Memorandum

Re: Final Emerging Issues Paper
Aircraft Fuels

This technical memorandum summarizes recent trends in the aviation fuels market and potential opportunities and impacts for the State of Washington.

Introduction

The aviation fuels market could undergo significant changes and challenges in the near-term as commercial airlines upgrade existing aircraft with winglets, and weight reduction efforts to decrease fuel burn or replace older aircraft with more fuel-efficient models, leading to a reduction or flatting in fuel demand despite growth in overall plane movements. In addition the existing jet fuel market could gradually change as the military and airlines experiment with various bio-jet blends as a way to mitigate against jet fuel supply and price volatility concerns and in anticipation of potential biofuel blend requirements as politician's debate carbon policies and biofuels mandates.

In the general aviation market there is ongoing political, environmental, and industry pressure to continue the phase out of leaded AVGAS fuels. As a variety of alternatives are being introduced and considered, including engines designed to run on diesel or jet fuel and ongoing testing of varying grades of conventional unleaded motor gasoline (MOGAS) there are corresponding concerns with providing a wider range of fuel options at general aviation facilities..

This document identifies recent trends in the aviation fuels in the context of their potential impacts on infrastructure within the State of Washington airport system, and associated aeronautic and airport programs.

Industry Trends and Outlook

Current Fuels Market

The focus of the general petroleum products markets has largely been on the volatility in price and mitigation of those effects through tools such as fuel hedging and improvements in fleet efficiency. During periods of high fuel prices in the aviation sector there tends to be a reaction by both commercial and general aviation users that leads to reductions in overall consumption.

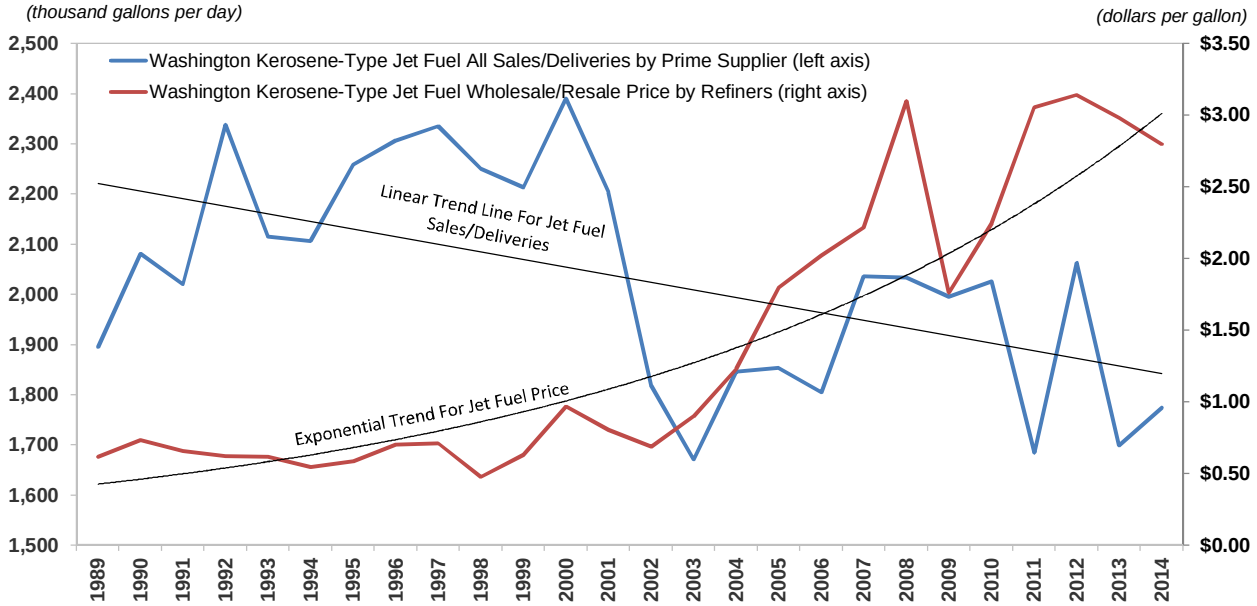
- **Commercial aviation:** airlines have increased ticket prices and/or reduced services and added fuel surcharges to the price of a ticket to offset increases in fuel prices[1]. Short term trends in higher fuel prices tend to also influence long term strategic decisions in which airlines incorporate aircraft fuel efficiency measures such as winglets, purchase more fuel efficient aircraft and/or discontinue services with less efficient and older aircraft, including regional jets[2].
- **General aviation:** private pilots tend to decrease their flying hours during periods of high fuel prices[3] and take additional measures such as request more direct routings, reduce their travel speeds, or when feasible switch to airports offering lower priced fuel or self-service options[4].

Price volatility and implications on demand

[1] Aaron Smith, *Fewer Flights, Higher Fares,* (New York: CNN Money, June 27, 2008).
[2] Scott McCartney, *A Prius With Wings vs. a Guzzler in the Clouds*, (New York: Wall Street Journal, August 12, 2010).
[3] Kamala Shetty, *Current and Historical Trends in General Aviation in the United States,* (Boston: MIT International Center for Air Transportation (ICAT), 2012)
[4] National Business Aviation Association. *General Aviation Industry Hurting During Economic Downturn,* https://www.nbaa.org/advocacy/issues/economic-downturn/high-fuel-prices.php, (July 16, 2008).

Since the late 1980s through 1999 jet fuel prices in the US and Washington state were fairly stable in nominal terms and declining in real terms which, combined with general economic growth, led to fairly constant increases in jet fuel demand as seen in *Figure 1*. As prices increased in the 2000s and the commercial airline industry dealt with the aftermath of the 2001 terrorist attacks, over-expansion of capacity, and the great recession in 2008, demand decreased and remained at relatively low levels compared with the late 1990's. Recent reductions in jet fuel prices and general economic expansion has led to a recent uptick in demand but overall levels remain close to 20 percent below levels in the 1990's.

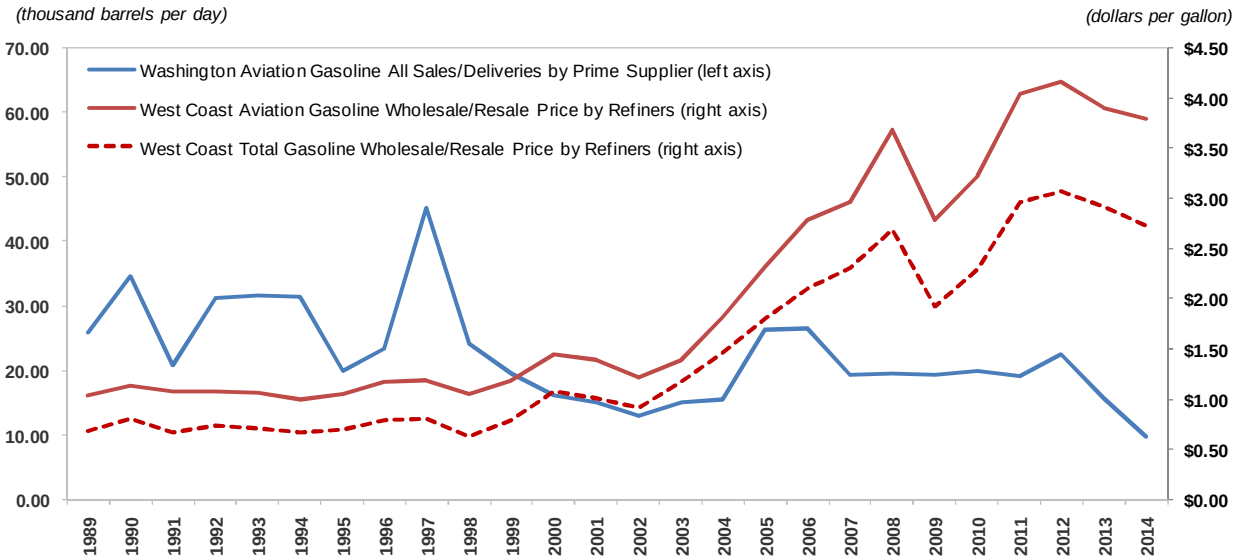
Figure 1: Washington State Annual Jet Fuel Demand and Prices



Data Source: U.S. Department of Energy - Energy Information Administration (EIA), 2015

As shown in *Figure 2* aviation gasoline sales in Washington appear to be slightly more price elastic in comparison with jet fuel sales, with the historical growth in prices leading to a parallel decrease in demand. In addition the trend towards alternative fuels such as unleaded motor gasoline (MOGAS), diesel, and jet fuel use in the general aviation sector could be starting to have a material impact on leaded aviation gasoline sales. ***The increasing delta in gasoline prices and aviation gasoline prices are primarily due to tightening supply of leaded products and increasing regulations on the distribution of leaded fuels*** which has led to an increase in the price differential from a premium of $0.30-$0.40 per gallon through 2004 growing to $1.00 per gallon in 2008, where it has remained since. In addition some MOGAS volumes are being transferred directly by individuals using items such as self-fill fuel cans and containers to aircraft at smaller general aviation and private airport facilities, and are therefore difficult to track and quantify.

Figure 2: Washington Annual Aviation Gasoline Demand and West Coast Prices

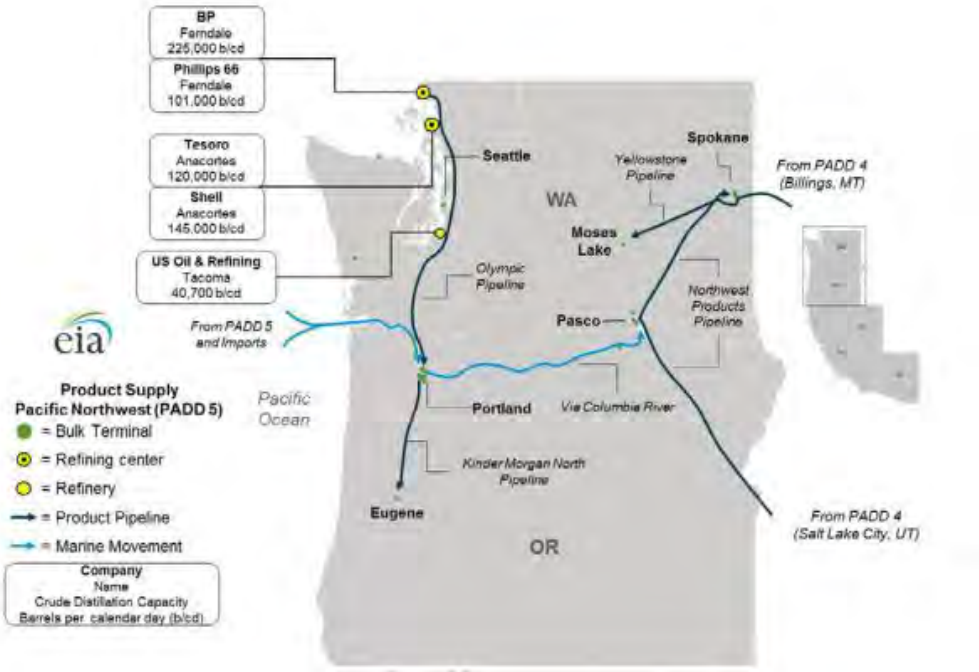


Data Source: U.S. Department of Energy - Energy Information Administration (EIA), 2015

Trends in oil product distribution and prices

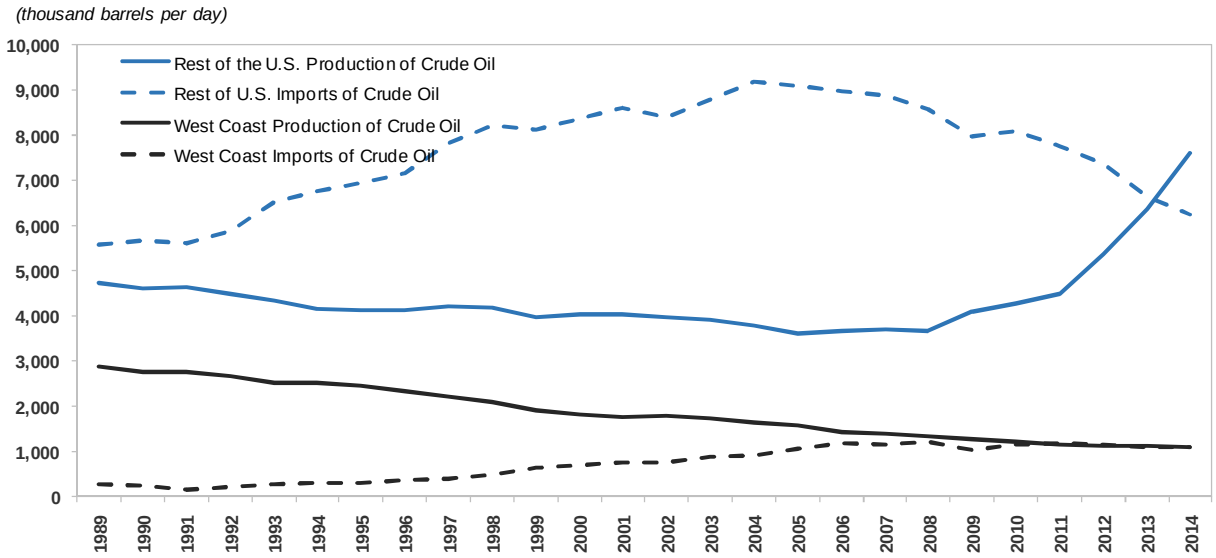
In terms of both crude oil supply to refineries and the supply of refined petroleum products to the end user, the U.S. West Coast is geographically isolated from the rest of the United States with limited pipeline or economically viable vessel connections to the refining centers in the Midwest and Gulf Coast. This results in an inability of West Coast producers and distributors to quickly adjust production and supply to align with demand using surplus crude or product from the rest of the United States, and exposes the West Coast to price fluctuations in the highly volatile Pacific Basin which includes emerging economies such as China and India. *Figure **3**3* shows the primary refineries in the Pacific Northwest and product pipelines. In 2014 jet fuel movements from the Mountain States to Eastern Washington and Oregon was less than one one-hundredth of a percent of total annual demand.

Figure 3: Pacific Northwest Product Supply (U.S. Energy Information Administration, 2015)



Most of the product supplied to the Washington market is sourced from larger refineries in Ferndale and Anacortes with additional supply coming from U.S. Oil and Refining's smaller facility in Tacoma which, with a direct link to the McChord Air Force base provides most of the military volumes of Jet Fuel in the region. The refineries in the region are primarily supplied by imported crude and while the rest of the country has benefited from recent decreases in crude market prices, generally attributed to growth in domestic unconventional crude production, the effect has been less noticeable on the West Coast where production, specifically in Alaska and California has contributed to a long term decline in the region as shown in *Figure 4*. With declines in local production on the West Coast there have been some increases in supply from the rest of the country using rail, but the primary offset has been through increased foreign imports. ***This increased reliance on foreign imports on the West Coast and the Washington refineries has contributed to the higher general prices on the West Coast compared to the rest of the U.S. and higher resulting price volatility.***

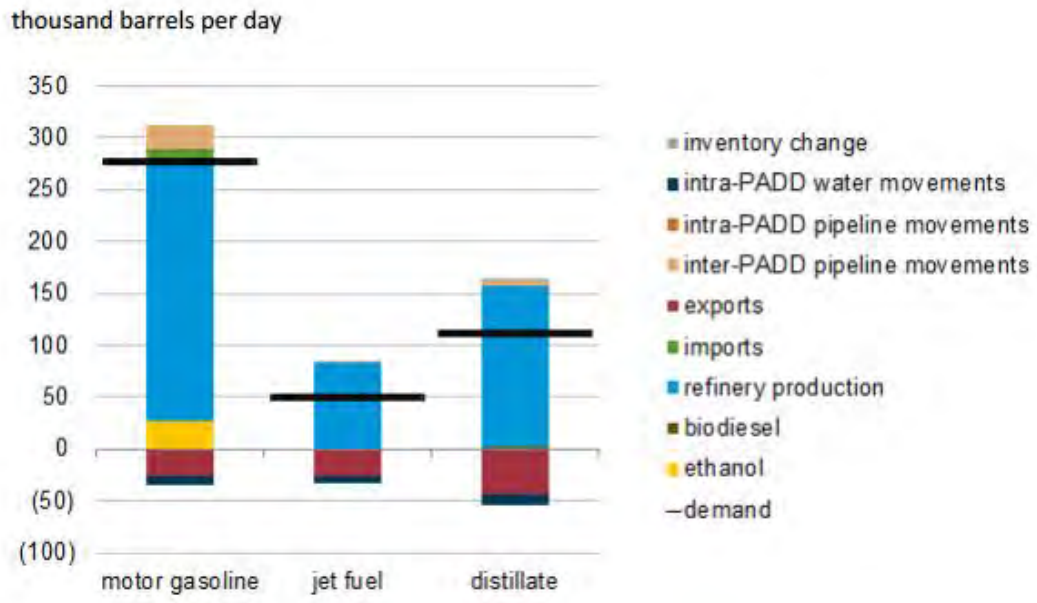
Figure 4: U.S. Annual Crude Oil Production and Imports by Region



Data Source: U.S. Department of Energy - Energy Information Administration (EIA), 2015

Refinery product yields in the Pacific Northwest as shown in **Figure** 5 are similar to the West Coast as a whole, with all types of gasoline's (AVGAS and MOGAS) accounting for 46.5 percent of production, jet fuel 17 percent, other distillates (primarily diesel) 23 percent and the remaining 13.5 percent attributed to residual fuel oil, petrochemical feedstocks and other products such as asphalt and petroleum coke. The primary difference with refinery yields in the rest of the country is in the higher percentages of jet fuel at 17 percent for the West Coast compared to a national average of 10 percent, with the difference accounted for in higher production yields for other distillates.

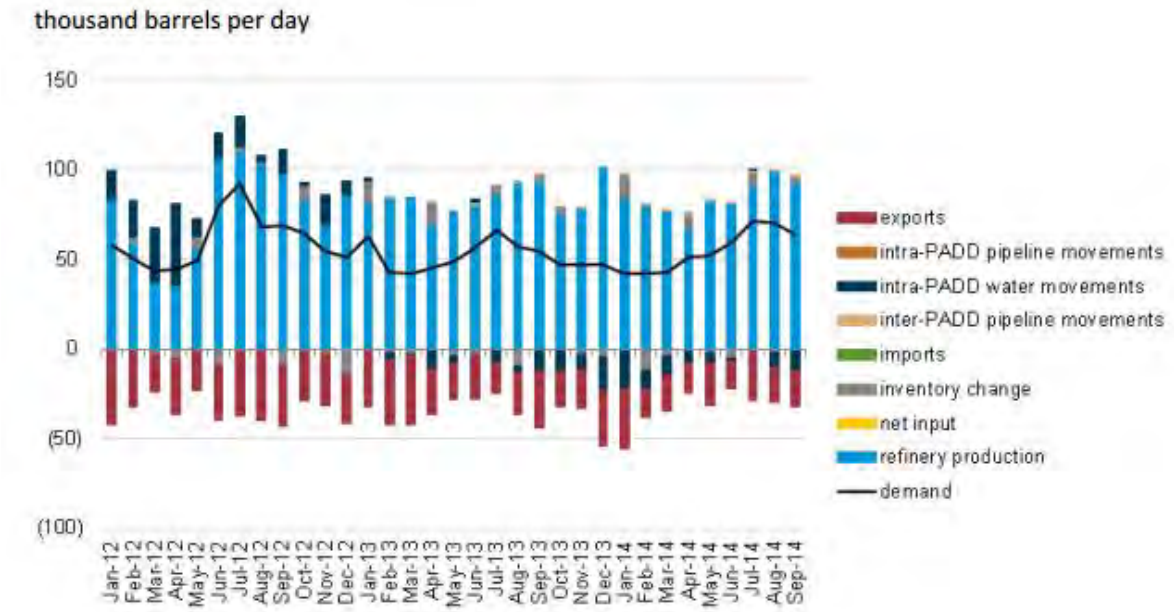
Figure 5: Pacific Northwest Product Supply (U.S. Energy Information Administration, 2015)



Source: Stillwater Associates analysis of U.S. Department of Energy - Energy Information Administration (EIA), 2015, PADD = Petroleum Administration for Defense Districts which are used to aggregate the U.S. states into 5 districts for data reporting and market analysis.

Although jet fuel production in the Pacific Northwest is higher than demand the region's refineries also export significant volumes, primarily to airports in British Columbia, Western Mexico, and occasional shipments to Northeast Asia and Latin America. In the past this has led to a slight imbalance in supply that was supplemented by production from California refineries, primarily via shipments directly to the Portland area. With flattening demand for all types of gasoline, refiners in the west coast have invested in upgrades to increase production of higher priced distillates, including jet fuel, leading to refinery yields of jet fuel increasing from 16.4 percent in 2009 to 17.3 percent in 2014. The increase in jet fuel yields, specifically in Washington State has led to a reversal in which ***the state's refineries now export jet fuel to other states in the region*** (*Figure* 6), including California, Alaska, and Hawaii. This surplus of production indicates that the refineries in the region are adequately prepared to deal with future increases in demand.

Figure 6: Pacific Northwest Jet Fuel Supply



Source: Stillwater Associates analysis of U.S. Department of Energy - Energy Information Administration (EIA), 2015, PADD = Petroleum Administration for Defense Districts which are used to aggregate the U.S. states into 5 districts for data reporting and market analysis.

The leaded AVGAS market continues to be primarily supplied by the local refineries in Washington State, however with continued decline in demand, and recent growth in unleaded gasoline demand for auto use along with prices ***there will be increased pressure on the refiners to decrease or completely stop production of AVGAS.*** Decreasing production will likely continue to put upward pressure on end-user prices which will likely help to accelerate trends towards alternative fuels. The trend in alternative general aviation fuels has led to growth in alternative distribution of fuels including self-service fuel stations, which tend to offer fuel at up to $1.00 less than full-service options. Other trends include some MOGAS volumes being transferred directly by individuals using items such as self-fill fuel cans and containers to aircraft at smaller general aviation and private airport facilities, in addition to the risk of fuel contamination, this trend represents a safety risk at smaller airports associated to flammable product spills and exposure to vapors. Some airports and fuel suppliers have helped decrease this risk by offering fuel trailers that are an inexpensive alternative to permanent facilities and may

be an ideal stop-gap until demand justifies the transition of existing AVGAS storage and pumps with MOGAS.

Mitigation of market price and supply factors

Both commercial and general aviation fuel users will continue to look for ways to decrease exposure to volatile fuel prices. ***In addition to investments in new and more efficient aircraft and engine technologies, continued work is being done to approve alternative fuels for use in existing aircraft*** (covered in the next section). Commercial airlines have increasing experience with fuel hedging strategies that have led to mixed results depending on actual market prices with airlines losing or gaining billions depending on the price(s) they hedged at the volume of those hedges[5]. Delta Airlines took fuel supply one step further by purchasing the Trainer refinery in Pennsylvania in 2012 (operated under Monroe Energy LLC), while the purchase helped guarantee supply and provide product pricing control, it exposes Delta to fluctuations in crude prices and refining margins[6]. Global airline alliances, specifically STAR Alliance members, have also pursued joint fuel purchases to take advantage of economies of scale and possible better contract deals with fuel suppliers at primary hub airports.

For general aviation users, future mitigation of exposure to volatile fuel prices will likely be similar to current trends with private pilots focusing on more direct routings, flying at slower speeds to reduce fuel consumption, cut back on flying hours, tinkering with fuel, and refueling at airports with the cheapest available fuel.

Market Developments in Fuels

Aviation gasoline (AVGAS) 100LL has been the most commonly used fuel by piston aircrafts in the US general aviation fleet. ***However, it remains the only leaded fuel used in US transportation today. Due to its harmful environmental impact, 100LL is being phased out by the Federal Aviation Administration (FAA) to be replaced by new unleaded fuel for general aviation by 2018***[7].

There are several reasons why MOGAS could be argued as a potential long-term replacement for the 100LL AVGAS. MOGAS was approved by the FAA as aviation fuel in 1982, and is already being used in general aviation. According to a recent study, about 80% of the current US general aviation piston engine fleet is capable of using, or obtaining the Supplemental Type Certificate (STC) to use MOGAS[8]. MOGAS is $1.14 cheaper than 100LL AVGAS, using the nationwide average across 3651 Fixed Based Operators (FBO)[9]. MOGAS is unleaded and thus satisfies one of the main reasons 100LL is being replaced.

There are industry concerns regarding the present supply of MOGAS. The Federal Renewable Fuel Standard program mandated addition of Ethanol to Autogas[10], making it undesirable for use in aviation[11]. There are some industry concerns regarding Ethanol possibly causing engine damage potentially as a result of the absorption of water. However, Ethanol-free MOGAS is still available at about 120 airports and from many distributors in the US[12]. Autogas is already distributed in large volumes by fuel pipelines, and can be transported from fuel terminals to airports via conventional fuel trucks[13]. There are also concerns over insurance and liability, as oil

[5] N.B., *Fuel Hedging and Airlines,* (Washington D.C.: The Economist, January 19, 2008).
[6] Linda Loyd, *Delta Profits from Trainer Refinery, Lower Fuel Costs,* (Philadelphia: Philadelphia Inquirer, April 17, 2015)
[7] https://www.faa.gov/about/initiatives/avgas/
[8] http://generalaviationnews.com/2012/07/12/new-study-shows-autogas-can-power-80-of-piston-aircraft/
[9] https://www.airnav.com/fuel/report.html
[10] http://www3.epa.gov/otaq/fuels/renewablefuels/
[11] Petersen Aviation Inc., http://www.autofuelstc.com/
[12] http://www.flyunleaded.com/airports.php
[13] http://generalaviationnews.com/2014/01/19/avfuel-eaa-and-mogas/

refiners do not approve the use of MOGAS for aviation, making it difficult to obtain aviation products liability insurance for its use[14]. ***Safety statistics are on MOGAS' side though, with an excellent safety record based on the 35,000 general aviation aircraft currently with the STC to run MOGAS***[15,16].

Swift Fuels has recently announced market release of the unleaded Octane 94 (Mon94) AVGAS at the 2015 Oshkosh Air venture[17]. Swift's Mon-94 AVGAS is expected to be compatible with aircraft that require lower-octane fuel. Aircraft with MOGAS STCs can already use this fuel, while those that require AVGAS can purchase the necessary STC to switch to the unleaded Mon-94. The Mon-94 AVGAS is derived from premium gasoline components but customized for the aviation specific standards, making it a commercially insurable aviation fuel. Mon-94 is expected to be cheaper than the 100LL, currently selling for $4-$4.25 by FBOs at airports that currently serve the fuel[18].

However, Mon-94 AVGAS is not going to be a single fuel alternative to the 100LL AVGAS. Swift Fuels is also working on a Mon-102 unleaded AVGAS, as part of the FAA's Piston Aviation Fuel Initiative (PAFI) program[19]. This fuel is still under evaluation by the FAA, and could serve as a fleet-wide replacement of the 100LL.

Due to their considerable cost advantages over gasoline engines, diesel engines may have found their way in the European aviation fleet, but their presence and use in the general aviation market in the US is still in its infancy[20]. Diesel engines are compatible with Jet fuel, which is less expensive than AVGAS. However, a fleet-wide switch from gasoline to diesel engines could be a difficult alternative compared to the other options discussed above to face the eventual shift away from the 100LL.

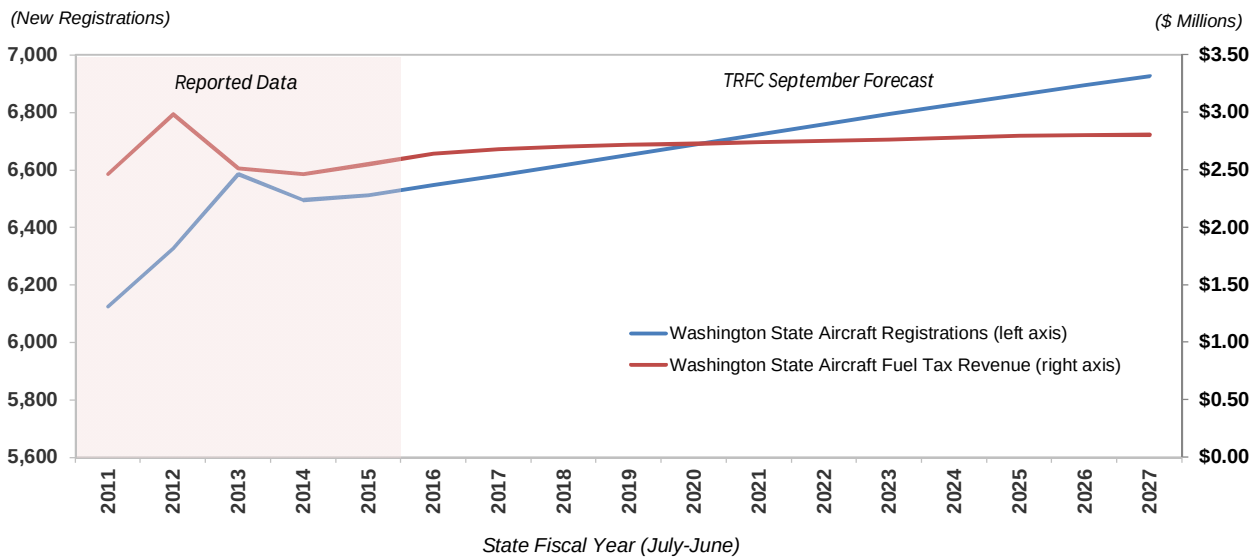
In addition to concerns over the lead content of the 100LL AVGAS, Sulphur has also been studied as a contender for mitigating its harmful environmental impact[21]. According to a recent study at the Massachusetts Institute of Technology, desulphurization of jet fuel would improve air quality and reduce 1000-4000 global deaths annually. However, the technology would cost the aviation industry $1-4 billion per year, which equates to an increase in the fuel cost by about 2%. The study also found that desulphurization would reduce the formation of cooling Sulphate particles that offsets global warming[22]. The authors point out that the costs and benefits of desulphurization of jet fuel are quite even in their analysis.

Washington State Market Outlook

The Washington State Transportation Revenue Forecast Council projects continued growth in aircraft registration and fuel tax revenue through Fiscal Year (FY) 2027 in their September 2015 forecasts[23]. Aircraft registration, which was up a quarter of a percent in 2015, is expected to grow by half a percent through the end of the forecast horizon in FY 2027.

[14] http://generalaviationnews.com/2013/09/30/the-mogas-debate/
[15] http://generalaviationnews.com/2011/03/16/10-mogas-myths/
[16] Petersen Aviation, http://www.autofuelstc.com/
[17] http://www.aopa.org/News-and-Video/All-News/2015/July/23/Swift-Fuels-to-offer-94-MON-avgas
[18] http://www.avweb.com/podcast/Podcast-Swift-Fuels-Chris-DAcosta-on-the-Road-to-a-100LL-Replacement-224588-1.html
[19] https://www.faa.gov/about/initiatives/avgas/media/media/PAFI_White_Paper.pdf
[20] http://www.flyingmag.com/aircraft/diesel-aircraft-engines-revolution?page=0,0
[21] Environmental Cost-Benefit Analysis of Ultra-Low Sulphur in Jet Fuel, Barrett et al, Partner, Partnership for Air Transportation Noise and Emissions Reduction, Massachusetts Institute of Technology.
[22] http://www.rsc.org/chemistryworld/2012/05/ultra-low-sulfur-jet-fuel-radar
[23] Washington State Transportation Revenue Forecast Council, *September 2015 Forecast Detailed Forecast Tables Volume II,* (Olympia: Office of Financial Management, September 24, 2015).

Figure 7: Washington State Aircraft Registration and Fuel Sales Forecast from September TRFC Report



Source: Washington State Transportation Revenue Forecast Council September 2015 Volume II

Aircraft fuel tax revenue, a proxy for aircraft fuel sales, was 3.6 percent higher in FY 2015 and is expected to maintain similar growth in 2016 as existing aircraft owners increase their flying time; afterwards growth is expected to slow to around half a percent through the end of the forecast horizon.

The reduction in growth in projected fuel sales will likely be the result of a combination of effects including continued improvements in aircraft efficiency, higher fuel prices, transition to alternative fuels that can be directly supplied (such as diesel and MOGAS) and slower growth in overall general aviation private aircraft registrations.

Carbon Taxes

A largely unknown factor is future carbon emissions regulations and taxation. The state of Washington is a member of the Western Climate Initiative, an agreement between Arizona, California, New Mexico, Oregon, British Columbia, Ontario, Quebec and Manitoba to "develop regional targets for reducing greenhouse gas emissions, participating in multi-state registry to track and manage greenhouse gas emissions in the region, and develop a market-based program to reach the target" (Western Climate Initiative Website – westernclimateinitiative.org). California instituted a cap-and-trade plan while British Columbia initiated a carbon tax in 2008. Washington Governor Inslee has come out in support of policies similar to California to institute a cap-and-trade program[24], which has not received strong political backing, while various individuals and organizations are endorsing a voter initiative I-732 in support of carbon taxes[25]. Experiences in California and British Columbia have seen an equivalent increase in the price of petroleum based fuels of $0.10 per gallon and $0.20-$0.30 per gallon respectively[26]. It is difficult to measure how much of this price increase is passed to the end user as some of the costs could be captured in lower refiner or distribution margins or through tax incentives meant to offset carbon costs for

[24] Jeff Spross, *Washington State is Gearing up a System to cut its Carbon Emissions,* (Seattle: Think Progressive, July 30, 2014).
[25] Jim Brunner, *Carbon-tax Initiative Divides Environmentalists,* (Seattle: Seattle Times, July 25, 2015).
[26] Alan Durning and Yoram Bauman, *17 Things to Know about California's Carbon Cap,* (Seattle: Sightline Daily, May 22, 2014).

producers who invest in technologies that reduce carbon emissions. In the cap-and-trade market some producers may end up profiting from the market by buying credits at lower current prices and selling them in future years if the prices of credits increase. ***Based on existing experience, the impact on prices due to carbon policies will likely be minimal in comparison to general economic factors and fluctuations in global and regional market prices for jet fuel and leaded AVGAS.***

Commercial airlines and the military have started to test alternative non-carbon intensive fuel such as bio-jet fuels made from used cooking oils, fats, and jatropha. Companies including Honeywell-UOP, Imperium Renewables, Neste Oil, Dynamic Fuels, Shell have produced bio-jet made from various types of feedstock that has been distributed by oil companies and SkyNRG for various commercial test flights. ***Over 35 airlines have participated in bio-jet test flights as of 2013.*** In Seattle, Alaska Airlines, and regional subsidiary Horizon Air, have led the effort through the use of 20 percent bio-jet made from cooking oil and meet product waste 80 percent conventional jet fuel blend in scheduled flights between Seattle and Washington DC and Seattle and Portland respectively[27]. The bio-jet and blended fuel was supplied to the aircraft by EPIC Aviation using dedicated and separate fueling infrastructure. In 2015 Alaska Airlines announced additional bio-jet test flights using bio-jet produced through Washington State University led Northwest Advanced Renewable Alliance. The 1,000 gallons of bio-jet will be produced using a feedstock of residual treetops and branches[28].

Although over 1,000 flights have been conducted with various blends of bio-jet, the technology is still being developed and proven, and the economics of bio-jet are relatively unknown. The production of bio-jet is similar to that of bio-diesel in terms of feedstock and manufacturing, which should provide a basis for assessing potential price differentials and performance compared to conventional fuels. However, the price elasticity of demand for jet fuel in comparison to diesel needs to be understood further, along with potential government financial incentives for the use of bio-jet. Unlike bio-diesel, which often receives a fuel tax exemption, conventional jet fuel is not taxed on international flights, and the tax on domestic flights remains relatively low, which will reduce the incentive to switch. Depending on the implementation of a potential carbon policy in Washington State and the associated costs and incentives, it is difficult to determine the potential impact on statewide demand for products.

In terms of general aviation, the same questions on performance and product standardization are being discussed along with testing to assess the potential for use of ethanol in AVGAS and MOGAS and bio-diesel in diesel fuels. Tests to date have proven inconclusive, and ongoing research is being conducted to assess the risk in use of both unleaded gasoline and gasoline blended with other octane enhancers.

Anticipated Impacts on Infrastructure Needs

Several of the industry trends outlined above would have potential impacts on refueling infrastructure requirements at airports. The increase in use of fuels such as MOGAS, diesel, and bio-jet could all require additional investments and oversight.

Fuel Supply and Distribution

Standard jet fuel will continue to be the primary fuel in the commercial aviation sector with some potential growth in bio-jet depending on pricing, carbon policy, and blend mandates. ***In the general aviation sector the price premiums for AVGAS over conventional gasoline, and continued reduction in availability of AVGAS will support the continued trend towards alternative fuels such as MOGAS, diesel and jet fuel.***

[27] Alaska Airlines, *Alaska Airlines Launching Biofuel-Powered Commercial Services in the United States,* (Seattle: Alaska Airlines, November 11, 2011).
[28] Washington State University, *Alaska Airlines Plans Biofuel Test Flight in WSU Partnership,* (Seattle, WSU News, June 3, 2015).

Current infrastructure for the production and distribution of jet fuel in Washington state should be adequate to handle future demand. Current demand still remains 20 percent below historic high levels indicating that ***the current infrastructure should be sufficient to handle a full rebound in the market which isn't projected until well after 2027-2028***. However, given the continued route growth by Delta Airlines and Alaska Airlines, who both maintain hubs at Seattle-Tacoma International Airport, there could be accelerated growth in fuel demand over what was previously forecasted. As such it will be important to monitor both airlines growth strategies to determine if and when expansion of on-site fuel farms may be necessary. Refinery production in the Pacific Northwest is also adequate to handle significant local growth in jet fuel demand with opportunity to divert foreign exports and shipments to other West Coast markets as required.

Depending on future carbon policy, fuel pricing, and technological acceptance, bio-jet may gradually be blended into the primary jet fuel supply, but until that time bio-jet will likely be used on a limited basis for demonstration flights or on specific test routes. Similar to ethanol and bio-diesel, bio-jet will likely be available for blending at the rack or on-site at the airport fueling facilities rather than at the refinery. This will help to avoid contamination of the primary jet fuel supply and blending downstream of the refinery, simplifying the process for assessing credits and meeting any specific bio-fuel blend mandates - if they are implemented. A majority of the jet fuel demand in Washington State is centered on military bases and Seattle-Tacoma International airport, which are directly supplied by the U.S. Oil and Refining facility in Tacoma and the BP Cherry Point refinery respectively via pipeline to onsite fuel farms. As such the opportunities for blending at offsite terminal facilities are minimal and if there were to be any blend mandates or trends towards increased use of bio-jet additional segregated distribution would be required. This would most likely be conducted by dedicated rail or truck deliveries in Washington State.

In the general aviation sector there is a risk of further reductions in production and primary supply of AVGAS to the market as the EPA increases pressure to remove lead and higher prices reduce demand for AVGAS and encourage transition to alternative fuels. There are only a limited number of global producers of Tetra Ethyl Lead (TEL), none in the United States, with Innospec in the UK being the primary supplier to the U.S. market. There are also three facilities in China that represent an increasing share of the global market, specifically the west coast of the United States. The two refineries on the West Coast that produce AVGAS are both in California and include the ExxonMobil facility in Torrance and the Chevron facility in Richmond. Given the limited number of suppliers of TEL and finished AVGAS, a further closure of a facility, discontinued production, or extended outage could have a significant impact on AVGAS prices and supply in Washington State. In addition the high cost of maintaining dedicated parallel infrastructure for the distribution of AVGAS or the extensive cleaning of equipment used in the handling of AVGAS for use with other petroleum products has become less economical as demand for AVGAS declines***. It is likely that with further reductions in demand, both the production and supply infrastructure for AVGAS, will be reduced or diverted to other products.***

As AVGAS is a relatively small share of the overall gasoline market, further shifts to MOGAS use in the general aviation sector would likely not have a significant impact on overall production and infrastructure in Washington State. However, there could be a significant challenge in providing MOGAS that is not blended with mandated ethanol if there are continued technological concerns with using blended MOGAS in aircraft engines. Providing unblended MOGAS will likely still require dedicated infrastructure downstream of the refinery gate, including pipelines, trucks, and terminals. ***A transition to diesel fuels will have a similar challenge in providing diesel that hasn't been blended with mandated volumes of bio-diesel and ensuring supply hasn't been contaminated with bio-fuel blends.***

Fuel Storage

Jet fuel storage capacity at Seattle-Tacoma International Airport is thought to be sufficient to handle near term demand, which will remain below historical highs. However, continued strong route growth by Alaska Airlines and Delta Airlines could accelerate the need for expanding storage and fueling facilities. It is expected that any further gate expansions will include fuel hydrant systems for direct supply.

Depending on future carbon policy, market prices, and bio-fuels blend mandates there could be growth in bio-jet consumption which would likely require dedicated parallel storage infrastructure, which could be accommodated by fuel trucks until volumes justify the building of more permanent terminal facilities and fuel hydrant infrastructure, at which point a standard market blend will likely have been established permitting full transition of the existing infrastructure to a Jet fuel bio-jet blend.

General aviation presents a more specific problem in that volumes tend to be small and some airports are relatively isolated and far from primary supply terminals. ***Continued changes in the market that lead to a combination of alternative fuels could require fuel storage infrastructure to handle AVGAS, MOGAS, diesel, and jet fuel.*** As of 2011, 94 airports in Washington State offered MOGAS, and only Pangborn Memorial airport outside of Wenatchee had a listed fuel tank capacity. Similarly 94 airports in Washington State offered AVGAS 80LL, and only Grant County International had a listed fuel tank capacity. The primary fuel offered is 100LL, with 99 airports offering the fuel and 61 of those with listed fuel tank capacity. Until alternative fuels demand justifies the transition of existing storage infrastructure to a specific fuel, parallel systems will be required. As seen in *Figure* 8 companies such as Aviation Pros and U-Fuel offer lower cost self-service equipment solutions starting at $35,000, this is compared to $400,000 or more for underground storage and pumps with a 20,000 gallon tank.

Figure 8: Alternative Fuel Supply Systems (Aviation Pros)

Figure 9: Mobile Fueler (Quality Fuel Trailers)

Other low cost options include fuel trailers (as shown above in *Figure* 9) that don't require a fixed location or significant capital investment and can be used as a short term solution until demand justifies more significant investments. Fuel trailers are becoming increasingly common at general aviation airports where multiple fuels are supplied but volumes don't justify investments in parallel infrastructure.

Summary

Airports and airport authorities face significant challenges in anticipating future fuel demand and increasingly, fuel types. While commercial aviation will still primarily rely on jet fuel, there is potential for growth in the bio-jet market to mitigate increases in prices related to carbon policies or blend mandates. However, either one would likely lead to widespread demand for jet fuel blended with bio-jet that could be accommodated with transition of existing infrastructure.

A greater challenge will be in general aviation and AVGAS supply. ***As the price differential between AVGAS and MOGAS, diesel, and jet fuel increases there will be increasing demand for access to those alternative fuels.*** Furthermore if one or more of the existing AVGAS suppliers were to stop producing AVGAS due to unfavorable margins and regulatory pressure to stop producing leaded fuels, there would be an immediate price impact that would lead to accelerated demand for a transition to an alternative fuel. ***Which alternative fuel is used will largely depend on turnover of the existing aircraft fleet and what products are being offered on the market. The most straightforward solution would be a transition to unleaded MOGAS but there are ongoing questions related to performance and safety that still require resolution before a large scale transition to MOGAS.*** Likewise the development of diesel engines (that burn diesel or jet fuel) could require the addition of two more fuel types at an increasing number of general aviation facilities. A cost effective means for addressing this challenge could be to invest in more temporary assets such as fuel trailers or above-ground self-service facilities until the industry has adapted a primary AVGAS alternative at which point existing permanent AVGAS infrastructure could be converted to handling that fuel.

As part of the WASP, WSDOT Aviation convened working groups to discuss aviation issues. A working group was established to discuss Aircraft Fuels. This group recommended the following actions be considered:

POLICY CONSIDERATION: The FAA and manufacturers should fund aircraft power plant recertification where required (regarding the new no-lead aviation gasoline).

POLICY CONSIDERATION: WSDOT should develop an outreach program to address/communicate the safety and benefits of MOGAS.

POLICY CONSIDERATION: WSDOT should support the FAA's lower octane No Lead AVGAS. Context – Products such as MON-94 are not refined locally and the distribution channel is problematic. The working group recommends that WSDOT work with the manufacturer/distributors to obtain the fuel, and airport sponsors to support fuel dispensing.

POLICY CONSIDERATION: The FAA should support the certification of Auto-fuel for aviation use.

POLICY CONSIDERATION: WSDOT should work with the FAA and WSU to educate the aviation community on bio jet fuel.

POLICY CONSIDERATION: WSDOT should promote options for dispensing MOGAS:

- Promote small systems of MOGAS
- Provide support guidance and educational information to airports
- Conduct education outreach to pilots.

POLICY CONSIDERATION: WSDOT should conduct pilot training to update pilots on various issues and listen to pilot concerns (These are related to goals of education and WSDOT should coordinate this effort with WPA similar to other statewide workshops).