Larkin *et al*, 2010–2013, GBP515,543

Shipping in Changing Climates, EP/K039253/1, awarded to Smith *et al* with Larkin as Manchester PI, 2013–2017, GBP3,512,257

NW Aviation study, Joule Centre and North West Development Agency, awarded to Anderson and Larkin, 2007–2009, GBP257,916.

4. Details of the impact**Context**

Greenhouse gas emissions from international aviation and shipping are largely unregulated. Tyndall-Manchester research in the period 2003–2007 overturned the prevailing orthodoxy in national climate change mitigation policy that regarded international shipping and aviation as unproblematic, minor sources of greenhouse gas emissions. Policy developments followed. The global nature of climate change necessitates a comprehensive emission mitigation framework, since partial coverage will be both physically ineffective and economically inefficient increasing the cost to society. If shipping and aviation are excluded from mitigation efforts then other emitting sectors will be required to go further by, for instance, reducing their economic activity or investing in more costly abatement technology, or suffer damages due to greater climate change impacts.

Pathways to Impact – Shipping

In 2009, the need for significant and meaningful CO₂ mitigation targets in the shipping sector was raised with the UK's Environmental Audit Committee through oral evidence given by Larkin (then Bows). Published research papers [1, 2, 3] and stakeholder engagement at industry and policy events further highlighted the scale of the challenge. This culminated in a submission and oral presentation on carbon budgets made by Larkin and Smith (UCL) to the International Maritime Organisation at their Marine Environmental Protection Committee meeting MEPC68 in summer 2015. Smith spoke predominantly about techno-economic potential in the sector, Larkin focussing on emissions consequences.

Tyndall-Manchester's research has led the debates that informed European policy decisions and contributed to global scale impact. The European Commission Committee on Environment, Public Health and Food Safety (ENVI) in 2016 proposed a new chapter to Directive 2003/87/EC that would include shipping within its Emissions Trading Scheme if not otherwise regulated. This put pressure on the IMO [A]. This decision was informed by European Commission Policy Department A for the ENVI Committee report [A] citing paper [1] for evidence around targets for aviation and shipping. The international NGO [Global Commission on the Economy and Climate](#), led by the former President of Mexico Felipe Calderon, produced a report [B] which cites Tyndall-Manchester's paper's '50% cut in CO₂ by 2050', and their *Nature Climate Change* commentary [2], with a recommendation that "the IMO adopts a global emission reduction target for international shipping...in keeping with 2 °C".

Larkin spoke prominently on shipping at both the 2015 and 2017 UN international climate negotiations (COP21 and COP23), including at an official EU side event alongside Tony De Brum from the Marshall Islands – the leader of the High Ambition Coalition [C]. At COP21, sector-specific NGOs cited Tyndall-Manchester's research in applying pressure to civil servants and political representatives [D] and by 2017, there was pressure also from *within* the industry fearing that if IMO did not set a target, the EU would do so instead. The link between UoM's research and these ongoing policy changes is evidenced by citations of research finding 2 (above) in EU [A], Pacific Nations' policy development background documents [E], and IMO internal newsletters [F] at relevant points in time.

Impact – Shipping

The UN body responsible for regulating shipping, the International Maritime Organisation (IMO), adopted ambitious climate change targets at the MEPC72 meeting in April 2018 with preceding discourse influenced directly by Tyndall-Manchester research [D, G]. The IMO estimate the resulting emissions reduction to be between 800 and 2,400 million tonnes of CO₂ in 2050, which

is greater than preventing all emissions from fossil fuels currently burnt in Germany. The international NGO Transport & Environment's Campaign Director summarises UoM's research and evidence contributions, saying, "...this work was instrumental in the IMO adopting global emissions reduction targets for international shipping" [D].

Action to reduce emissions from shipping is necessary for comprehensive climate change mitigation. If this sector is excluded from obligations applicable to other sectors, then it is much less likely that global warming will be limited to 1.5 °C; the IPCC identify that up to several hundred million people would be exposed to additional climate related risks and poverty by 2050 compared to 2 °C (IPCC 2018 SPM B5.1). The UK Chamber of Shipping's Director of Policy emphasised the importance of the IMO's adoption of these targets, saying, "This is not only vital work for our industry but also critical in helping to ensure shipping meets its climate change obligations which will be key to the wider global strategy" [G]. The reach of Tyndall-Manchester's impact on the shipping sector is global due to the adoption of an international 2050 emissions reduction target by the IMO [G].

Pathways to Impact – Aviation

Based on research findings 2 and 3 (above), Broderick and Larkin submitted evidence to the DfT development of the 2019 Aviation White Paper and an expert statement to the judicial review of the approval for the development of plans for a new runway at Heathrow Airport (Airports National Policy Statement (ANPS) 2018) [H].

Broderick and colleagues also held a series of workshops (November 2017 to March 2018) with the Assistant Director (Environment) of Greater Manchester Combined Authority (GMCA), representatives of Manchester Airport Group and other stakeholders. The conclusions from these workshops were widely circulated in a report advising GMCA to account for the impact of international transport within their own climate change mitigation framework. Prior to this work, aviation had been considered outside of the city scale, however Tyndall-Manchester's research showed that DfT national aviation forecasts resulted in too high a mitigation burden for the GM city-region. The researchers proposed a new emissions pathway for aviation that was presented to the GMCA Low Carbon Hub board, and as a keynote presentation at Greater Manchester Mayor Andy Burnham's Green Summit in March 2018. This was followed up with further research and workshops in late 2019 and early 2020 culminating in a report and presentations to Manchester Climate Change Partnership.

Impact – Aviation

The reach of the impact on UK aviation policy is at two levels. The first level is the acknowledgement of the comparative scale of DfT forecasts in relation to Paris Agreement carbon budgets. This was particularly highlighted in relation to Heathrow expansion. Following Larkin's statement [H], during the Judicial Review of the ANPS (2018), the Court of Appeal in February 2020 ruled that the Government's ANPS was unlawful because it failed to take into account the UK's commitment to the Paris Agreement. As of February 2021, Heathrow Airport acknowledge they have to prove expansion is compatible with the Paris Agreement before construction could being.

The second impact is at the city-regional level where the research has helped the City of Manchester to understand the implications of unfettered aviation expansion for their own emissions reductions plans. Manchester City Council, which owns a controlling stake (35%) of Manchester Airport, formally endorsed the draft Manchester Zero Carbon Framework (2020-38) in March 2019, which contains analysis that is dependent upon Tyndall-Manchester's aviation research [I]. Subsequently (Nov 2019) Manchester Climate Change Agency (MCCA) commissioned the Tyndall-Manchester research team to report on policy options for monitoring and managing emissions from Manchester Airport. Without this research MCCA would not have communicated the importance of aviation emissions at city scale to senior policy makers and stakeholders and achieved the formal adoption of targets and actions for aviation within the city's Climate Change Framework [J]. The latest Manchester Climate Change Framework 2020-25 therefore includes new aviation emissions objectives and was subsequently endorsed by Manchester City Council in March 2020, formally establishing it as the city's climate change strategy.

5. Sources to corroborate the impact

- [A] The study provided by [Policy Department A for the Committee on Environment, Public Health and Food Safety \(ENVI\) related by the EU Directorate-General for Internal Policies, Environment, Public Health and Food Safety entitled 'Emission Reduction Targets for International Aviation and Shipping cites 'High Seas, High Stakes, 2014](#), which contributed to amendment of Directive 2003/87/EC to include shipping and aviation in the EU ETS, documented through process [2015/0148\(COD\)](#)
- [B] The study by New Climate Economy entitled 'Raising Ambition to Reduce International Aviation and Maritime Emissions' cites our Smith *et al.*, paper that was submitted and presented orally to the IMO, arguing for a 50% cut in CO₂ by 2050 (Smith, T., Traut., M., Bows-Larkin, A., Anderson, K., McGlade, C. and Wrobel, P, (2015). CO2 Targets, trajectories and trends for international shipping. <https://tyndall.ac.uk/publications/co2-targets-trajectories-and-trends-international-shipping>) It also uses the graph from our article published in *Nature Climate Change*, Bows-Larkin *et al.* (2015), on page 13. Main conclusion and recommendation – 'the IMO adopts a global emission reduction target for international shipping...in keeping with 2C'. Citation: [Gençsü, I. and Hino, M., 2015. Raising Ambition to Reduce International Aviation and Maritime Emissions. Contributing paper for Seizing the Global Opportunity: Partnerships for Better Growth and a Better Climate. New Climate Economy, London and Washington, DC. Available at: http://newclimateeconomy.report/misc/working-papers](#)
- [C] Tony de Brum, Marshall Islands Foreign Minister and leader of the High Ambition Coalition, was identified by specialist reporters who were present throughout the conference as a key actor: Guardian 13 December 2015, [How the historic Paris deal over climate change was finally agreed](#)
- [D] Testimonial letter available from Bill Hemmings, Campaign Director of the international NGO Transport & Environment. At Paris COP21 (2015) Pressure was applied to government delegations by NGOs citing our work for example: https://www.transportenvironment.org/sites/te/files/publications/2015_11_COP21_bunkers_briefing_final.pdf
- [E] United Nations Conference on Trade and Development Sustainable Freight Transport Portal Small Island Developing States Case Study Report (2016) <http://unctadsftportal.org/wp-content/uploads/2016/07/PRINT-1-The-International-Shipping-Context.pdf>
- [F] IMO awareness bulletin that references an interview with Traut in 2015 <http://www.imo.org/en/KnowledgeCentre/CurrentAwarenessBulletin/Documents/CAB%20229%20December%202015.pdf>
- [G] A testimonial letter from David Balston, UK Chamber of Shipping, 4 February 2020.
- [H] A testimonial letter from Friends of the Earth Head of Science, Policy and Research regarding the expert statement of Larkin to the High Court Judicial Review of the Airports National Policy Statement (2018).
- [I] Appendix 6 of Draft Manchester Zero Carbon Framework 2020-2038 <http://www.manchesterclimate.com/sites/default/files/Draft%20Manchester%20Zero%20Carbon%20Framework%202020-38.pdf> and Greater Manchester's Springboard to a Green City Region <https://www.greatermanchester-ca.gov.uk/media/1317/springboard-report.pdf> (2018) p24
- [J] Manchester Climate Change Framework 2020-25 available at <http://www.manchesterclimate.com/framework-2020-25> and testimonial letter from Manchester Climate Change Agency Programme Director regarding input of Broderick to its development on the subject of aviation emissions.