# Airport management perspectives on aviation biofuels: drivers, barriers, and policy requirements in the US Pacific Northwest


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**Abstract:** This study explores perspectives of airport management on aviation biofuels in the Pacific Northwest of the USA by administering an online survey of airport managers in FAA certified airports in the region. Respondents provided their opinions on factors important for sustainable aviation fuel (SAF) development in the Pacific Northwest, including perceptions of various potential drivers and barriers to scale-up in the region. Most respondents indicated that policy certainty to attract capital, higher oil prices, and technology breakthroughs are required for a viable industry, and they also indicated that government intervention is important to ensure successful adoption and implementation. Respondents indicated that aviation biofuel tax credits, a system to issue and trade sustainable biofuel certificates, and fuel sustainability certification criteria are required policies/protocol to ensure viability. We suggest that a regional approach to examining barriers, drivers, and policy requirements provides more nuanced perspectives regarding key SAF development and scale-up issues.

**Keywords:** sustainable jet fuel; aviation biofuel; airport management; drivers and barriers; biofuel policy; US Pacific Northwest; policy requirements; industry scale-up; policy certainty; oil prices; technological breakthroughs; government intervention; biofuel tax credits; sustainability certification.

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## 1 Introduction

With growing concerns over carbon emissions, global warming, and the price of crude oil, it is not surprising that there is growing public support for biofuels. In fact, a 2015 national poll found that the majority of US support a renewable fuels standard (RFS) that requires a specific amount of fuel be produced each year that comes from renewable sources (Morning Consult, 2015). Specific percentages vary; however, majority support for this RFS was found among republicans, democrats, and independents; men and women; whether the respondent identified as liberal, moderate, or conservative; and across various education levels. While aviation accounts for only about 2.5% of global carbon emissions, it accounts for between 3.5% and almost 5% of total global anthropogenic radiative forcing, meaning that aviation's various other emissions and the direct release of these emissions into the upper atmosphere make it a particularly strong contributor to climate change (Lee et al., 2009). These reasons, along with growth forecasts in the industry and substantial increases in the price of crude oil from 2001 to 2012 (Wyman, 2013), prompted and have continued to drive research into SAFs (Gegg et al., 2014). This research coincides with industry targets to achieve reduced carbon emissions, including efforts by IATA to achieve carbon neutral growth by 2020 (IATA, 2015), and FAA efforts to produce 1 billion gallons of jet fuel from renewable sources by 2018 (FAA, 2015).

The growing interest in SAFs among various national and international entities has led to a corresponding growth in studies examining barriers and drivers to SAF production industries. This research includes efforts to examine feedstock sources, policy interventions, and stakeholder perceptions, among various other topics. While aviation industry stakeholder perceptions of biofuel drivers and barriers have been examined either directly or indirectly (Cortez et al., 2015; Gegg et al., 2014; Kivits et al., 2010; Moraes et al., 2014; Upham and Dendler, 2015), very few studies examine these issues from a regional perspective, particularly in the USA. Additionally, these studies rarely examine the opinions of aviation management, even when directly examining the opinions of key aviation biofuel stakeholders (see Adams et al., 2011; Gegg et al., 2014). With the exception of Smith et al. (2017), most studies that have examined drivers of SAF scale-up conduct country-level case studies, small comparative studies, or content analysis of stakeholder documents. However, a regional perspective provides an opportunity to conduct a more nuanced analysis of drivers and barriers to SAF production and how perceptions of constraints and opportunities differ across regions.

The Pacific Northwest Region of the USA is currently the focus of several research projects attempting to develop an economically viable biomass-to-SAF industry in the region. These efforts include the Sustainable Aviation Fuels Northwest (SAFN) project, the USDA-funded Northwest Advanced Renewables Alliance (NARA) project and Advanced Hardwood Biofuels (AHB) Northwest project, and the Federal Aviation Administration's Aviation Sustainability Center (FAA-ASCENT). An important component of these projects is examining the opinions of aviation stakeholders regarding drivers and barriers to developing economically viable SAF supply chains in the region. Research indicates that airlines are an important driver of SAFs in the region (Smith et al., 2017), many of which have established commercial partnerships in order to develop sufficient supplies of alternative fuels. However, in order for SAFs to be integrated into the fuel supply chain and help the aviation industry meet its carbon emissions and renewable fuel requirements, cooperation among key industry stakeholders is necessary, as well as understanding the various drivers and barriers to achieving these targets. This need for stakeholder cooperation, as well as managing varied concerns and interests for successful development and implementation of SAFs, suggests that aviation management is a key stakeholder group to include in research. Their role in linking divergent interests, such as airlines and fuel handlers, both on and off airport premises make them uniquely positioned to provide key insights into the factors that will contribute to SAF success in the region, yet their inclusion is minimal in most stakeholder research (Cortez et al., 2015; Gegg et al., 2014; Kivits et al., 2010; Moraes et al., 2014, Upham and Dendler, 2015).

Our research addresses this gap in stakeholder perceptions present in other aviation biofuel stakeholder research by presenting the results of an online survey of airport management in the US Pacific Northwest region (Washington, Oregon, Idaho and Montana) to better understand their perceptions of the drivers, barriers, and policy considerations to developing a regional SAF industry. In exploring the perspectives of airport management on aviation biofuel, we first review the literature on barriers and drivers to SAF development and implementation, followed by an explanation of our methodology and sampling design. Lastly, we present our survey results and the implication of these results for SAF implementation, with a focus on policy implications.

## 2 Literature review

Hydrocarbon-based 'drop-in' (Ibarrola, 2015) SAFs represent a viable means of achieving carbon emission reduction targets for the aviation industry due to their compatibility with existing equipment and infrastructure (Zuckerman, 2015). While some research suggests SAFs have the potential to reduce aviation emissions, contribute to price stability and economic development, particularly in rural areas (Macfarlane et al., 2011; Wyman, 2013; Miller et al., 2013; Maniatis et al., 2013), other research points to several constraints to developing a global aviation biofuel market, including high production costs, limited feedstocks, and lack of policy support, among several others (Gegg et al., 2014). Winchester et al. (2013) suggest that fuel prices, and overall carbon emissions would not be noticeably impacted if aviation goals are achieved due to the fact that renewable jet fuel would account for less than 2% of commercial aviation fuel use by 2018.

Feedstocks are particularly important for ensuring cost effectiveness and sustainability of SAF industries. Currently, five ASTM-approved SAF pathways exist: Fischer-Tropsch (FT) (certified in 2009); hydroprocessed esters and fatty acids (HEFA) (2011); synthetic iso-paraffin from fermented hydroprocessed sugar (SIP) (2014); Fischer-Tropsch plus aromatics (FT/A) and alcohol to jet (ATJ). Each pathway relies on specific feedstocks, has different blend limits, has different conditions under which they are cost competitive (Miller et al., 2013), and each has been subjected to numerous test flights. These tests include 75 flights flown in 2011 by Alaska Airlines, a primary airline in the PNW, fuelled by used cooking oil and Alaska's recent demonstration of ATJ, which included two flights powered by a 20% blend of biofuel made from sustainable corn (Alaska Airlines, 2016). These two ATJ flights, flown in June 2016, represented the first commercial demonstration of ATJ biofuel, which was certified by ASTM International in March of the same year (Lund, 2016).

Despite numerous test flights, the development of a national SAF production industry has been daunting due to difficulties obtaining sufficient amounts of SAF (Gegg et al., 2014). This challenge has necessitated commercial partnerships between airlines and fuel producers in order to acquire the necessary amounts of biofuels. While some of these partnerships have ended in the face of competition from low oil prices, lack of financial support, and little to no policy action (Neslen, 2016), other partnerships, like United and AltAir (United Airlines, 2016), FedEx and Red Rock Biofuels (Murdock, 2015), Southwest Airlines and Red Rock Biofuels (Southwest Airlines, 2014), and Cathay Pacific and Fulcrum Bioenergy, Inc. (Cathay Pacific, 2014) have led to fuel purchase agreements, test flights, and commercial use of aviation biofuel.

### *2.1 Barriers to adoption and diffusion of SAFs*

As these promising partnerships continue and more test and commercial flights from new types of biofuels are conducted, the drivers and barriers to widespread adoption of aviation biofuel are becoming more apparent. Barriers receive significant attention in the literature due to ability to prevent full scale-up of SAFs. High production costs vis-à-vis petro-fuels are a major barrier to full commercial scale-up of SAFs (Gegg et al., 2014).

High costs were mentioned by all stakeholders in the Gegg et al. (2014) study, and the importance of this barrier is confirmed by Smith et al. (2017) who also found it to be a major barrier to SAF commercialisation in the Pacific Northwest region of the USA. Additional constraints included lack of investment, sustainable feedstock supply, lack of legislation, strict environmental hurdles for aviation biofuels, and lack of supply chain certification (Gegg et al., 2014). In their interviews with aviation stakeholders in the Pacific Northwest, Smith et al. (2017) found concerns regarding logistical/quality control issues, safety concerns, lack of stable policy and biorefinery siting issues as major barriers. Numerous other studies globally have found much the same, pointing to lack of government support, a lack of public information, high costs of biofuels, lack of research and development investments, and problems with land use and crop designation as barriers to second generation biofuel development (Chang et al., 2012; Cheng and Timilsina, 2011; Izdebski et al., 2014; Klessmann et al., 2011; Smigins and Shipkovs, 2014).

The accumulated research clearly indicates that barriers to SAF development and implementation include both market and government factors. While high costs are frequently mentioned, government policies and protocols clearly impact SAF success. These studies indicate that the government can hinder SAF scale-up through limited activities in aiding production and implementation, such as lack of legislation and insufficient policy support. However, in both Gegg et al. (2014), and Smith et al. (2017), market-based factors were predominately discussed by respondents, and the studies referenced above frequently mention market-based factors as major challenges to biofuel implementation.

### *2.2 Drivers to adoption and diffusion of SAFs*

While several barriers to the development and sustainability of SAFs exist, research also points to several drivers of the SAF industry. Gegg et al. (2014) found that carbon reduction and energy security were important drivers of SAFs; these factors were the most mentioned by all of their interviewed stakeholders. Gegg et al. (2014) acknowledge the high interdependency between many drivers, but identify three drivers most mentioned by their participants: carbon reduction, energy security, and volatile oil prices. Legislation was also a prominent driver, but received more focus among European respondents (Gegg et al., 2014). While Smith et al. (2017) show that the predominant driver of SAFs in the Pacific Northwest was the commitment on the part of airlines to support these endeavours, emissions and government policies were also important drivers noted by several participants.

### *2.3 Other factors impacting adoption and diffusion of SAFs*

Additional key factors for developing sustainable SAF industries are stakeholder and community support. Miller et al. (2013) suggest that assessing stakeholder support for alternative fuel projects is particularly important, especially for airports attempting to meet the various needs of divergent entities. In fact, the authors identify several

challenges that airport executives in particular will face with stakeholders, including concerns over safety, need for political and economic support, and institutional inertia to creating change. Concerns impacting community acceptance include re-allocating food feedstocks for SAFs (food vs. fuel), and water scarcity (water-energy-food nexus) (Miller et al., 2013).

Miller et al. (2013), Gegg et al. (2014), and Smith et al. (2017) all point to the importance of stakeholder support for sustainable SAF industries. These studies have examined the perceptions and opinions of various stakeholders, but few airport managers have been included in these studies. Gegg et al. (2014) included one airport manager, while Smith et al. (2017) interviewed eight. Miller et al. (2013) identified airport executives as important proponents of alternative fuels, and identified barriers that these particular stakeholders may face. Airport management as a group provide a distinctive perspective for others to better understand the various drivers and barriers to SAFs. Because engaging various stakeholders is important for successful SAF implementation and since management of divergent needs is a daily expectation for this occupation, understanding airport management insights and concerns is important to the development and implementation of SAF.

This research examines perceptions of aviation management in the US Pacific Northwest regarding the development and implementation of an economically viable SAF industry in the region. As outlined above, several research projects exploring the adoption and diffusion of an economically viable SAF industry are currently being conducted in the Pacific Northwest to investigate potential SAF feedstocks and specific actions necessary to create an SAF industry in the region. Since airport management is a particularly important stakeholder for understanding the various drivers and barriers to creating such an industry, this research builds on previous work by focusing on this key stakeholder group.

Of particular importance to this research are the drivers and barriers identified by airport managers that include policy solutions. While prior research indicates that airlines play one of the most important roles in the adoption of SAFs, along with concerns over fuel prices and feedstock supply, and while many stakeholders identify a lack of policy stability as a barrier, little research examines how aviation management believes these specific concerns can be addressed, particularly through policy, if policy is to play a role at all. This research explores the role of policy by considering whether airport managers believe government plays a role in the adoption of SAFs and, if so, what kinds of policies might be necessary to help sustainable aviation biofuel become commercially viable.

## 3 Methods

To examine airport management perceptions regarding SAF production and implementation, an online survey of airport management in the Pacific Northwest of the USA was conducted over a period of three months during the summer of 2015. Utilising an FAA database that includes 506 US airports, airport managers at all FAA commercial and non-commercial airports in the Pacific Northwest whose contact information was available received an invitation to participate in the survey. As a result, a total of

80 survey invitations were sent, including all airport management in commercial airports (27) and select non-commercial airports in the region (53) whose managers' contact information was accessible. Of the 80 survey invitations sent, 31 managers completed the survey, yielding a 38.7% response rate. This response rate, as noted by Sheehan (2006) and Barch and Holtom (2008), is actually above current survey response rates, which have been declining over the last few decades. We are also confident that this response rate is representative of commercial aviation in the Pacific Northwest, as it accounts for over 90% of enplanements and fuel usage in the region. The survey contained both open- and closed-ended questions asking participants about barriers and drivers to the development of SAFs, existing policy and protocol and potentially necessary changes to these, and logistics requirements for SAF scale-up.

## 4 Results and discussion

The survey yielded results from 31 airports in the four-state Pacific Northwest region (WA, OR, ID and MT). The results were analysed based on the type of airport according to the FAA's National Plan of Integrated Airport Systems (NPIAS) categories[1] and whether the airports are located to the east or west of the Cascade mountain range. The FAA classifies airports according to their annual passenger boardings (enplanement); classifications for commercial primary airports as a proportion of total annual US enplanement ($x$) include large hub ($x \geq 1\%$), medium hub ($0.25\% \leq x < 1\%$), small hub ($0.05\% \leq x < 0.25\%$), and non-hub (10,000 total $< x < .05$). Additionally, the FAA database includes non-primary commercial airports (at least 2,500 passengers but no more than 10,000) and non-primary airports that are not commercial (less than 2,500 passengers or no scheduled service). Using the NPIAS categories allows comparison of responses based on the size of the airport, which includes factors like enplanement and fuel usage. The geographic comparison allows for responses to be compared to the unique political and cultural aspects of geographic location, which are distinctly divided in the Pacific Northwest by the Cascades. The west side of the mountain range is generally more urban and politically liberal, while the east side of the range is generally more rural and politically conservative. While we did not ask respondents for their political views, this unique geographic split can potentially stand in as a proxy for political and cultural views towards aviation biofuels. Table 1 displays frequency data for each of these categories and lists total enplanement numbers for these categories using the latest data from the FAA (FAA, 2016). As displayed in Table 1, the five large and small hub airports included in this survey account for 98% of total enplanement for these 31 airports, and the western, urban side of the region accounts for 91% of this total. Thus, respondents represent airports responsible for most aviation fuel consumption in the region. In what follows, we explore respondent opinions regarding the importance of government intervention, various requirements (barriers and drivers) for an aviation biofuel industry in the Pacific Northwest, and the necessity of various policies/protocols. All questions were asked using a five point Likert scale (1 = not important/strongly disagree to 5 = very important/strongly agree), and each of the following figures displays mean values for this scale to the right of each bar.

**Table 1** US Pacific Northwest airport category frequency data

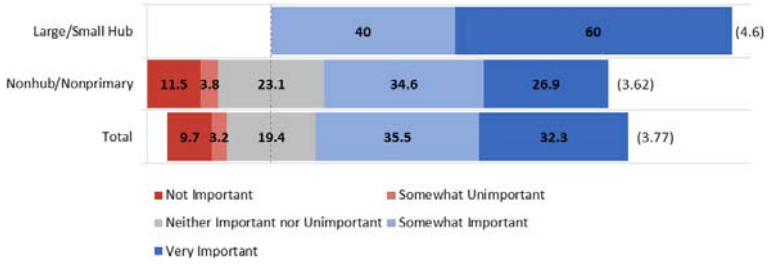
| *Primary category* | *Subcategory* | *Total respondents* | *Regional airport* | *Totals* | *Response rate (%)* | *Enplanement* |
|---|---|---|---|---|---|---|
| | | | | | *2015* | *% of PNW total* |
| NPIAS airport category | Large hub | 2 | 2 | 100 | 28,489,214 | 90 |
| | Small hub | 3 | 6 | 50 | 2,475,181 | 8 |
| | Non-hub | 8 | 19 | 42 | 706,139 | 2 |
| | Non-primary | 18 | N/A[a] | N/A[a] | 5,761[b] | .001 |
| Geographic location category | West | 9 | N/A[a] | N/A[a] | 28,942,768 | 91 |
| | East | 22 | N/A[a] | N/A[a] | 2,733,527 | 9 |

Notes: [a]Non-primary airports make up the bulk of all airports in any given region. Due to these airports' small size and infrequent use, a comprehensive, reliable list that includes all non-primary airports is not available, making regional totals difficult to calculate. [b]Nine of the 18 airports in this category had no data available or had enplanement values of 0.

## *4.1 Importance of government intervention – airport size*[2]

Respondents were asked to rate how important they perceived government intervention to be in order to establish an economically viable aviation biofuel production industry in the Pacific Northwest by 2020. As can be seen in Figure 1, there is clear agreement between both groups that government intervention is important, with strong majorities in each group taking this position. While there is slightly more emphasis on government importance in the large/small hub group, and more respondents in the non-primary group indicate that government is not important, the differences are negligible. The mean values to the right of the bars emphasise this, showing high levels of agreement on the question for both airport categories. It is important to note here that every respondent from large and small hubs in the Pacific Northwest, which account for the bulk of the air traffic and fuel use, believes government has an important role to play in the establishment of an aviation biofuel network. It should also be noted, however, that despite this strong belief in the importance of government intervention, it is still unclear as to whether these respondents would want such an intervention to take place. There is a clear distinction between whether respondents feel government intervention is necessary and whether they want such an intervention to take place, and our questions regarding intervention primarily focus on the former.

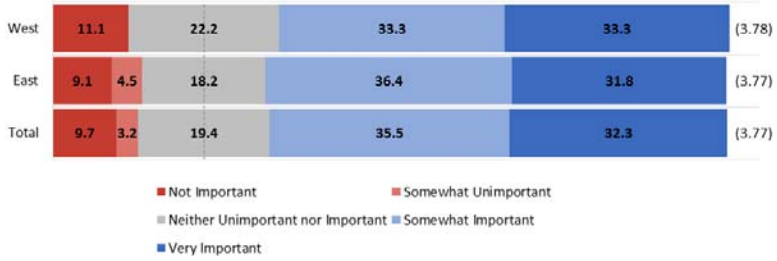
**Figure 1** Importance of government intervention by airport category (%) (see online version for colours)



### 4.2 Importance of government intervention – geographic location

A majority (over 60%) of respondents in both the east and west believe that government intervention will be either somewhat important or very important in establishing a production industry (see Figure 2). Interestingly, the results reveal that eastern and western respondents rated importance of government intervention similarly, as the mean for both groups is nearly equal and the percentage of responses in each Likert category are similar. This reveals essentially no difference between the opinion on importance of government intervention and geographic location.

**Figure 2** Importance of government intervention by geographic location (%) (see online version for colours)

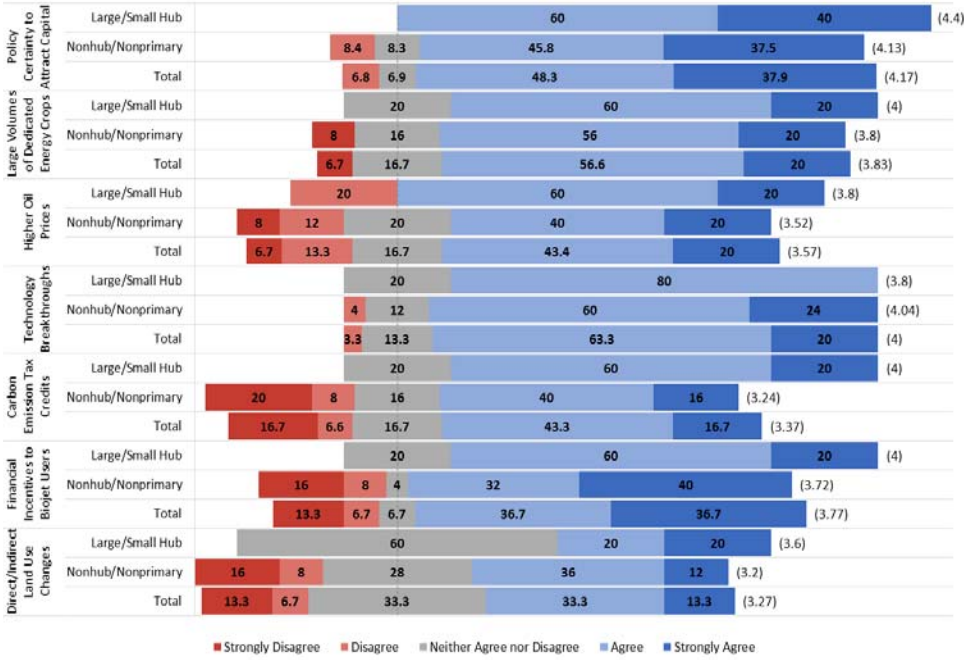



### 4.3 General barriers and drivers – airport size

Next, respondents were asked about potential drivers and barriers that might affect the viability of an aviation biofuel production industry in the Pacific Northwest. As shown in Figure 3, the vast majority of large/small hub and non-hub/non-primary airports agree or strongly agree that policy certainty to attract capital is required for building a viable biofuel industry. In fact, large/small hub airport managers unanimously agree that this policy certainty is required, while over 80% of non-hub/non-primary airports agree or strongly agree. Additionally, regardless of airport size, respondents clearly agree or strongly agree that large volumes of dedicated energy crops, higher oil prices, and technology breakthroughs will be essential. Only small numbers in each group believed higher oil prices would not be an important factor for the future of aviation biofuel.

The last three factors in this question are related to specific policies or mechanisms that might be part of the creation of an aviation biofuel industry, and respondents here disagreed a little more strongly and in greater numbers about the necessity of these factors. About 20–25% of respondents in each group indicated that carbon emission credits, financial incentives to users of biojet, and direct or indirect land use changes would not be necessary for the establishment of an aviation biofuel network. Despite that disagreement, strong majorities in both groups indicated that financial incentives and emissions credits would be necessary for aviation biofuel success, and this was, once again, especially true for respondents from large and small hubs. The final factor, direct/indirect land use changes, reveals much more neutrality among respondents, especially in the large/small hub group, which might indicate that respondents were not certain about the necessity of land use changes or declined to take a position. Despite both greater levels of disagreement and greater numbers of neutrality on this factor compared to any other, there are still significant levels of agreement among both groups.

**Figure 3** Level of agreement on requirements for aviation biofuel industry by airport category (%) (see online version for colours)




The general pattern for this question is clear. Both groups tended to agree that these factors would be necessary, with no mean value for either category on any factor falling below 3 (neither agree nor disagree) and a total mean value of 3.27, indicating more agreement on all factors. Large/small hub respondents agreed most strongly, with respondents from this group disagreeing on necessity only once (on higher oil prices), and even this disagreement was minor. On the other hand, respondents from non-primary airports revealed a little more disagreement over the necessity of these factors than respondents from large and small hubs, but this disagreement was also minor.

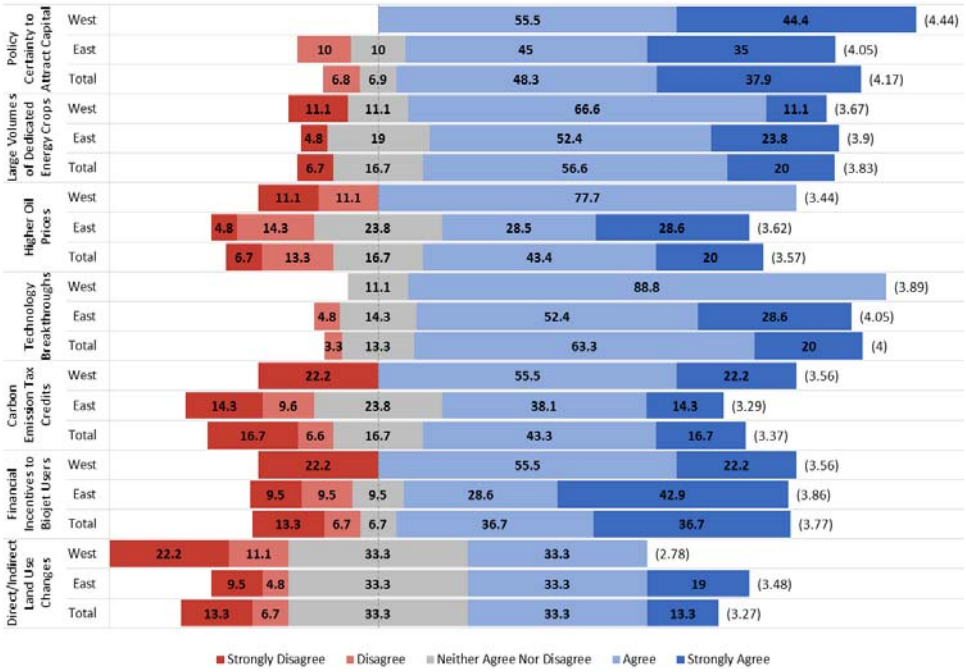
## *4.4 General barriers and drivers – geographic location*

Figure 4 shows eastern and western respondents tended to agree on most factors, with the exception of two: carbon emission tax credits and direct/indirect land use changes. On carbon emission tax credits, majorities in both groups agreed or strongly agreed that these credits would be necessary.

However, the agreement was somewhat higher in the west, and more eastern respondents took the neutral position. For land use changes, a majority of eastern respondents believed that these changes would be necessary, while only a third of western respondents felt the same. In fact, a third of western respondents disagreed with this – over twice the proportion of respondents from the east who felt the same. This factor also yielded the lowest mean scale score at 2.78 for western respondents, indicating a slight lean toward disagreement for these airports. The other factors showed majorities in each group agreeing or strongly agreeing; with only minor differences

between groups in neutrality and disagreement (mean values for both groups in other factors are relatively similar).

**Figure 4** Level of agreement on requirements for aviation biofuel industry by geographic location (%) (see online version for colours)




In general, geographic location makes little difference in the way most factors are perceived. Respondents on both sides of the cascades are in general agreement that almost all of these factors will be necessary for the success of an aviation biofuel network. The differences that are present are relatively minor. However, eastern respondents were more likely to agree on some level that land use changes would be required. This region is more heavily dependent on agriculture, which may explain these differences.

## *4.5 Policies and protocols – airport size*

Lastly, while the previous question explored a few general drivers and barriers that might be important to an aviation biofuel network, stakeholders were also asked about specific policies or protocols that might be necessary. The previous questions reveal that both categories of respondents, regardless of airport size or geographic location, recognise the important role of government and indicate with generally mutual agreement what might be necessary for aviation biofuel success. This question seeks to identify more specifically what role government might have through various policies.

**Figure 5** Level of agreement on necessity of policies/protocols by airport category (%) (see online version for colours)

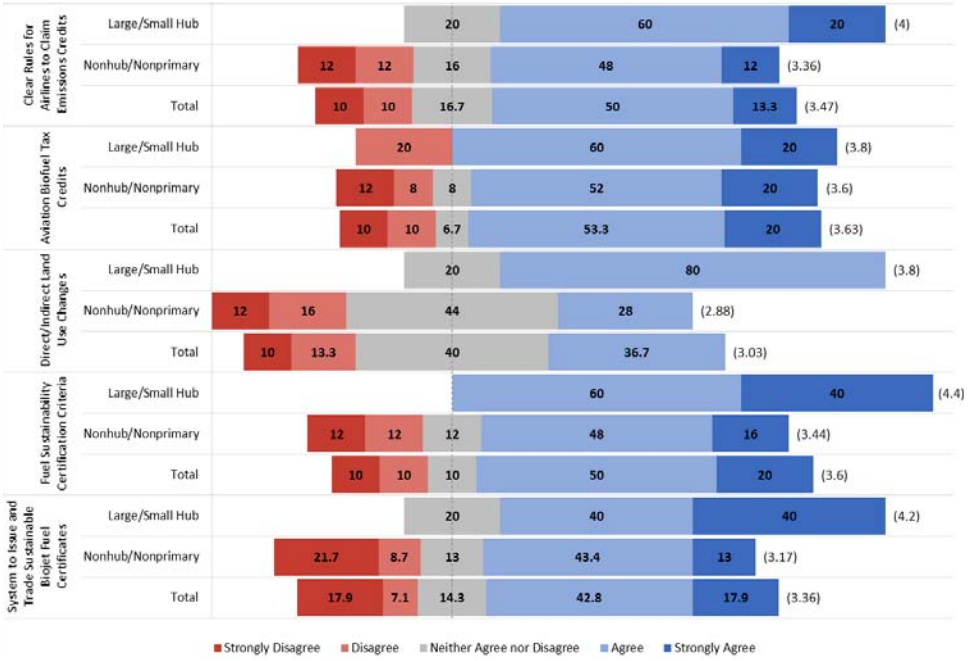



Figure 5 shows that there seems to be general agreement among airport hubs that these particular policies and protocols will be necessary for a successful aviation biofuel network. A majority of respondents in both groups either agree or strongly agree that most factors are necessary, with one exception. Analysis of responses to these questions revealed a clear difference between large/small hub respondents and those from non-primary airports with regard to the necessity for policies or protocols addressing land use changes. In the previous question, the large/small hub group showed more neutrality to this factor than agreement, with no respondents disagreeing. The non-primary group was less neutral on this factor and actually showed more agreement than the large/small hub group on the necessity for land use changes while also expressing some disagreement. Here, however, the groups seem to express different opinions. While the large/small hub group was less certain as to how necessary land use changes would be (mean scale value of 3.6), they more strongly agree that there must be policies or protocols in place addressing these changes (mean of 3.8). The non-primary group, however, was split rather evenly on the necessity of policy addressing these land use changes, with most respondents taking a neutral position, even if they generally agreed land use changes would occur (the mean value of 2.88 would even indicate a very slight lean toward disagreement on the necessity of this policy). Other than this single instance, both groups tended to be in general agreement that policies and protocols like the ones listed in this question would be necessary if a viable aviation biofuel network is to

successfully exist by 2020 in the Pacific Northwest. Respondents indicated that claiming emissions credits, biofuel tax credits, sustainability certification criteria, and a trading system for sustainable biofuel credits will be necessary for a viable biofuel production industry in the Pacific Northwest. Regardless of the airport size, respondents indicated clear agreement that some form of an incentive and credit trading program would be necessary. Like the previous questions, respondents from the largest and most fuel intensive airports in the region were the most likely to be in agreement regarding the necessity of such policies.

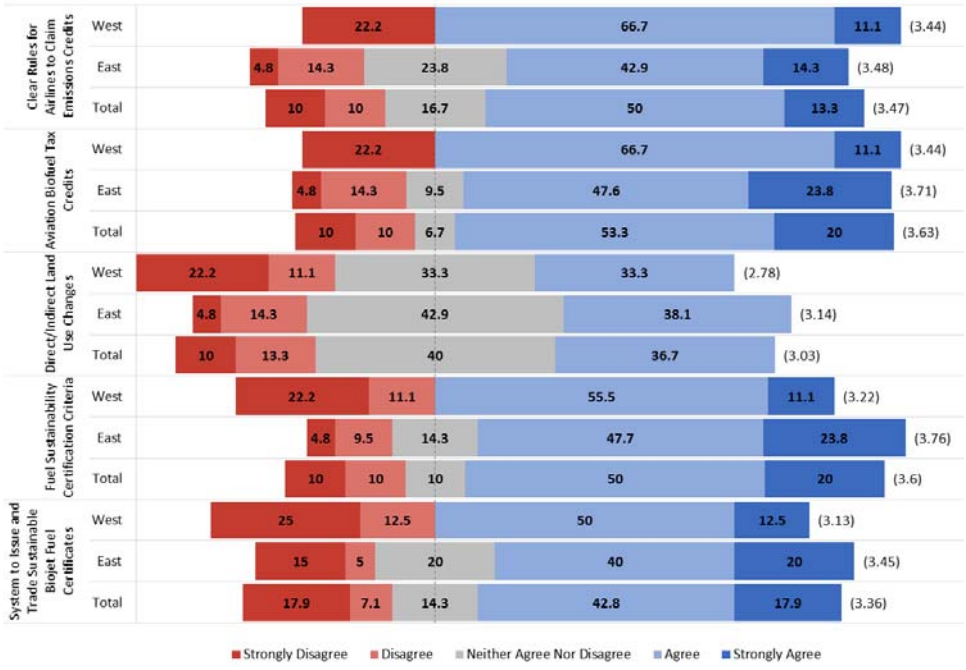
There is very little difference between the size of the airport and how respondents feel about the necessity of various factors or policies addressing these factors. There is slightly more disagreement on the necessity of these factors and policies among those at the smallest airports, but most respondents from these airports are in agreement. There is also a pattern of general or even unanimous agreement among those at larger airports that these factors and policies will be necessary, with very few respondents from this group disagreeing on any of the factors. As a whole, respondents indicated that in order to see aviation biofuel become a reality in the region, government must play an important role, and this role may involve the establishment of policies that incentivise the use of biofuels.

### *4.6 Policies and protocols – east/west*

Similar to the breakdown by airport size, Figure 6 shows there is overwhelming agreement among eastern and western respondents regarding the policies and protocols that will be necessary for SAF in the region, with one exception: land use changes. While the differences between east and west on this factor are not particularly stark (there is slightly more disagreement in the west and more neutrality in the east), the overall results are much the same as the analysis based on airport size, with mean values of 2.78 and 3.14 indicating a slight lean toward disagreement for western respondents and slight lean toward agreement for eastern respondents, respectively. The two groups here are split somewhat evenly between agreement, neutrality, and disagreement, which are similar to their views regarding land use changes in the previous question. Generally, there seems to be no consensus on whether land use changes will be necessary, and there is similarly no consensus on whether policy should address these potential changes. This is especially true for the latter, indicated by a mean scale score for all respondents of 3.03, which represents almost exactly the middle position. Every other factor, however, shows clear majorities and mean scale values in both groups recognising the importance of policies establishing financial incentives and biofuel credit trading programs.

It is important to note that where western and eastern rates of disagreement do not match, there is slightly more disagreement over the necessity of these policies among those in the west than in the east. Opinions on direct land use changes, certification criteria, and a credit trading system reveal this trend, which is somewhat unexpected, given that the west is typically more urban and liberal and was expected to favour government policies more than respondents in the east. This could be explained by the fact that more eastern respondents chose the neutral position, or it may indicate that the west/east divide among aviation stakeholders in the Pacific Northwest does not necessarily conform to traditional expectations.

**Figure 6** Level of agreement on necessity of policies/protocols by geographic location (%) (see online version for colours)




## 5 Conclusions and policy implications

Although there are some differences between the groups as compared on the importance of select factors, the differences are not notable. Regardless of whether respondents are broken down by airport size or geographic location, there is a similar level of agreement regarding the necessity for government intervention, drivers and barriers, and specific policies. Most respondents agree or strongly agree that government intervention is necessary, and that several protocols and policies are necessary to successfully build an aviation biofuel industry in the Pacific Northwest by 2020. The group with the largest rate of agreement on the necessity of governmental intervention and policy is the large/small hub group. This is particularly important, since this group accounts for the largest enplanement numbers and fuel use in the area. While belief in the importance of government intervention may be high, intervention is a general concept and belief in its importance does not necessarily equate to a strong desire for the government to intervene. This is why assessing how respondents react to specific policies is important and why we asked questions about several policies and protocols. There is much more nuance to the belief in the importance of government intervention than this question alone can extract. Indeed, there were respondents who felt there was a need for some policies and not others, even if they indicated generally that government intervention was important.

Earlier research (Smith et al., 2017) identified airlines as a primary driver for the adoption of aviation biofuels alongside other drivers such as concerns over greenhouse gas emissions, policy stability, energy security, and stakeholder support. The primary

barrier was identified as high production costs, alongside limited feedstocks, lack of policy support, safety issues, and fuel logistics concerns. Our research largely confirms these drivers and barriers, with our survey showing that airport management in the region recognises the need for a strong and stable supply chain, fuel prices that can compete with the cost of conventional fuel, land use changes and technology breakthroughs to handle production and supply of biofuel, and the need for some level of government intervention. In terms of government involvement, our research suggests the importance of specific policy interventions that incentivise the use of aviation biofuel, ensure its sustainable certification, and create and maintain the policy structure necessary to make aviation biofuel competitive with conventional fuel.

Whereas previous research detailed the general barriers and drivers of adopting aviation biofuel, this research explores these drivers and barriers through the perspectives of aviation management and identifies specific policy approaches that stakeholders themselves not only feel are necessary, but actually support. In fact, the research reveals great interest in aviation biofuels among aviation management in the Pacific Northwest (51.6% of respondents claimed their airports were interested or very interested and 67.7% claimed they were personally interested or very interested). Despite high levels of interest, only 38.7% of respondents believe that a viable aviation biofuel production industry in the Pacific Northwest by 2020 is likely. Our results indicate that, in addition to other drivers and barriers, including market mechanisms, airport management believes government action and policy is important for the development of aviation biofuel to become a viable alternative to conventional fuel. These results are even more stark, given that our research reveals that the strongest support for aviation biofuel and relevant policies comes from the largest, busiest and highest fuel consuming airports in the region.

Our research more clearly indicates which barriers and drivers are likely to be of issue in the Pacific Northwest. This regional perspective provides valuable information regarding region-specific impediments to SAF production and implementation from the perspectives of airport management. As stated, airport management has a unique perspective on these issues because their position requires satisfying the needs of various aviation stakeholders to ensure airport success. In addition, this research provides insight into more specific policy pathways that airport management in the Pacific Northwest feel are necessary to make aviation biofuel economically viable. While the questions looking to identify the primary drivers and barriers may largely be answered, future research must still explore how driving mechanisms work in various regions and how the primary barriers can be overcome from a regional perspective to aid SAF scale-up. If policy is to play a role in the adoption of aviation biofuel, it is necessary to understand the specific policy perspectives of other aviation stakeholders, like fuel handlers or airlines, as well as how government intervention is perceived in other US regions. With more research on both stakeholder perspectives and regional differences, the importance of policy intervention can be better understood and, if deemed necessary, policy that specifically targets stakeholder and regional concerns can be more effectively developed.

We recognise that our research is limited to perspectives from airport management in the Pacific Northwest and may not reflect the views of airport management or other aviation stakeholders in other regions of the USA. These constraints make it difficult to generalise our findings nationally, and our research does not speak to drivers and barriers or policy preferences in other countries. However, it is important to recognise these limitations, since they emphasise that the global aviation industry is not a single entity, but is very much beholden to the market and policy mechanisms of any given country or

region. In other words, what works for SAF scale-up in the Pacific Northwest may not work in other parts of the country or the world? Nonetheless, our research clarifies the potential for SAF scale-up in the Pacific Northwest and sets the stage for similar research in other geographic regions in order to determine what drives and hinders scale-up there and how successful SAF scale-up can be achieved.

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## Notes

1 The Pacific Northwest has no medium hub airports, so the category breakdown for this research was large, small, non-hub, and a general non-primary category for airports that are classified as non-primary commercial and non-primary non-commercial.

2 The airport categories have been merged to preserve anonymity. Large and small hubs are merged together into one group, while non-primary airports are in another group.