

Geologically Balanced Fuels: equity, justice, and public perceptions

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Aviation is important for sustainable development, helping deliver goods and services to places quicker and more efficiently. In 2022, aviation accounted for only 2% of global CO₂ emissions [1]. Although demand for aviation is projected by the industry to grow considerably up to 2030 [2], the aviation sector is considered to be one that will be ‘hard to decarbonise’ but needing to decarbonise nevertheless. As of 2018 (i.e. before the disruption by the Covid-19 pandemic), only 2- 4% of the global population flew internationally, meaning that 1% of the world population emitted 50% of CO₂ from commercial aviation [3]. This demonstrates the urgent need to identify ways to decarbonise the aviation sector equitably. The aviation sector provides a unique opportunity to examine questions around what types of net zero outcome are accepted, valued and championed, and how principles of equity and justice can be operationalised in this sector.

This briefing paper discusses the equity, justice and public perception considerations of Geologically Balanced Fuels (GBFs) for the aviation industry. A GBF is a conventional aviation fuel whose CO₂ emissions are compensated for by an equivalent quantity of CO₂ being captured and permanently stored in geological formations (see Jenkins et al [4] for a detailed definition). GBFs would complement proposals such as Sustainable Aviation Fuels (SAFs) which may encounter scaling-up, logistical, and operational challenges [4]. For GBFs to become a reality, we must also pay attention to the potential impact on society, and seek to understand the conditions under which GBFs would or would not enable equitable transitions across spatial contexts. In this briefing paper, we present initial findings from analogous technologies and interventions in the aviation sector, to begin to understand the potential implications of GBFs for equity, climate justice, and public perceptions.

GBFs: Equity considerations

The ‘value’ of a net zero technology does not simply depend on the amount of CO₂ that can be sequestered and the financial cost. It is also crucial to consider the regulatory and social contexts in which these technologies are designed and implemented, as well as the environmental, social and political impacts of these technologies [5], [6]. Applying a justice lens to GBFs means carefully examining who benefits from the development and use of GBFs, who pays and loses, and whose climate and development vulnerabilities will be exacerbated [7]. Below, we set out some initial thoughts on these questions.

Who benefits from the deployment of GBFs?

One of the key beneficiaries of GBFs could be the aviation sector itself, by reducing in-sector emissions through storing CO₂ permanently and durably without large-scale replacement or retrofitting of aircraft, and without requiring reductions in passenger demand [4]. This could facilitate a larger ongoing use of aviation, potentially benefitting all established and developing aviation markets. GBFs could also encourage or backstop investment in carbon capture and storage (CCS) more widely, depending on the implementation at both point sources and via direct air capture, benefiting the CCS sector and – by extension – countries and hard-to-abate sectors relying on CCS to meet their climate goals. If Just Transition Principles are embedded into these processes, there could be indirect benefits to oil and gas (O&G) producing regions and to workers in the O&G and aviation sectors [8].

In theory, GBFs could be beneficial to individuals, groups, or states with small aviation needs: for instance, those with lower consumption of airborne goods or air travel. These groups disproportionately experience climate impacts from the actions of those who drive emissions from the aviation sector. Therefore, if the climate impacts from those flights were addressed, groups with lower aviation needs would encounter a climate benefit. That said, GBFs do not tackle the non-CO₂ impacts of aviation or the inequitable distribution of travel and consumption, discussed in more detail below.

Tourism-dependent economies are another potential beneficiary. There are currently few options for tourism decarbonisation without severely damaging the tourism economy [9], on which many developing countries rely [10], [11]. Many of these countries are also highly vulnerable to climate impacts (for instance, Small Island

Developing States), meaning that reductions in tourism for climate mitigation could perpetuate the ‘triple injustice’, where those least responsible for climate change are both more vulnerable to climate impacts *and* to adverse impacts of efforts to mitigate [12]. GBFs could be used as an insurance or backstop measure to guarantee decarbonisation in the absence of timely alternative net-zero-fuel technology deployment, or willingness to manage demand.

Who pays, who loses, and whose vulnerabilities get exacerbated?

Net losses from GBFs depend on their implementation in practice, their mechanisms for regulation, and how costs are passed through both financially and in the carbon accounting system. Under a widespread adoption of GBFs, one potential loser would be fossil fuel companies, *if* suppliers felt it beneficial to absorb a portion of the CO₂ capture and storage costs in order to maintain lower (geologically-balanced) fossil fuel prices than competitors. Such an outcome would likely require GBFs to be implemented more widely than just the aviation sector, at minimum so the entire kerosene market were subject to a level playing field. If successful, such an outcome would see a proportion of suppliers’ gross revenue being reinvested into CO₂ capture and storage technologies [13]. In the case of aviation, such fuel supplier subsidy would be predicated on factors such as a high passenger-demand-elasticity and limited alternatives for suppliers to offload kerosene. Conversely, low demand-elasticity and the aviation sector’s isolated adoption of GBFs could result in the full cost being borne by airlines and their customers. The transfer of costs to O&G suppliers, while protecting airlines and workers, could risk reducing the income of O&G-dependent countries and regions, and by extension O&G workers (particularly in low-income regions). Alternatively, if the higher cost were picked up by governments as a means of compensating the industry and socialising the cost, this could be regressive, since the costs would be disproportionately borne by individuals who do not directly use aviation services. In developing countries with state-owned O&G companies, the cost imposed by GBFs could be burdensome by reducing public revenue, at least in the short to medium term. Here, there is risk of costs being transferred to airlines and passengers.

Although aviation is a whole-of-economy sector, there are issues of class and wealth that are embedded into discussions on the nature and future of the aviation sector. The aviation sector is characterised by highly unequal consumption [3], and we must consider whether supply-side approaches such as GBFs are sufficient to address such inequalities. Although GBFs are (in theory) intended to shift responsibility onto fossil fuel producers, there is limited knowledge on whether these interventions would generate systems and processes that transfer all or part of the costs to consumers. GBFs costs, whether borne by the supplier or consumer of fuels, should entirely be borne by those within the supply-chain benefitting from the ongoing use of fossil fuels. If some costs of GBFs were passed through to customers, this would impact frequent flyers and businesses reliant on staff travel, whilst non-flyers and most low-income groups would benefit [14]. Higher fares could also create losses for geographically-isolated locations. However, the largest share of aviation emissions come from high-income islands such as New Zealand and Iceland, which may be more able to absorb such losses [15], [16]. GBFs could also exacerbate the vulnerabilities of migrant workers, because higher fares could be prohibitive and greatly impact quality of life for some low-income migrant groups [17], [18]. GBFs are not unique from SAFs or e-fuels in this regard: all would almost certainly involve transferring costs to the passengers. Demand-reduction policies such as carbon taxes and Frequent Flier Levies would also increase ticket costs, but would also create public revenue, which could reduce equity impacts if appropriately distributed.

There is a risk that an overriding focus on CO₂ overlooks other injustices – for example, those present in extractivist fossil fuel regimes, or from resource use for capturing and storing carbon [7]. Carbon removal technologies face constraints in terms of energy demand and/or land availability. GBFs therefore run the risk of burden-shifting onto other countries or sectors [19] (although this is also the case for bio-based SAFs and e-fuels). Aviation also creates non-carbon impacts such as non-CO₂ GHGs, as well as noise, pollution, and land-use from airports. For example, implementing GBFs alongside a policy of airport expansion to meet increased aviation demand would potentially be an inequitable approach due to the non-carbon impacts on those who live nearby but who fly less or consume fewer imported goods. Overall, the equity implications of GBFs depend on whether they are seen as an *alternative* or a *complement* to demand-reduction strategies. Such perspectives might differ substantially between different aviation markets and regions.

As shown by the literature cited in this briefing, a large proportion of the available English-language studies were conducted in wealthy industrialised nations, which have a relatively high proportion of people with direct access to aviation services. Since only a small proportion of the world directly use aviation services, basing policy decisions on the views of this minority group has major equity implications. As a result, papers on high-consumption groups dominate the literature on aviation equity (e.g. [3], [20], [21], [22]). Ecological privilege, like other forms of privilege, has become so embedded in society that it is seen as ‘natural’ [21]. Flying norms are also strongly gendered [20], and gender disparities are crucial to the study of climate justice more broadly, underlining the importance of taking an intersectional approach.

Public perceptions

It is now widely acknowledged that social science is crucial for the ethical and effective upscaling of novel technologies and innovations. Principles of equity and justice will also be crucial determinants of public attitudes toward GBFs and whether they can build and maintain ‘social license’. Perceptions of ‘fairness’ are a strong and consistent predictor of public attitudes [23], [24], and lay publics around the world show broad support for core principles of procedural and distributive justice [25].

GBFs are a highly novel topic, meaning that work on public or stakeholder perceptions of GBFs is currently lacking. There is literature examining public attitudes to novel aviation fuels such as bio-SAF, although a 2022 review [26] noted a distinct lack of public acceptance studies on SAF *per se*, relying instead on studies of perceptions of biofuels and renewable energies. Studies on bio-SAF in the UK and Poland find consistently low public awareness, although perceived safety varies between countries [27], [28], [29]. However, amongst informed stakeholders, societal perceptions of biofuel sustainability are mixed, and the conditions for affordable, sustainable, large-scale supply of biofuel are lacking [30]. Meanwhile, a study on CO₂-based jet fuel finds that attitudes to Carbon Capture, Utilisation and Storage are the strongest predictors of attitudes to the fuels [31], whilst another finds that CO₂ transport encounters heightened risk perceptions [32]. Thus the CCS component of GBFs is likely to be a strong driver of public attitudes; a large literature exists on attitudes to CCS (see for example [33], [34], [35], [36], [37]). Policies and governance will also play a crucial role in public perceptions of GBFs (see ‘next steps’, below).

The vast majority of social science work on aviation focuses on demand-side interventions – particularly on passenger behaviour change (e.g. [38], [39], [40], [41]). Long-distance travel has become rapidly institutionalised & normalised, and relying on voluntary demand-reduction alone is unlikely to be sufficient to address aviation emissions [42], [43]. There also tends to be more public support for measures targeting the aviation industry rather than individuals [44], [45]. That said, these findings should not be seen as immutable, because the aviation sector itself plays a crucial role in making and sustaining public imaginaries of aviation [20], [46]. Demand-side policies such as Frequent Flyer Levies also tend to be perceived as fair and effective [47] and are generally considered to be socially progressive [17].

Next steps

Whilst the literature on analogous technologies and policies gives us some valuable initial insights, it is constrained by a lack of empirical social science research on GBFs. As such, the next step under this project will be to collect primary data on GBFs in terms of their public acceptability, perceptions of key stakeholders, and their implications for equity and justice. As demonstrated above, this will depend in large part on how GBFs are implemented, therefore close attention also needs to be paid to policy and regulatory frameworks, and the interplay between policies and social justice.

To keep up to date on the project or to get in touch go to <http://www.netzeroclimate.org/net-zero-aviation>.