# A FORMATIVE EVALUATION OF WASHINGTON STATE'S BIODIESEL RENEWABLE FUEL STANDARD

by

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ABSTRACT

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Jennifer L. Dunn

The increasing need to curb greenhouse gas (GHG) emissions, for climate change mitigation, has led the U.S. government to promote biodiesel as a fuel source. Biodiesel burns cleaner than petroleum-based diesel, prompting the federal government to establish the Renewable Fuel Standard (RFS), in order to increase its production and use. As a result of the federal government's biofuel policy, states have introduced their own policies to promote biofuels through renewable fuel standards, low-carbon fuel standards, etc.

Washington State, in 2008, introduced its own Renewable Fuel Standard for biodiesel to increase in-state production and increase feedstock supply. To date, no formative evaluations of the policy have been done, and most evaluations that have been done of other states' policies were completed prior to implementation. Through surveys and interviews with Washington State biodiesel industry leaders and stakeholders, this formative evaluation of Washington's RFS for biodiesel examined how certain sectors view the implementation of the RFS and the need for alteration or replacement. The results of this study suggest that the RFS is not enforceable, and that most sectors view a replacement policy as a necessity in order to target the real issue of carbon emission reduction. Based on these results and the literature reviewed, this study suggests that Washington State look into alternative options to the RFS that would more effectively achieve the same goals, and that stakeholders and policymakers create education and outreach programs to promote biodiesel statewide.

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# Chapter 1: Introduction

## Introduction

A change in petroleum supplies and advancement of climate change have led governments across the globe to reassess their transportation sectors and emissions. Governments have reacted to these changes in numerous ways, such as renewable energy portfolios that tackle each concern of supply, demand, and environment by energy type. In particular, for fuel most countries have chosen to diversify their portfolios by promoting advanced fuel sources such as ethanol and biodiesel. By endorsing these alternative fuels they are creating domestic production, increasing growth through job creation and investment within their country, and reducing dependence on foreign petroleum supplies. In addition, these countries are targeting the reduction of greenhouse gas emissions. Since policy is a factor that can lead to alterations in the environment, economies, and societies, it is essential to make them as strong and sound as possible to achieve the goals necessary for climate mitigation. One policy approach that does aid in climate mitigation is the continued promotion of biofuels to reduce emissions.

One form of policy that the United States uses for climate change mitigation is the Renewable Fuel Standard, which promotes biofuels by targeting emissions. The federal RFS, for the U.S., was created in 2005 to mandate certain percentages of alternative fuels that must be produced and used (DOE 2013a). Following this, several states implemented their own RFS and biofuel policies, including Washington State. This thesis assesses the Washington State Biodiesel Renewable Fuel Standard and sectors' views on how the policy is being carried out. An assessment of the policy is necessary, as there has been no formal evaluation completed of the mandate. This thesis begins with an exploration into the literature surrounding the federal RFS, how and why it was crafted and what current implementation issues exist. Then, the thesis turns to address states that have enacted an RFS or biofuel policy and what other policy options are available that could achieve the same goals as an RFS, at the state level. Following this, the literature review chapter then shifts to look at how and why Washington State's RFS for biodiesel was created and the gaps in literature surrounding its assessment. To assess the gap in the literature of an evaluation or assessment of Washington State's biodiesel RFS, the literature review chapter shifts to then focus on what types of evaluations exist for policy. The literature review revealed that environmental and economic assessments are the preferred choice of evaluation, but they often have shortcomings, as they fail to address social costs and sector views which are essential in revising policy or crafting new policy.

This thesis then addresses this literature gap through conducting a mixed-methods form of research, combining interviews and surveys from key individuals who are involved in the biodiesel industry in Washington State, to determine how different sectors assess or evaluate the biodiesel RFS.

The remainder of this chapter will provide the background necessary to understand biodiesel, its connection with the environment and climate change, and the histories and policies surrounding its usage at the federal and state level. This will be followed by a conclusion highlighting the intended outcomes and contributions of this thesis.

## Biodiesel

Biodiesel is a domestically produced, alternative fuel that is considered renewable because it is derived from vegetable oils, animal fats, and recycled grease. This alternative fuel source has a molecular structure similar to petroleum-based diesel, but burns with fewer emissions (DOE 2011). These decreased emissions are a huge attraction for this fuel source, which has led to multiple policies in order to promote the product, as well as increased funding and research to stimulate the market. Not only do the lower emissions attract governments and consumers to the product, but the plentiful feedstock does as well. The feedstock is purely plant- and animal-based which, if sustainably managed as a renewable resource, can be maximized through agricultural practices that produce optimal yields on a yearly basis (DOE 2003). The plants are a prime source for energy-creation because they derive their energy from photosynthesis, which can then undergo manipulation into other forms, while maintaining their energy potential (DOE 2003).

Biodiesel has become widely accepted as a fuel source and fuel additive across the globe, leading to its mass production in the U.S. of 128 million gallons in August of 2013 (EIA 2013). Additionally, biodiesel is growing in production and consumption because its chemical composition makes it biodegradable and nontoxic (DOE 2003; Santacesaria et al. 2012). Unfortunately, biodiesel can corrode rubber seals in older engines and is only suggested for use in diesel engines that were created after 1992 in the United States. Otherwise, modifications must be made to the engine to ensure compatibility (DOE 2003).

The corrosive nature of the fuel source and the blends will be discussed later in this section.

According to a study done by the U.S. Department of Energy (DOE), using pure biodiesel (100%) can reduce decrease “the fuel economy and power of diesel engines by 10%,” leading to an equivalency ratio of 1.1 gallons of biodiesel to one gallon of diesel (petroleum-based) (DOE 2003). In addition, because biodiesel is physically similar to diesel, it can be added at many blend percentages. Currently the most common blend is B20, which is 20% biodiesel and 80% diesel (Pahl 2008). The motivation for creating blends is to continually introduce and expand the biodiesel economy, while keeping the fuel source as economically feasible as possible, until the market is as competitive and resilient as petroleum-based diesel. The competition among fuels has led to many initiatives and legislation to help expand the biodiesel economy, but a true analysis of the state and national legislation’s effects on the market is limited. In order to accurately assess the policies’ role in the growth of a biodiesel economy, the role of agriculture and biochemistry need to be illustrated in order to demonstrate the overall constraints and possibilities that biodiesel has as an alternative fuel source.

## Biochemistry

Biodiesel was first created in 1853 by chemists E. Duffy and J. Patrick while they were experimenting with methods to create soap from vegetable oils. It was not until the 1890s that Rudolph Diesel created the first functional diesel engine to run on biodiesel made from peanut oil. Since Diesel's engine was created in the 1890s, biodiesel has risen and fallen in usage and popularity mainly in part because its competitor, petroleum-based diesel, has historically been cheaper to produce. During World War II, biodiesel usage rose as petroleum fuels were scarce, but usage subsided again after the war. It was not until the early 1980s, after the energy crisis of 1973, that biodiesel was first produced on a large test scale and seriously considered for use in the transportation sector. This step forward, in the industry, occurred because of Dr. Martin Mittelbach's attempt to expand biodiesel production and the transesterification process by recruiting support from farmers to test rapeseed biodiesel in their tractors across Europe (Pahl 2008).

Vegetables and plants that are oil-based are sought out for biodiesel production because of their chemical makeup. Chemically, a vegetable oil is composed of three fatty-acid molecules, which are connected to a glycerol molecule. Together, they form what is known as a triglyceride. Transesterification is when a vegetable oil, alcohol, and a catalyst are combined, which results with the glycerin being detached from the vegetable oil. This process makes the oil thinner and causes two products to form: alkyl esters (biodiesel) and glycerin (Pahl 2008). Ethanol and methanol are the most common alcohols used in this process, with methanol being preferred because it is cheaper and more reliable. There is a concern when using methanol because it dissolves rubber and has a higher toxicity than ethanol. The homogeneous catalysts that are commonly used in this process are sodium hydroxide (NaOH) and potassium hydroxide (KOH) (Pahl 2008).

The majority of large-scale, commercial biodiesel production uses sodium hydroxide as the catalyst, because it requires lower quantities to foster the chemical reaction. However, this process is very susceptible to water from moisture and the cleaning process, which leads to wastewater that cannot be reutilized in the production process. Since the transesterification process contains many variables such as oil, catalysts, water, etc., safety is a huge concern which has pushed the industry to look for alternatives for the current catalysts that will help to refine the process and decrease any risk associated with production (Huang, Zhou, and Lin 2012). One proposed solution is a heterogeneous catalyst that is solid and insoluble in methanol, which would result in a more cost-effective material because it would be reusable while creating less toxic waste (Huang, Zhou, and Lin 2012).

The transesterification process starts by mixing the alcohol, catalyst, and vegetable oil together. The correct quantities of each component are determined by the pH of the vegetable oil. In some cases, the process can be a little more complex because certain feedstocks bring free fatty acids into play. When used in the transesterification process, the free fatty acids can soak up too much of the catalyst, creating soap. This is remedied by ensuring that the ratio of catalyst is appropriate for the pH of the oil. Once mixed over a period of time, the oil molecules tend to “crack” and the methyl esters (biodiesel) float to the surface. In a large, commercial-scale biodiesel production facility, the average reaction time is about eight hours. After the appropriate amount of time has passed to complete the reaction, the glycerin and catalyst are removed from the bottom of the tank, leaving the biodiesel. This biodiesel is then washed with water to remove any excess traces of the unwanted products and then left to sit for a few days. The used water is toxic and most be disposed of properly, according to industry standards (Fukuda, Kondo, and Noda 2001; National Biodiesel Board 2012a; Pahl 2008). The general process is illustrated in Figure 1, with glycerin and biodiesel as outputs along with methanol. The presence of wastewater and excess catalyst material is not depicted in the diagram, but are byproducts in the transesterification process as mentioned above.

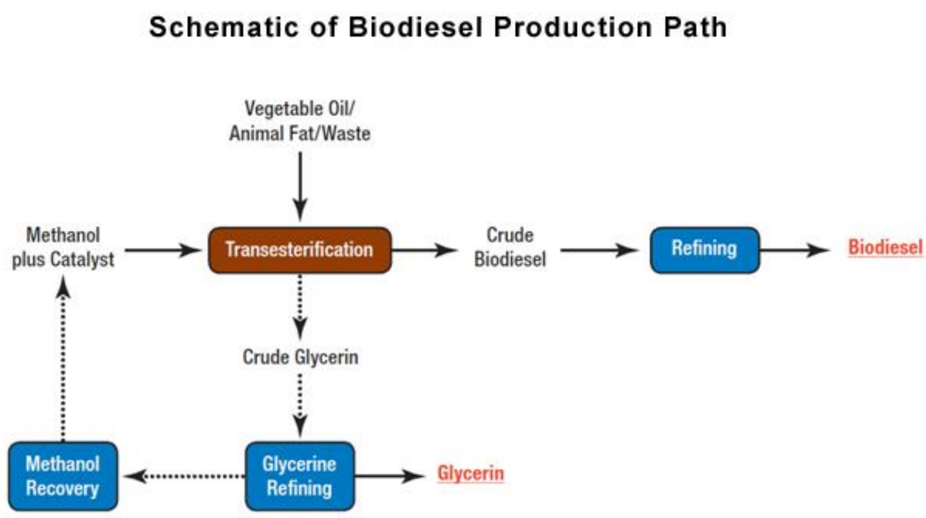


**Figure 1: Simplified Version of the Transesterification Process (DOE 2013b)**

For the most part, the process is simple, but it does require constant management and the technology still needs improvement in order to be cost effective for producers and to compete with petroleum diesel. The best method to improve cost effectiveness is through continued research of catalysts, low feedstock prices, and cheap distribution of the final biodiesel product.

## First-Generation Biodiesel Feedstocks

Biodiesel, as mentioned above, is produced from crops, discarded oil, animal fats, and recycled grease. Generally, biodiesel is produced from feedstock crops of soy, corn, rapeseed, cottonseed, peanut, sunflower, avocado, hemp, and mustard seed (Pahl 2008). For the purpose of this study, the feedstock to be concerned with is canola, as it is Washington State's primary source for producing biodiesel (Lang 2013).

Another potential feedstock is algae, but it is still in the experimental phase and is not yet in the commercial markets. Since the energy source that is tapped to create fuel from these crops is created from photosynthesis, biodiesel has also been called "liquid solar energy" (Pahl 2008). The feedstocks for biofuels have been categorized into two groups: "first-generation" and "next-generation" (WorldWatch Institute 2007). First-generation feedstocks are characterized as crops that are harvested for their sugars and oils, which are then processed into liquid biofuels. Next-generation feedstocks require more reliance on advanced technology to convert the crops to biofuels and are generally used in production of cellulosic ethanol. These feedstocks consist of tall grasses, woody biomass, and crops that have a high potassium content, which is problematic in conversion because they create unwanted compounds when heated at high temperatures (WorldWatch Institute 2007).

Palm oil is a common feedstock for much of the world because it has the highest yield, with 5950 liters/hectare. There are two types of oil extracted from the fruit of this crop and they are used to make products such as soap, candles, ice cream, and mayonnaise. It is mostly grown along the coast of the Indian Ocean and is not a desirable feedstock because it requires a large input of energy and heat to produce biodiesel (Pahl 2008). Additionally, in 2011, the EPA reported that biodiesel produced from palm oil only reduced GHG emissions by 17% when compared to petroleum-based diesel. Since this feedstock failed to meet the 20% reduction required by the Clean Air Act (CAA), production of biodiesel from this feedstock was halted in the United States (EPA 2011). The 20% reduction is a minimum requirement that falls under the CAA and is referenced in the federal RFS2, which requires that all renewable fuel produced in the United States must meet a 20% reduction of lifecycle GHG emissions. The RFS2 is the revised version of the United States initial RFS and was passed in congress in 2007 through the Energy Independence and Security Act. The RFS2 increased the requirement of gallons produced of each alternative fuel and expanded the definition of transportation sector vehicles to include off-road, locomotives, and marine vehicles (Schnepf and Yacobucci 2013). Under the CAA, biomass-based diesel must reduce emissions by 50% and cellulosic biofuels must reduce their lifecycle GHG emissions by 60%. This means that biomass-based diesel must reduce its emissions by 50% compared to its conventional counterpart (petroleum-based diesel). Since the federal RFS2 abides by and references the CAA, which was amended by the Energy Independence and Security Act of 2007 (EISA), palm oil does not meet the requirements and is not recognized as a feedstock source for biodiesel (EPA 2011; Solecki, Scodel, and Epstein 2013).

Jatropha (*Jatropha curcas*) is another feedstock plant, but it is commonly used to make lamp oil, candles, and pesticides. It is a medicinal plant found in the tropics of countries such as Brazil, Honduras, India, and much of Africa. This plant is widely used not only for its potential as a feedstock for biodiesel, but because it also helps with soil erosion and serves as a hedge or fence in some regions of the world. On average, jatropha can produce 1590 liters/hectare (Pahl 2008). Jatropha is viewed as a possible feedstock due to reduced production costs, because it is made up of inedible oils. The fact that jatropha will not compete with food uses makes it highly marketable for biodiesel, unlike corn, soybeans, and peanuts (Akbar et al. 2009).

Rapeseed (*Brassica napus*), which was first used to create biodiesel in Mittelbach's experiments, is commonly grown in Europe for livestock feed and in North America for canola oil. Rapeseed produces 1190-1500 liters/hectare. This crop is the most common feedstock for biodiesel production in Europe and accounts for 59% of the world's biodiesel production (Fonseca et al. 2010; Pahl 2008). Unfortunately, rapeseed production has limitations due to plant disease and crop rotation. It is advised that growers of rapeseed rotate their crops so as to not deplete the soil's nutrients. In addition, it is also advised that rapeseed fields should be left open for two years, between crop rotations, to avoid the spread of plant disease. Despite this restriction, the global growth of this plant increases about 2% annually (WorldWatch Institute 2007).

Peanut and sunflower oil can also serve as feedstocks for biodiesel, but are in constant competition with demand for their food purposes. Peanuts, on average, can create 1059 liters/hectare, while sunflowers can yield 952 liters/hectare. Since the major market for these crops is food demand, it is hard to warrant using the crop for biodiesel. Because of this competition, biodiesel derived from sunflower oil makes up only 5% of the world's biodiesel (Pahl 2008).

Soybeans, which are commonly used for livestock meal and oil, produce 446 liters/hectare. In addition to its common uses, the crop is also cultivated for shortening, paints, insecticides, and disinfectants. However, this crop is regularly used for biodiesel in the United States. In August 2013, 510 million pounds of soybean oil were used to produce biodiesel in the United States (EIA 2013). Unfortunately, it is not the most efficient crop to use for biodiesel production because it requires copious amounts of water and constant crop rotation. Despite these downfalls, soybean cultivation continues to expand across the globe because the plant has attractive qualities to farmers and the biodiesel industry. The soybean plant is able to grow in temperate and tropical climates, and is a nitrogen-fixing crop, meaning that it naturally restores the soil's nutrients and requires less fertilizer (WorldWatch Institute 2007).

Despite the abundance of agricultural feedstocks, farmers, producers, and policy makers are still hesitant about the role feedstocks and agriculture play in the production of biodiesel (Cassman and Liska 2007; Tenenbaum 2008). In addition, the technology and capital investment used for production is costly and can hinder investment in the industry.

## **Biodiesel Distribution**

Biodiesel distribution is comparable to ethanol distribution, as it is generally shipped by rail, since a majority of the refineries are not located along a pipeline. In some cases, only with permits, biodiesel can be transported a short length through pipeline, as long as it does not degrade the quality of the fuel or leave traces in the pipeline. Leaving trace amounts of biodiesel in the pipeline is unacceptable, as the same pipelines transport jet fuel, which can only have low traces of biodiesel or none at all. With repetitive use, harm to the pipelines can occur because most pipelines were initially constructed for petroleum and not biofuels (U.S. Energy Information Administration 2012). The exceptions to this restriction are on the individual company level. For example, Kinder Morgan has allowed trace amounts of biodiesel to be transported along its pipeline from Mississippi to Virginia, as well as its Oregon pipeline (U.S. Energy Information Administration 2012). The only way that biodiesel shipping will expand to pipelines is if the restrictions on biodiesel in jet fuel are relaxed or removed. In addition, heating points must be constructed on different sections of pipeline to accommodate for transportation of biodiesel through pipelines during cold weather. Lastly, with the continued growth of biodiesel infrastructure, investment may increase leading to the construction of biodiesel pipelines (McElroy 2007; U.S. Energy Information Administration 2012).

In terms of pump infrastructure for biodiesel, most pumps are able to accommodate a blend of biodiesel and diesel without modification. It is only if a higher blend percentage is introduced, that modification will need to occur on the retail side of distribution. As of 2012, the only pumps that required modification were in states that required a blend higher than B20 (EIA 2012). Prior to 2013, equipment used at biodiesel stations required a waiver from local authorities or jurisdictions to use dispensers and tanks that were not made specifically for B20. Existing tanks and pipes used for transportation of biodiesel had to be flushed clean before B20 was able to be used in the systems so as to avoid contamination from built up residue (Alternative Fuels Data Center 2013a).

*Percentage Blends*

Biodiesel can be blended at different levels, but it can also stand alone as a fuel source. If it is in its purest form, it is identified as B100, but if blended with petroleum diesel then it is identified by the percentage of the blend. The blend, B20, is used in order to comply with the Energy Policy Act of 1992. B5 and B2 are used widely across the United States and need few or no modifications to the diesel engine. In fact, they are quite unnoticeable by the user at these ratios (DOE 2005). According to the Department of Energy, the American Society for Testing and Materials International (ASTM International) developed the specifications for biodiesel blends within the United States. These low-level blends have been approved by the ASTM for use in diesel cars and trucks, tractors, and boats.

The most popular blend on the market is B20, because it is cost-efficient, limits emissions, performs moderately well in cold weather, and most diesel engines are compatible with it. In terms of cost effectiveness, this biofuel blend, and anything above it, qualifies for biofuel use credits under the Energy Policy Act of 1992. Lastly, B20 generally does not require engine modification because it has a higher lubricity than petroleum diesel (DOE 2013c). Petroleum-based diesel and biodiesel naturally serve as a lubricant in a diesel engine, but with the removal of sulfur compounds from petroleum-based diesel there is less lubricity than that present in biodiesel (National Biodiesel Board 2012b).

B100, according to the EPA, reduces CO2 emissions by 78% when compared to petroleum diesel. In comparison, B5 reduces emissions by 3.8%. Overall, biodiesel usage reduces, in miniscule amounts, the emissions of hydrocarbons, carbon monoxide, and particulate matter. On the downside, the Department of Energy acknowledged that biodiesel use could lead to a slight increase in nitrogen oxide (NOx), a component of smog (DOE 2005). The final downside to biodiesel, in comparison to petroleum diesel, is that the energy content is 10-12% lower due to the higher oxygen content in the biodiesel, which causes it to emit fewer emissions. This lower energy content makes it more favorable to use low-level blends of biodiesel (Pahl 2008).

A caution with biodiesel is its susceptibility to cold weather at higher blend levels. The common B20 blend can lower the functioning temperature of the fuel by 7° to 10° F. The susceptibility to cold weather is inherently determined by the feedstock and the blend percentage (DOT 2007). These cold weather issues also occur in petroleum diesel because the “cloud” point is at 32°F. When the cloud point is reached, the fuel filters become clogged and cause the engines to stall (Pahl 2008). When the temperature drops below freezing, the petroleum-based diesel reaches a point, called the pour point, which is “the temperature below which it will not pour” (Pahl 2008). With biodiesel, the cloud and pour points are altered and in colder climates and colder months, biodiesel must have additives to keep it from reaching these points. Unfortunately, the calculations must be very precise in order to avoid susceptibility to cold weather, which has caused many distributors to change to lower fuel blends in the winter months, since it is generally not seen in blends under B20 (Pahl 2008).

## **Economic Development and Policy**

Economics are a driving factor in the growth of the biodiesel industry at the global and national scales. Historically, biodiesel has been more expensive than its petroleum competitor. In October 2001 the earliest reported price date for B20 in the United States by the DOE, B20 was priced at $1.35/gallon while petroleum based diesel priced as $1.19/ gallon. The price difference between biodiesel (B20) and petroleum based diesel is not significantly large, but still enough to make B20 less competitive in the market (Alternative Fuels Data Center 2014). This has caused investors to stay away from the market until it is financially stable and able to stand alone from government subsidies and tax incentives. Despite biofuel prices, biodiesel continues to grow, due in part to the economics involved in the transportation and agricultural sector.

The transportation, retail, and production economics for biodiesel are all intertwined, not only with themselves, but also with petroleum diesel. The economics of biodiesel in the transportation sector start with the fact that the global transportation sector relies on the petroleum industry for 96% of its energy (WorldWatch Institute 2007). In addition, the United States transportation sector is responsible for 35% of the country's GHG emissions (DOE 1999; Pahl 2008). According to Pahl (2008), over 700 fleets in the United States are using biodiesel; this includes military and commercial fleets. The most observable users of biodiesel to the public eye are mass transit fleets. Fleets that use biodiesel span the country, including cities such as Olympia, Washington, and Oklahoma City, Oklahoma. That shows how dependent the sectors are on petroleum and how much biodiesel needs to accomplish in order to wedge itself into the market and become competitive.

As mentioned above, biodiesel is historically priced higher than petroleum diesel, but with increases in technology and feedstock supply, price differences between biodiesel (B20) and petroleum based-diesel are beginning to drop. In June of 2004, the United States saw the largest difference in price/gallon between petroleum-based diesel and biodiesel at a thirty-four cent difference. In January of 2014, the price difference between the two products was reported to be thirteen cents, which is significantly smaller than previous years (Alternative Fuels Data Center 2014). Table 1 indicates the price differences in January 2014 in the United States for different types of fuels. It is evident from this figure that diesel prices ($3.89/gallon) are generally lower than those of biodiesel ($3.97/gallon of B20) by roughly 8¢.

**Table 1: Average U.S. Fuel Prices in January 2014 (DOE 2014)**

| Fuel Type | Nationwide Average Price 1/2014 | Nationwide Average Price for Fuel Last Report (October 2013) | Change in Price This Report (January 2014) vs. Last Report (October 2013) |
|---|---|---|---|
| **Gasoline (Regular)** | $3.34/gallon | $3.45/gallon | $0.11 (-) |
| **Diesel** | $3.89/gallon | $3.91/gallon | $0.02 (-) |
| **Compressed Natural Gas (CNG)** | $2.09/GGE[1] | $2.09/GGE | $0.00 |
| **Ethanol (E85)** | $3.04/gallon | $3.04/gallon | $0.00 |
| **Propane** | $3.12/gallon | $2.96/gallon | $0.16 (+) |
| **Biodiesel (B20)** | $3.97/gallon | $4.02/gallon | $0.05 (-) |
| **Biodiesel (B99-B100)** | $4.28/gallon | $4.18/gallon | $0.10 (+) |

The benefits to biodiesel in the transportation market are that, unlike petroleum, the market is not dependent on unstable political alliances. Since biodiesel is generally produced domestically, it creates more revenue for the local producers and incites job creation. According to the WorldWatch Institute (2007), small-scale production of biodiesel helps with distribution cost, limits environmental impact generally associated with long-distance shipping, and brings profits to rural communities. On the large-scale production side, the company benefits because production costs are concentrated in one region, but it

[1] GGE is Gasoline Gallon equivalent, which means the amount of CNG it takes to equal a liquid gallon of gasoline (DOE 2014).

requires greater infrastructure for distribution. The major concern with either scale is that feedstock is generally 80% of the production cost.

The methods to remedy and soak up some of these costs have come in the forms of government subsidies and tax credits. In today's economy, the direct competition between oil and biodiesel rests in large part on the issue of subsidies. Subsidies for petroleum have historically been larger than those for biofuels. In 2005, the United States government subsidized ethanol with $100 million, which was roughly twice as much what was given to biodiesel. Not only does the federal government subsidize the biodiesel industry, but state governments also do, through incentives and tax credits. Most of the state subsidies come through assistance in construction of biofuel plants or exemptions from excise taxes (Koplow 2006; WorldWatch Institute 2007). An example of all the avenues through which the biodiesel industry receives subsidies can be viewed in Figure 2.

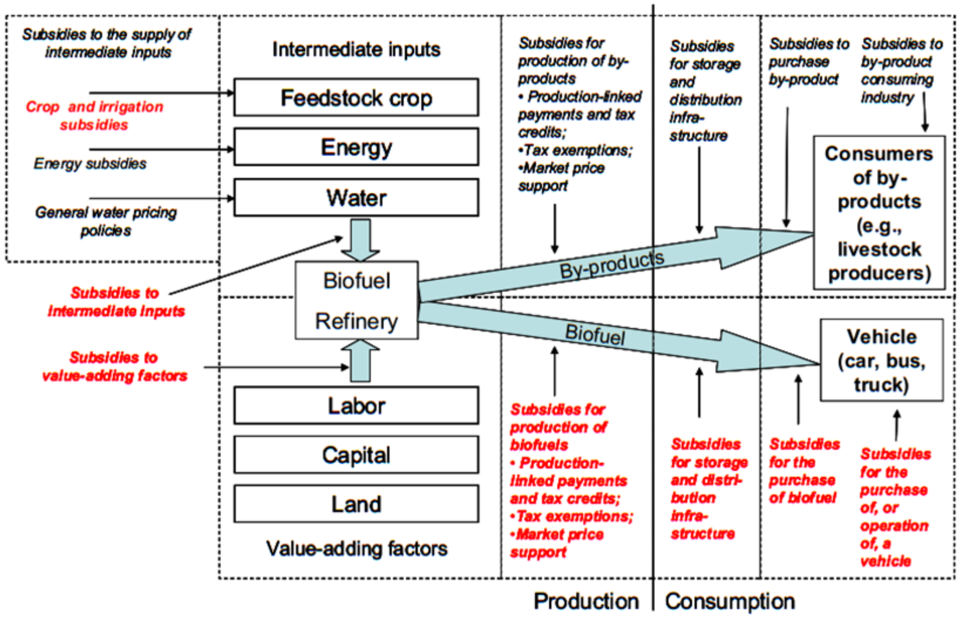


**Figure 2: Subsidies at Different Points in the Biodiesel Supply Chain (Koplow 2006)**

Despite subsidies across the globe for biodiesel production, there are still limited amounts of international trade of the product globally, it was estimated that 23,000 kilotonnes (Ktonnes) of biodiesel are produced annually, and in 2010 2,249 kilotonnes of it were traded internationally. This is a significant rise from the year 2006 that only saw the equivalent of 73 kilotonnes traded (see Table 2).

**Table 2: Total World Biodiesel Trade**

| | 2000-2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Total Trade (ktonnes) | 0 | 73 | 882 | 2,358 | 2,195 | 2,249 |

NOTE: Trade is measured in kilotonnes (Lamers 2011)

Although international trade is expanding, it is still limited because countries create policies that promote domestic production and consumption and limit trade through export tariffs (National Renewable Energy Laboratory 2013a).

A main reason that export from the United States is limited, is because biofuels produced in the US and shipped overseas do not count towards a producer's RFS requirements (Paulson and Meyer 2014). In 2009 and 2010, there was a huge decrease in imports and exports as the EU implemented countervailing and dumping duties to prevent what is referred to as "splash-and-dash." This term refers to the importation of biodiesel from a third country, to the United States, where a company then claims the U.S. Tax Credit for biodiesel and then re-exports the product to Europe, hence the splash-and-dash (Lamers 2011). The EU proposed policies that helped to fend off this type of trade and protect the quality of the product they were importing.

It was not until 2007 that the United States became a net exporter of biodiesel, but demand is limited due to policies promoting ethanol. With the expiration of the Volumetric Ethanol Excise Tax Credit (VEETC) in 2011, biodiesel export and consumption was predicted to increase, as seen in Figure 3 (Alternative Fuels Data Center 2013b; National Renewable Energy Laboratory 2013a). The VEETC is a tax incentive of $0.45 per gallon of ethanol blended with gasoline and is available to ethanol blenders. Exports are expected to rise with growing demand from Europe, while imports are expected to decline because the expiration of the VEETC means possibly more domestic consumption (Lamers 2011).

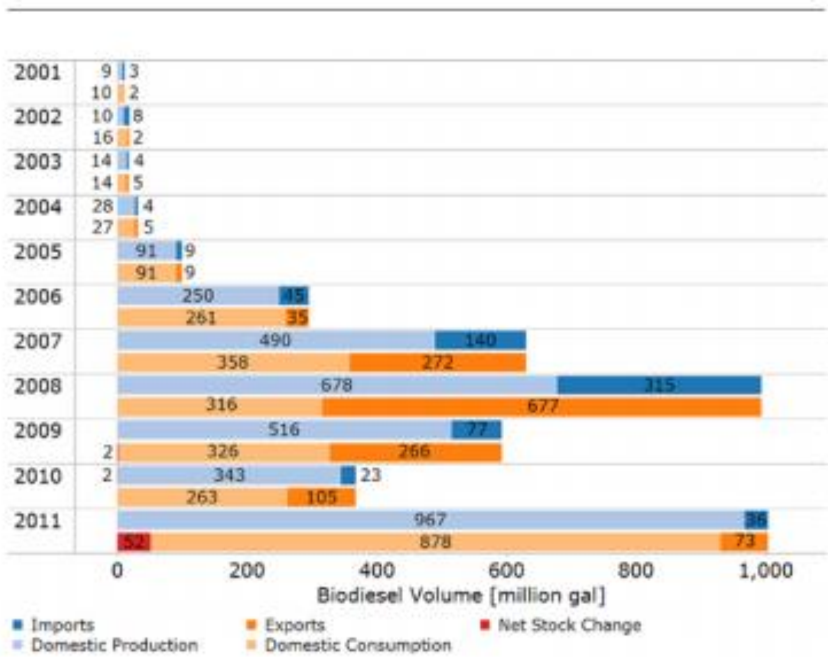


**Figure 3: Imports, Exports, and Production of Biodiesel for the United States, 2001-2011 (National Renewable Energy Laboratory 2013a)**

Since there is a limited amount of trade, this has been a major benefit and deterrent for investors. With no large corporations dominating the market, it has left the doors open for smaller producers to get their foot in the door, but it has also created unstable prices and demand. On the other hand, some tariffs can in fact help promote trade depending on how they are crafted and implemented. The United States participates in unilateral tariff reductions with developing countries, which encourages importation of some agricultural goods and biofuels. In terms of global tariffs around biodiesel, there are virtually no tariffs on whole oilseeds, but there are tariffs on the oil (liquid form of the feedstock) used for biodiesel. Although tariffs can affect trade, they are not the largest concern for promoting biodiesel trade, which is a fuel quality standard. The real issue with the market is not in the tariffs, but in a global standard for biodiesel quality (WorldWatch Institute 2007).

The agricultural sector raises some of the same short- and long-term concerns as the transportation sector when it comes to biodiesel. In terms of agriculture, the global market constantly struggles with demand and subsidies, which leads to an excess supply of some crops, such as corn. The biofuel market can help absorb some of this excess supply and transition land to more suitable oil crop cultivation for biodiesel. Removing excess supply helps raise commodity prices that have historically been low due to supply and subsidies. Not only does this aid the farmers, but it can also create more jobs. The downside of this switch to biodiesel crops is that short-term price increases can hurt food consumers. According to the WorldWatch Institute (2007), an increase of 1¢ in food prices leads to a decrease in consumption of food by three-quarters of a percent in developing countries. In the long-term, the economics surrounding biodiesel for the agricultural sector look promising with increased prices of oilseeds sold for feedstock, job creation, and less GHG emissions.

## Capital Investment

Capital investment is a huge determinant in the success of the biofuel industry in the United States of America. Biodiesel plants can be expensive, with estimated construction costs exceeding $80 million for a 50-million-gallon annual production plant (Einowski et al. 2006). Companies that have proven to be successful in financing, and who have weathered the recession, have a combination of capital investment secured through oil company support, strategic partnerships, co-locating near feedstock, and public support in the form of state and federal grants and loans (Solecki, Scodel, and Epstein 2013). Co-locating for biodiesel is essential because the cost of transporting food oils is rather high (Curtis 2010). Public investment for the advanced biofuel industry largely comes from the Department of Agriculture, Department of Energy, and the Department of Defense (Solecki, Scodel, and Epstein 2013).

Einowski et al. (2006), authors of the article *Law of Biofuels*, have classified financing for capital investment into two distinct categories—equity and debt—but they acknowledge that most successful projects require a creative combination of financing consisting of both categories. They define equity as being more expensive for sponsors than debt, but fortunately it is becoming more available for biofuel projects. The largest concern for an investor providing equity is the return on investment, projected earnings, and stability of those earnings. Debt financing is categorized as attaching a loan package to the project, which offers a guarantee to the lender that the debtor is creditworthy and will pay the loan in time, with interest. Debt financing is less of a gamble for those providing the financing than equity. The struggle to generate capital investment and support derives from the issues of policy uncertainty, lack of public support, and volatility in commodity prices of petroleum-based diesel and vegetable oil. Some researchers have even identified capital investment as the largest barrier to biodiesel industry growth in the United States (Solecki, Scodel, and Epstein 2013).

Since 2000, roughly 2 billion gallons of biodiesel have either been produced or are in the process of being produced, which is equivalent to an estimated $1.8 billion dollars of capital investment in the industry. This is low compared to ethanol, which has had an equivalent of 6.5 billion gallons produced, equal to roughly $10 billion dollars (Koplow 2006).

The final economic concern that could be placing constraints on biodiesel growth and demand in the United States is the “blend wall” (Robbins 2011). While, the blend wall is not currently an issue for biodiesel, but is for ethanol, it could soon become an issue in the coming years. The “blend wall” refers to the cap that the EPA has put on the amount of ethanol to be blended into transportation petroleum and sold at the pump. If the ethanol percentage blend remains low, this caps the amount of ethanol that will be in demand. Despite a shift towards higher blends of ethanol, this economic cap will remain in place until more research is done on the effects of ethanol on the environment. This can create an issue as federal RFS mandated ethanol floods the market causing it to exceed the maximum amount that can safely be added to petroleum. So, what does this in fact mean for biodiesel? Biodiesel markets could in fact have this same concern as states and the federal government introduce 2-5% biodiesel mandates, which will increase production that eventually exceeds that which is mandated and used leading to push for higher blend percentages (Snow 2013). Currently, biodiesel faces no blend limits, but it is unsure if it will have one in the future.

## **Environmental Concerns**

Biodiesel is inherently categorized as a renewable fuel source that is cleaner than its petroleum competition, but due to a rise in climate change awareness, large opposition has arisen against its use. Climate change awareness leads to opposition because individuals become skeptical of energy sources that are labeled renewable or sustainable, but may not be fully tested or may only be sustainable in certain conditions. Opposition to biofuels has arisen because of concern surrounding the sustainability of feedstocks, emissions counting, and negative environmental impacts that might not be evident yet since biodiesel production on a large scale is just beginning. Currently, numerous studies across the globe have highlighted the environmental concerns that are surrounding biodiesel: emissions, loss of biodiversity, water usage, soil degradation, and feedstock sustainability (Nanaki and Koroneos 2012). It is necessary to highlight the environmental concerns that surround the production of biodiesel as they can contribute to reasons why policymakers chose not to implement policies that promote biodiesel.

### *Land Use Change*

Demand for agricultural land will continue to increase as biodiesel markets continue to expand, calling for larger feedstocks. The International Energy Agency (EIA) noted in 2011 that around 65 million hectares of land will be used for biofuels by 2030 (International Energy Agency 2011). In a synthesis study done by Miyake et al. (2012), four pathways were identified as changing land-use for bioenergy production: 1) clearing of forests and grasslands for bioenergy cropland, 2) transforming livestock land to bioenergy cropland, 3) transitioning existing agriculture land to bioenergy crop land, and 4) converting waste agriculture land, in which there is soil depletion and limited water, to bioenergy feedstock land (Miyake et al. 2012).

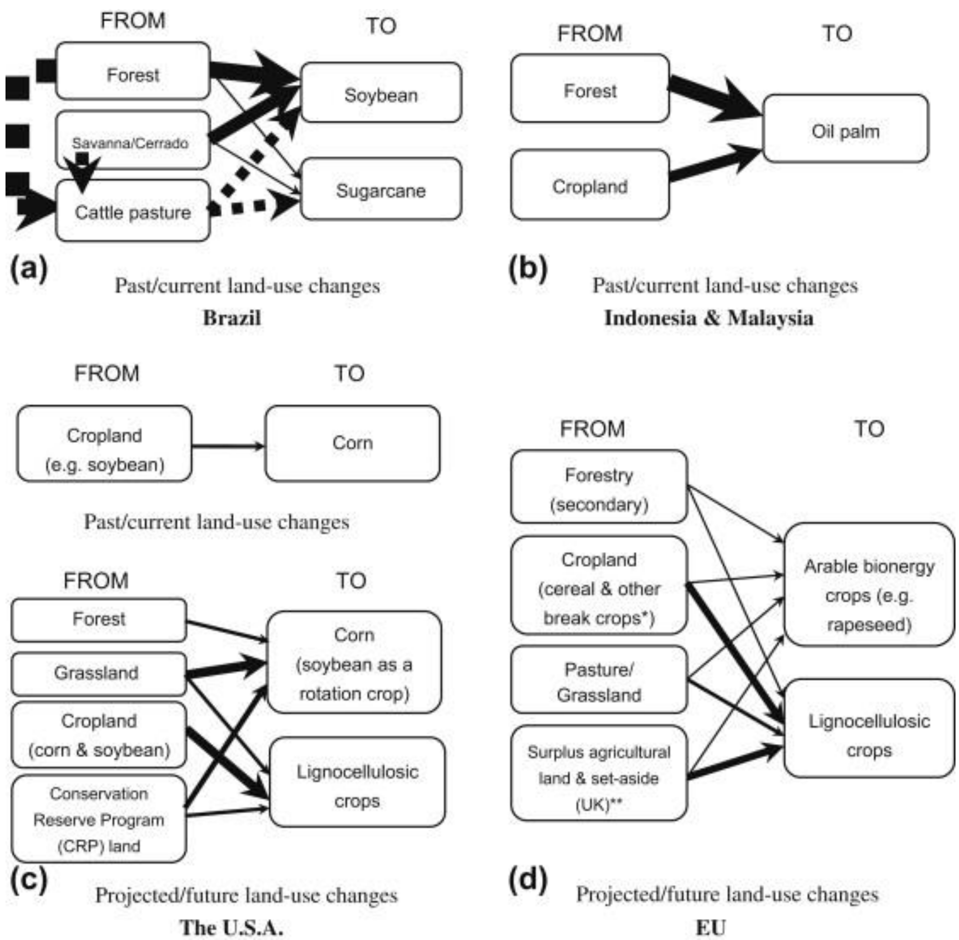


**Figure 4: Bioenergy Driven Land-use Changes**

NOTE— This figure highlights the four pathways by geographic region. The arrow width is proportional to the amount of documented land-use changes found by (Miyake et al. 2012).

The first pathway of transitioning forests to bioenergy cropland generally occurs in developing regions such as Asia, South America, and Africa, although it can occur in the United States and the European Union on a smaller scale. The negative externalities of using this pathway are that it destroys ecosystems, limits biodiversity, and can lead to deforestation which is a source of carbon emissions. The second pathway occurs mainly in Brazil, while the third pathway occurs in the United States and the European Union with a few occurrences in parts of Asia. The land-use change that occurs in the second pathway has caused concern across the globe, because it places livestock in tighter quarters and leads to a higher risk of disease being spread between animals and humans, as well as intensified pollution. It also brings into debate the issue of using human food crops to feed livestock (WorldWatch Institute 2007). Finally, the fourth pathway occurs in the United States and has raised concern because it does not produce as high a yield and because plants need more water on degraded land (Miyake et al. 2012).

Although land-use change is a cause for concern for some countries and communities, other communities view biodiesel as attractive because of its ability to change a parcel of land's use. Biodiesel can also be viewed as attractive because of the opportunity to change land-use based on the markets. This means that if there is a high demand for a feedstock crop that could grow in that region, governments and landowners can change their choice in crop to produce that specific feedstock and gain a higher profit (Pahl 2008). Despite the attractiveness of biodiesel to alter land-use, the concerns still remain, in large part because of the connection that land-use change has with emissions.

*Emissions*

The transportation sector in the United States accounts for 28% of the greenhouse gas emissions in the country. Biofuels can be viewed as solution to limit these emissions, but some are still skeptical of the role they can play due to uncertainty surrounding emissions created during the life-cycle of biofuel production (U.S. Environmental Protection Agency 2014). Emissions from biodiesel are a huge concern for investors and policymakers, especially when emissions are calculated through life-cycle assessments, because each feedstock, fuel blend, and production type has different emissions from production, distribution, and use of the product, from "cradle to grave" (U.S. Environmental Protection Agency 2012). According to a life-cycle analysis done by the National Renewable Energy Laboratory, biodiesel can lower $CO_2$ emissions up to 78% compared to its petroleum counterpart (Elms and El-Halwagi 2012; Huang, Zhou, and Lin 2012). It was determined that if the agricultural sector could limit its input of fertilizer and pesticide use, and the production plants could limit their energy usage as much as possible, then the net benefits of reduced carbon could potentially outweigh the land-use change.

The one thing that has been overlooked in LCAs, in the past, is the carbon released during land-use change. If land-use change is limited, then the carbon emissions of the biodiesel will not be as high but, in current models, it takes years for the carbon debt to be paid off if land-use change is involved (Searchinger et al. 2008). Besides emissions of $CO_2$, combusting biodiesel also emits sulfur oxides ($SO_x$) which, when combined with water vapor, cause acid rain. In comparison to petroleum diesel, however, biodiesel emits less of this gas. Lastly, in terms of emissions, the International Agency for Research on Cancer categorized petroleum-based diesel as containing carcinogens. Biodiesel has been determined to have fewer carcinogens, but can still be harmful to humans (Ng, Ng, and Gan 2010).

Opposition to and support of biodiesel are inevitable, but some groups, such as the IPCC, have chosen to take a more nuanced approach to the emissions debate surrounding biofuels. For example, the IPCC states "biofuels have a direct fuel-cycle GHG emissions that are typically 30-90% lower per kilometer than those for gasoline or diesel fuels. However, since for some biofuels indirect emissions—including from land use change—can lead to greater total emissions than when using petroleum products, policy support needs to be considered on a case-by-case basis" (Intergovernmental Panel on Climate Change Working Group III- Mitigation of Climate Change 2013). The International Institute for Sustainable Development (ISSD), on the other hand, has not been as diplomatic regarding biofuels by highlighting in their report, "Biofuels—At What Cost? A review of costs and benefits of EU biofuel policies," that biofuels—apart from some minor GHG savings—are worse for the environment and human health than fossil fuels. Research indicated that biofuels negatively impact health, terrestrial ecosystems, and deplete water sources. Lastly, the ISSD also cited that biodiversity loss can be attributed to biofuel production in the EU (Charles et al. 2013). For the purpose of this thesis, biofuels and biodiesel are viewed as a cleaner source of fuel than that of petroleum-based diesel, since their emissions are less, as they are required to reduce emissions by 50% compared to their petroleum competitor.

*Water Quality*

Water usage surrounding biodiesel is determined through the feedstock growth and the production process. Worldwide, the agricultural sector uses 70% of the world's freshwater (WorldWatch Institute 2007). Feedstock growth affects the water supply in two ways: production of the crop and runoff. Water plays an integral part in crop growth and is utilized through irrigation that is generally inefficient. When large amounts of water are used inefficiently, it can cause water prices to rise and limit the supply. The Environmental Working Group, a non-profit research group, opposed the federal RFS in 2008, in part due to concerns about water usage to produce biofuels. A survey done by the U.S. Department of Agriculture Farm and Ranch Irrigation Survey noted that corn ethanol production requires roughly 391,000 gallons of water per acre (Westenskow 2008). Compared to the crop alfalfa, which uses 1,500,000 gallons of water per acre the water usage is small, but against wheat, which uses 434,500 gallons/acre it is relatively close (Hanson 2009). The main concern with using the water is that it is viewed as such an expensive commodity that it might be a waste to use it on something that does not produce food or livestock feed.  On the runoff side of the water quality issue, fertilizers and pesticides are commonly used on biofuel crops and can seep into the ground water, causing contamination of the water supply. With the expansion of cropland for biodiesel production through the land-use change pathways, listed above, there is potential for water supply and quality to be altered, if it is not carefully regulated (National Research Council 2011; WorldWatch Institute 2007).

*Soil Degradation*

Soil degradation is another key environmental concern involved in biodiesel production. In general, when land is converted from a natural ecosystem to crop-producing land, the soil nutrients degrade over time. In order to limit the degradation, crop rotation, fertilizers, and pesticides are utilized, but this process lowers the biodiversity of the soil (WorldWatch Institute 2007). With continued annual production of crops, erosion also occurs, which leads to runoff, as mentioned above, and eutrophication. Eutrophication is defined as adding anthropogenic nutrients to natural water sources such as lakes and rivers (Chapin, Matson, and Mooney 2002). The upside to biodiesel's effects on soil is that certain feedstocks, such as with Jatropha, can restore depleted nutrients. One of the groups to question biodiesel usage, in regards to environmental concerns such as soil degradation, is the Environmental Working Group (EWG), normally a supporter of renewable fuels. This non-profit, research group was skeptical of supporting an RFS due to "unintended consequences" of a federal ethanol mandate (2008).

The unintended consequences listed are numerous, including fertilizer usage leading to nitrogen runoff causing concerns in the Gulf of Mexico and the possibility of soil erosion (Westenskow 2008). The EWG, noted that their main reasons for opposition to the federal RFS stemmed from concerns for the environment, suggesting that if the federal RFS was passed (which it was) that some form of environmental protection minimums needed to be enacted, such as soil sampling requirements, limits to emissions in crop production, and restrictions on water usage (Westenskow 2008). These environmental concerns will continue to exist until more testing and studies have been implemented, but the concerns can be lessened with government regulations such as Congress's ruling that the Environmental Protection Agency (EPA) must publish a report every three years assessing the current and potential future and environmental impacts associated with biofuel production (U.S. Environmental Protection Agency 2013).

## Overview of Washington's Renewable Fuel Standard

The Renewable Fuel Standard was introduced to the United States by the federal government in 2005 through the Energy Policy Act, but was altered in the Energy Independence and Security Act of 2007 (United States Congress 2005; United States Congress 2007). Since the implementation of the Federal RFS in 2005, it has undergone revisions, producing an updated RFS2 in 2010. Prior to the enactment of the federal RFS, only two states—Minnesota and Hawaii—had pursued this form of policy (Alternative Fuels Data Center 2013c; Mosey and Kreycik 2008; Schnepf and Yacobucci 2013). Since the enactment of the first federal RFS, seven states have joined the ranks to create state-level biodiesel RFS mandates, but two states suspended their mandates due to cost and inability to meet requirements. State RFS mandates began to occur as states found a need to comply with the federal law, while also pushing for industry growth and sustainability within their own state boundaries.

**Washington State Biodiesel Policy**

This thesis is an examination based on the Revised Code of Washington (RCW) 19.112.110 regarding the 2% biodiesel RFS mandate (Washington State Legislature 2006). The RFS was originally created in 2006 by the state legislature. At the time of Washington State's introduction of its RFS, only two states, Louisiana and Minnesota had introduced a biodiesel RFS, and Louisiana's was passed in the same year as Washington's (Mosey and Kreycik 2008).

The Washington State RFS initially had three goals (discussed in more detail, below): 1) institute a minimum renewable fuel content and fuel quality standards for biodiesel, 2) establish the Biofuels Advisory Committee and 3) demand state agencies to use at least 20% biodiesel in diesel vehicles and equipment (Senator Rasmussen et al. 2006) (Washington State House of Representatives Technology, Energy, and Communications Committee 2006). The Washington State Senate Bill ESSB 6508, which was the proposed bill to pass in the state legislature was implemented in 2006 and its companion bill in the House 2738, was let go, which is typical to the legislative process. These bills defined biodiesel according to the already existing definition by the RCW 82.29A.135, which states that biodiesel fuel is, "a mono alkyl ester of long chain fatty acids derived from vegetable oils or animal fats for use in compressionignition engines and that meets the requirements of the American society of testing and materials specification D 6751 in effect as of January 1, 2003" (Washington State Legislature 2014a). Although the legislation was passed in the 2005-2006 legislative session, the RFS did not go into effect until November 30, 2008.

*Goals*

The first goal of the Washington State Bill ESSB 6508 was to institute a minimum renewable fuel standard for biodiesel. The renewable fuel standard, which went into effect in 2008, requires that for all the diesel sold in the state of Washington, 2% must be biodiesel (Leidos 2013; McCullough et al. 2011). This went into effect in 2008, but the language of the bill established no enforcement mechanism. The Department of Licensing was charged with tracking the sales for the RFS, but was unable to do so because companies submit fuel tax reports, which are different than fuel sales reports. While the Department of Licensing was charged with tracking sales, they were not charged with enforcing the RFS as the Department of Agriculture was supposed to then receive the reports and enforce the mandate. The failure of the reports means there was no way to correctly measure sales from the beginning of implementation(Senator Rasmussen et al. 2006).

Since, it was implemented in 2008, there have been attempts to revise it through the introduction of bills in the state legislature, but none of the bills were passed. The first attempt at fixing the RFS came during the 2008 legislative session in which the Substitute House Bill 2512, was approved by the House Committee on Technology, Energy, and Communications, but made it no further in the legislative procedure. This bill would have made the RFS enforceable by forcing all special fuel licensees in the state to present evidence that at least 2% of its total diesel fuel sales are biodiesel (Representative Morris et al. 2008). In addition, the bill would have ordered the Governor to nominate a state agency to adopt new regulations to administer the RFS and reporting requests.

The next attempt at revision came in the 2010 legislature with the House Bill 2504, which was designed to change the volumetric RFS to a universal RFS, which is what Oregon currently has in place. This bill was introduced by the state's biodiesel industry with support from the Governor's Office, Department of Commerce, and Washington State Department of Agriculture (WSDA), but faced substantial opposition from the oil industry. After extensive revisions in the Senate Environment, Water, and Energy Committee followed by the Senate Transportation Committee, it was dropped and not voted on by the full senate (Representative Eddy et al. 2010a; Representative Eddy et al. 2010b).

In the 2011 Washington State Legislative Session the third attempt at revision of the RFS took place with an introduction of the House Bill 1606 by state agencies. This bill did not hold up in session and was dropped the 3rd Reading Calendar (Washington State House of Representatives Technology, Energy, and Communications Committee 2011). The final and last attempt at revision came in the 2012 legislative session with House Bill 2740, but it never made it out of the House Technology, Energy, and Communications Committee.

It was dropped on January 31, but was soon followed by an effort from Representative Liias to reintroduce the 2011 session bill (HB 1606) (Representative Liias et al. 2012; Washington State House of Representatives Technology, Energy, and Communications Committee 2012). To the dismay of Representative Liias, the bill was never picked up and dropped from the House Calendar on February 14th (Washington State Legislature 2014b). Despite these pursuits of revisions, the RFS for biodiesel still remains in its current unenforceable state and no evaluations of the mandate have taken place since the Biofuels Advisory Committee's report in 2007 (see paragraph below), which was written prior to the RFSs effect date in November 2008.

The second goal of the bill was to create a Biofuels Advisory Committee, which was created in 2007. This committee includes stakeholders from different sectors, such as industry representatives from oil companies such as BP America and Conoco Phillips, academics from Washington State University, and state agency personnel from the Departments of Ecology, Licensing, and Transportation.

The committee was created as a compromise during the legislative session under the bill ESSB 6508, and was charged with offering suggestions to the Director of Agriculture about the RFS before it would go into effect in 2008. At the time of the committee's report submission in 2007, the RFS had passed the state legislature, but would not become active until a year later. The report AGR PUB 110-197, crafted by the committee, reported that the state was in a great position for successful implementation of the biodiesel RFS (Washington State

Biofuels Advisory Committee 2007). Since this report was done prior to implementation, there has in fact been no formal written evaluation of the biodiesel RFS for Washington State since its implementation in 2008, but there have been two academic papers that discuss the RFS briefly and promotion of a biofuel industry in the state. The first academic paper was written by professors at WSU in December 2008, as directed by the Washington State Legislature in 2007 and provided recommendations for bioenergy market incentives and research (Yoder et al. 2008). The second, academic paper written in 2011 is mentioned in Chapter 2; section: Environmental Analysis because it employs a Computable General Equilibrium Model (CGE) (see page 63).

In addition to supporting the RFS, the committee supplied recommendations for successful implementation. The recommendation topics are: 1) fuel quality, 2) feedstock agronomics, and 3) feedstock economics (Washington State Biofuels Advisory Committee 2007). The fuel quality recommendation was that there be continued support of Washington State's Department of Agriculture (WSDA) Motor Fuel Quality Program, which continues to educate and monitor fuel quality. This is essential for biodiesel because the program monitors biodiesel quality and if this is compromised it could lead to loss of consumer confidence in the product and potential loss of retail and export markets (Washington State Biofuels Advisory Committee 2007). Not only did they recommend support, but also continued monitoring and annual reporting. The second recommendation involved the agronomics of feedstocks for biodiesel and suggested that the state secure financial support for short-term research regarding feedstocks. Financial support for research is essential to growing the biodiesel industry and, therefore, the committee recommended that there continue to be cooperation between WSDA and research institutions, such as Washington State University (WSU). The final recommendation provided by the committee regarded feedstock economics. The committee recommended reviews of federal and state support and incentive programs for growing feedstock; funding for education and outreach regarding feedstock; and launching a feedstock database for insurance purposes (Washington State Biofuels Advisory Committee 2007).

The final goal of the bill ESSB 6508 was to demand state agencies use 20% biodiesel in their fleets and was implemented June 1, 2009. From the three main goals of this bill, this one has been the most successful in promoting a biodiesel industry in Washington. In the first six months of implementation from June 2009 to January 2010, the fleet purchased 172,000 gallons of biodiesel (General Administration State of Washington 2010). In 2010, state fleets purchased over 480,000 gallons of biodiesel. In 2012, Washington had almost doubled that amount, purchasing over 840,000 gallons, with the majority of it being used for the state ferry system. In the state of Washington, according to state officials, the state agencies are leading the way in promoting and using biodiesel (Lang 2013).

For the purpose of this study, five other goals were connected with the RFS and biodiesel industry growth in Washington. These goals were developed from the Washington State House Bill 1303 in the 2007-2008 legislative session a year after the RFS was passed, but before it actually went into effect. This bill developed five goals: 1) increase production of biofuels, 2) increase in-state production of biofuel feedstocks, 3) reduce petroleum dependence, 4) reduce carbon emissions, and 5) foster environmental sustainability (Representative Dickerson et al. 2007; McCullough et al. 2011). These goals are what the state has focused on moving forward in promoting a biofuel industry in the state of Washington.

## **Conclusion**

Although Washington's RFS policy was intended to boost biodiesel production in the state, it has fallen short of its goal, and a formative evaluation would be beneficial to determine the next steps—whether it should be scratched all together, or modified to craft new legislation that aims to achieve the same goals of increasing state feedstock supply, increasing state biodiesel production, decreasing dependence on petroleum, decreasing carbon emissions, and fostering environmental sustainability (Leidos 2013; McCullough et al. 2011). Such a formative evaluation is the purpose of this thesis. It is anticipated that the results of this thesis will improve understanding of Washington State's Biodiesel Renewable Fuel Standard and may contribute to its revision or replacement in state policy. State agencies and the state's biodiesel industry might find the study useful in their own efforts to evaluate the RFS policy and push for different policy outcomes. The results of this thesis may also be valuable to academics and policymakers who are looking to identify the next steps, as well as being helpful to others in the state and region concerned with biofuels and climate change policy.

Through surveys and interviews with individuals involved in different sectors of the biodiesel industry in the state of Washington, this study attempted to determine how different sectors view the implementation of the RFS for biodiesel and to identify views on the next steps in state-level policymaking for biodiesel. As will be seen in chapter four, the results of this study suggest that the majority of the sectors agree on determinants that hinder and contribute to the success of current policy, but their recommendations differed with respect to goals and necessary policy alterations. This study found that there is agreement that a mandate, either in the form of a state RFS or carbon tax needs to be implemented.

This thesis intends to fill a gap in literature regarding written formal evaluations of the Washington State RFS, but specifically formative evaluations, since the Biofuels Advisory Committee created a report that was completed before the effective date of the RFS. Chapter two will review the literature surrounding renewable fuel mandates at the federal and state levels, including reasons for enacting such policies, implementation issues, and alternative policy options. In addition to reviewing RFS policies, the literature review highlights the different forms of policy evaluations such as economic, environmental, and social that exist. The evaluations are broken into environmental, economic, and social and other forms. The chapter concludes by addressing how this thesis fills the gap in literature surrounding the Washington State's biodiesel RFS.

The third chapter highlights the methods used in the study to conduct surveys and interviews. In addition, this chapter notes why this form of evaluation was chosen and how different individuals were chosen to participate in the study. The fourth chapter, reports the results and discussion from the study, highlighting that certain goals and environmental determinants were preferred by certain sectors. The interview results reported in chapter four are broken down into six distinct themes that the sectors as a whole mentioned, which need to be addressed by a revised state RFS. Lastly, the chapter provides a discussion of the results and the intended outcomes and contributions it can provide to the literature. The final and fifth chapter concludes the thesis by indicating how this study fits into the bigger picture of biodiesel policy and why biodiesel policy is important moving forward for climate change mitigation.

## Chapter 2: Literature Review

### Introduction

Research for this study was conducted on federal and state biodiesel policy, policy analysis, economic policy analysis, and biodiesel production. There has been a good amount of literature in the last fifteen years regarding biodiesel, but only in the last ten years have renewable fuel requirements at the state and federal level been established. At the time of Washington State's issuance of a RFS for biodiesel, only five other states in the US had state-mandated RFSs (see Table 3). This literature review will discuss the policies that have led to the establishment of Washington State's RFS and how this study design was chosen over other research methods that help to understand and address the formative questions surrounding a policy mandate. In short, there have been few analyses done regarding state-level RFS programs, especially those highlighting stakeholder views of the policy.

### Federal Biodiesel Policy

Studies regarding the federal RFS are numerous, with the National Renewable Energy Laboratory serving as the best source for program components and implementation. The National Renewable Fuel Standard Program was established by the 2007 Energy Independence and Security Act (EISA) and has been altered on an almost yearly basis. The federal government created the program in an attempt to increase the production of renewable and alternative fuels for the transportation sector. The program, as mentioned above, was finalized through the EISA in 2007, but the call for it was established by the 2005 Energy Policy Act (DOE 2013a). The requirement holds that by 2006, 4 billion gallons of renewable fuel must be used in the nation and it was increased to reach a volume of 7.5 billion gallons by 2012 (Schnepf and Yacobucci 2013). The requirement has since been annually evaluated and broken down into different renewable fuel types, requiring that the country use a certain percentage of specific types of renewable fuel. These types consist of biodiesel, cellulosic ethanol, and advanced biofuels. Cellulosic biofuel is derived from cellulosic waste such as agricultural waste or wood waste. This fuel is only certified and considered cellulosic biofuel if it attains a 60% reduction in greenhouse gas emissions. Biodiesel, also referred to as biomass-based diesel, is a renewable fuel transportation additive or blend made from oil-seed crops and waste oil, and is only certified as biodiesel if it attains a 50% reduction in greenhouse gas emissions. Lastly, advanced biofuels are defined as any renewable fuel, not derived from corn ethanol, that reaches a 50% reduction in greenhouse gas emissions (U.S. House of Representatives Committee on Energy and Commerce 2013c). In addition to the volume requirement being evaluated, the Energy and Security Act of 2007 changed the RFS to the RFS2 and included all diesel fuel used for highway motor vehicles, non-road, locomotive, and marine diesel (Schnepf and Yacobucci 2013).

The EISA, once enacted, built upon the RFS1 to create a stronger RFS2 with four main distinctions between the two policies. The RFS2 increased the volumes mandated, extended the time frame to 2022, and divided the volume mandate into four distinct categories of renewable fuel. Also, under the RFS2, each of the four categories of fuel has a standard of GHG emissions reduction they must meet. Lastly, the RFS2 requires that all fuels be derived from feedstocks that meet an updated definition of renewable biomass and land-use change restrictions (Schnepf and Yacobucci 2013).

On a yearly basis, the Environmental Protection Agency (EPA) completes a report that determines parties' obligations for the RFS. This obligation is titled as the Renewable Volume Obligation (RVO), and has been renamed and carried over into states' RFSs. This standard is crafted by dividing the amount of renewable fuel (gallons) required each year by the amount of gasoline expected to be used that year by the transportation sector. Then, any party that produces, imports, refines, or blends oil in the United States is branded as a required party and given a RVO. To track parties' compliance with the RFS, the Environmental Protection Agency must create Renewable Identification Numbers (RIN) to signify renewable fuels produced or imported. There is a trading system that is in effect, so that parties can buy RINs so they are in compliance with their RVO, but the parties involved in the trading must be registered with the EPA for the sale to be legitimate. All RIN ownership is reported on a quarterly and annual basis to the EPA's Office of Transportation and Air Quality. This is required so the EPA can track the emissions that are connected with renewable fuels (DOE 2013a).

According to the National Renewable Energy Laboratory (NREL), the renewable fuel standard has been defined as a "policy mechanism that focuses on building a market for renewable fuels in the transportation sector" (NREL 2013).

When enacted properly, an RFS can correct for market failures such as petroleum infrastructure dependence, risk of development, limitations of public knowledge, and uncertainty regarding investment costs and benefits (Mosey and Kreycik 2008). The RFS requires a percentage mandate, but the actual implementation of it can vary depending on the geographic region and the economy. A typical RFS, such as the federal RFS, implements the requirement at the producer-level through volume obligations, but other RFS mandates, such as those implemented by the states, implement at other parts of the supply chain.

*Implementation Issues of the RFS*

States have had a different experience with the federal RFS and have begun to implement their own RFSs under the umbrella of the federal mandate. States' experiences differ based upon geography, resources, goals, and economies. These differences translate into distinctive forms of the mandate through cost differentials, feedstock incentives, and transportation infrastructure. The NREL has stated that although an RFS can be implemented anywhere in the country, certain characteristics make a state a stronger candidate for this type of program. These factors are feedstock supply, commitment to the biofuels industry within the state, public outreach and market accessibility for biofuels and advanced fuel vehicles, and state commitment to a cleaner burning fuel supply or reduction of greenhouse gas emissions (NREL 2013).

An RFS policy is successful when it encourages innovation of renewable fuels production and use in a low-cost manner, with limited cost to the state from subsidies. The NREL has associated the following designs of the mandate with being the most effective in promoting a biofuel economy: 1) stringent specifications of higher blend usage of alternative fuels; 2) adoption of a plan that will lessen measurement and accounting of RIN burdens and help ensure that alternative fuel targets are; 3) avoiding a trigger mechanism, which is safe guard put in place to waive a mandate if the targets are not able to be achieved, because it potentially could reduce investment; 4) resilience and adjustability of fuel requirements to allow for innovation and realistic market outcomes; and 5) employment of verification and measurement standards that ensure attainment of the RFS goals (NREL 2013).

In article written by Bruce Babcock, a professor at Iowa State University, it was noted that critiques of the RFS come from the claim that it “picks a winner,” since the outcomes of the policy do not stem from a realistic market situation (Babcock 2007). Researchers and the National Renewable Energy Laboratory (NREL) have published studies that suggest a “technology-neutral” policy to remedy this concern (Hahn and Cecot 2008; NREL 2013; Schnepf and Yacobucci 2013). A more neutral policy allows for winners and losers to be established through the market via a carbon tax, cap-and-trade system, or a floor price on imported petroleum. Hurt et al., point out that the RFS should be monitored to assess its continued utility (Hurt, Tyner, and Doering 2006). For example, after initial implementation, some of the federal incentives for the ethanol industry were no longer necessary, since it wasn’t in its infancy and had been generating a profit, making continued incentives a waste of tax payers’ money. Addressing the change from the RFS1 to the RFS2, the NREL noted that the mandate could have unintended consequences in other areas of policy importance that might be overlooked in their connection with biofuels, such as fleet accommodations, energy security, and commodity markets (NREL 2013).

The United States House of Representatives Committee on Energy and Commerce recently produced a series of five papers addressing concerns about the federal RFS. These white papers were published as a review of the RFS since its last revision over five years ago. Each white paper provided an overview of an issue and solicited comments from stakeholders. The issues addressed in the white papers are 1) blend wall/ fuel compatibility issues; 2) agricultural sector impacts; 3) greenhouse gas emissions and other environmental impacts; 4) energy policy; and 5) implementation (U.S. House of Representatives Committee on Energy and Commerce 2013a, 2013b, 2013c, 2013d, 2013e).

The first and initial white paper highlighted the blend wall and the concern that, in order to achieve the RFS mandate goals, higher percentages of ethanol blend must be approved for use in transportation vehicles. As mentioned above the "blend wall" refers to a barrier in the ethanol industry caused by a cap placed on ethanol allowing it to only be blended at certain low levels, until the environmental effects of it can be fully assessed. This cap ultimately reduces the amount of ethanol in demand. According to the paper, the blend wall is advancing sooner than expected. The largest problem with increasing blends allowed in vehicles is that the EPA must waive the Clean Air Act requirement that any new fuel being introduced must meet certain emissions standards on a life-cycle basis.

Therefore, the blend wall is a becoming a concern for the RFS ethanol targets, because if the blend wall is reached demand will go down and ultimately production targets will not be met (U.S. House of Representatives Committee on Energy and Commerce 2013a). State RFSs fall under and observe the guidelines and restrictions of the federal RFS and therefore could see the blend wall as a cause for concern in their state economies as well

The second white paper highlights the agricultural sector impacts of the RFS, such increased feedstock price, job creation, and land use change. The paper highlights that the RFS has received both support and opposition from the agricultural sector. Support has come from producers of corn, soybean, and other feedstock crops, due to increased prices for their crops. An example of this is corn, which averaged around $2.15/bushel during the years of 1997 to 2006, and, in 2013, had risen to roughly $7/bushel. This increase in prices is similar for biodiesel feedstock crops, such as soybean (U.S. House of Representatives Committee on Energy and Commerce 2013b). Opposition to the federal RFS comes from farmers who use the same feedstock as meal for their livestock. In 2012, ten state governors requested the EPA to waive the Federal RFS in their states for this exact reason (U.S. House of Representatives Committee on Energy and Commerce 2013b). State-level RFSs face these challenges from the agricultural sector as well because commodity prices are volatile.

The third white paper, titled "Greenhouse Gas Emissions and Other Environmental Impacts," focuses on the intended benefits that the RFS was supposed to produce by encouraging renewable fuel usage nationally. The largest concern of the RFS's implementation regarding environmental impacts is the validity of LCAs. LCAs are complex in nature as timeframe, inputs, and outputs are all variable, leading to uncertainty in the methodology. To help mitigate some of the concerns regarding environmental impact uncertainty, the EPA is required to report to the U.S. Congress every three years about the perceived environmental benefits and impacts of the RFS. The first report to Congress by the EPA, titled "Biofuels and the Environment: First Triennial Report to Congress," found numerous negative environmental impacts of the federal RFS but categorized them as minimal in scale and chiefly associated with the increase of ethanol production (U.S. Environmental Protection Agency 2011). These concerns with ethanol production stem from the choice in feedstock, land use change, and conservation methods (U.S. Environmental Protection Agency 2011). Environmental impacts of RFS mandates are unclear due to the uncertainties involved with Life-Cycle Assessments (LCAs). This uncertainty has caused opposition in legislatures and led to the failure of some states to pass RFS mandates or similar legislation (U.S. House of Representatives Committee on Energy and Commerce 2013c).

The fourth paper raises the issue of energy policy and how the RFS was created to provide energy security nationally and stabilize the cost of fuels by limiting imports and promoting domestic production. This paper noted that some reduction in petroleum consumption has been attributable to the RFS, but it is unclear how much. The main concern this paper raises is whether or not the RFS and the biofuel industry are still providing this benefit to the U.S. For the most part, the committee determined that an increase in alternative fuel production, along with other energy sources such as natural gas, have diversified the transportation sector significantly, leading to an increase in energy security. Unfortunately, the concern will remain as the industry continues to expand and the RFS continues to be implemented. On the state level, the largest concern regarding energy policy is trying to develop markets in the state that diversify the state's fuel supply and domestically increase the state's revenue as well. All state RFS mandates struggle with this concern, which is a large reason why review of these mandates is necessary (U.S. House of Representatives Committee on Energy and Commerce 2013d).

The final white paper draws attention to the ongoing implementation issues that have arisen with the RFS. The first issue to address is that the cellulosic biofuels requirements are not being met currently, as there are no commercial production facilities in operation yet. The paper also shed light on the failure of the Renewable Identification Numbers (RIN) system created by the RFS and implemented by the EPA. In many cases, there has been RIN fraud, in which companies create and sell RINs, but do not actually produce the fuel that corresponds with the RIN. Finally, RIN affordability has also become an issue as prices have gone up, which has sometimes pushed smaller producers out of the market entirely. State-level RFSs have to follow the national guidelines regarding RINs, but their forms of accountability may be stronger depending on the type of legislation they have in place (U.S. House of Representatives Committee on Energy and Commerce 2013e).

As seen from the white papers and a review of the literature, the federal RFS still has plenty of kinks to work out before it will become completely successful. Fortunately, states have seen the pitfalls of the federal RFS and have learned from these mistakes when crafting their own versions and implementation procedures.

**State Biodiesel Policy**

Prior to 2006, only Hawaii and Minnesota had experimented with a state-executed RFS, but since the federal RFS enactment in 2006, nine more states have joined the ranks.  A study done by the National Renewable Energy Laboratory in 2008 indicated that state-implemented RFS programs have incited positive results for rural economies, reduction of petroleum dependence through fuel diversification, and environmental benefits including, but not limited to, health, air quality, and reduced $CO_2$ (Mosey and Kreycik 2008). The study done by the NREL is the strongest in terms of measuring the effectiveness of state RFS mandates and how more states could benefit from a similar policy structure. Unfortunately, this study was created in 2008 and, since then, few reports have been done on state RFS mandates. Therefore, there still is a large need for research to measure the impacts of an RFS policy.

**Table 3: State RFS Mandates for Biodiesel**
(Mosey and Kreycik 2008; DOE 2013c)

| State | Mandates | Date of Compliance |
|---|---|---|
| LA | Total diesel sales must contain 2% biodiesel (B2). | 2015 or 10 mgy capacity[2] |
| MA | All diesel motor vehicle fuel sold in MA must contain at least 2% renewable diesel fuel. | July 2010 (program suspended due to cost) |
| MN | Total diesel sales must contain 2% biodiesel (B2). | 2013 |
| NM | All diesel fuel used in state vehicles must be 5% biodiesel by July 1, 2010; and two years later, all sales in the state must be 5% biodiesel. | 2010, 2012 (suspended until April 2014) |
| OR | All diesel fuel sold in the state must be blended with 2% biodiesel. | 2008 |
| PA | All diesel fuel sold in the state must be at least %2 biodiesel one year after in-state production has reached 40 million gallons. | 2013 |
| WA | Equivalent of 2% of diesel sales must be biodiesel. | 2008 |

NOTE— States in highlighted rows also have RFS mandates for ethanol

An analysis done by Mosey and Kreycik (2008) highlights the goals and parameters for states that have a biodiesel RFS, as seen in Table 3. The states listed above are on the forefront of pushing biodiesel incentives, infrastructure, and production because they have chosen to construct a state-level RFS mandate. While these states are the few that have taken the initiative to enforce an RFS at the state level, many states have in fact introduced but failed to pass RFS legislation. Figure 5 (created in 2006) shows how many states introduced, but did not pass, a state-level RFS.

[2] mgy- Million gallons a year (Mosey and Kreycik 2008)

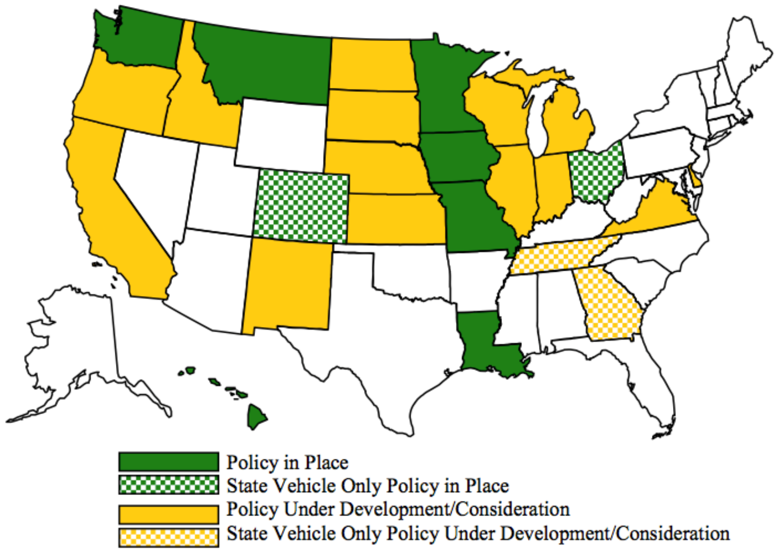


**Figure 5: States with Existing or Proposed RFS for Biodiesel, Ethanol, or Both as of 2006 (Brown, Cory, and Arent 2007)**

In 2006, the National Biodiesel Board reported that they were tracking more than 160 pieces of legislation that supported state-level biodiesel production either as an RFS, subsidy, tax credit, etc. (Koplow 2006). Since that report, the only source that compiles a list of biodiesel legislation is the Alternative Fuels Data Center, which reported 386 laws nationally regarding biodiesel, of which 355 were at the state level, including the District of Columbia. This suggests the question "what actually drives states to create an RFS?"

*Policy Drivers*

At the time of the study done by Mosey and Kreycik (2008), another study had been done that highlighted the main drivers for states to choose policy in the form of an RFS (Brown, Cory, and Arent 2007). The study emphasized that states had five main drivers for creating an RFS: build renewable fuels markets, improve rural economies, increase use of domestic fuels, and improve health and air quality. Of the seven states studied, all indicated building renewable fuel markets as a driver for policy. Despite the five primary drivers, Louisiana and Washington also listed energy security, due to the instability of fossil fuel prices and supply. Lastly, the study remarked that, since creating a state RFS is a complicated process due to scale and complexity in building the market, many states have opted to create stakeholder groups to help develop the policy and shorten the time it takes to agree and vote in state legislatures. Washington State created a similar group named the Biofuels Advisory Committee, but this stakeholder group's mission was slightly different in that it researched and analyzed the effects the RFS would have on the state, before the RFS went into effect, but after the legislation had passed. Since the RFS is not the only option to promote biofuel use and reduction of carbon emissions, it is necessary to review complementary and alternative policies, as well.

*Complementary Policies*

An RFS is a free-market policy approach but, if not constructed appropriately, it can fail due to implementation and enforcement mechanisms. Therefore, there are complementary policies that should also be addressed, to help direct production, distribution, and consumption (Mosey and Kreycik 2008). On the state level, this can be implemented through policy instruments such as tax credits, subsidies, and grants. In the analysis done by the NREL, it was found that production incentives, biofuels promotion plans, infrastructure grants, tax credits, educational programs, investment taxes, retail regulations and lower excise taxes were the most effective complementary policies (Mosey and Kreycik 2008). Minnesota demonstrated that a production incentive could be effective, when the state offered early investors a 20¢ incentive per gallon of ethanol for the first few years of the mandate. In terms of biofuels promotion plans, eight states in the Midwest have created goals to lower carbon emissions through the introduction of biofuels to their economies. This is slowly being done along the West Coast as well. Infrastructure grants are a straightforward complementary policy, as they supply some initial funding for investors through matching grants or fee waivers. This has been established in the State of Washington in an effort to spark investors to join the biofuels market. Tax credits can be complementary, as they provide a break to retailers who sell a higher blend of biodiesel at the pump. The rest of the complementary policy options are self-explanatory, with many states opting to invest in tax plans rather than educational programs (Mosey and Kreycik 2008).

*Alternatives to the RFS*

The literature regarding alternatives to an RFS is limited. The main alternative policy option is a Low Carbon Fuel Standard (LCFS), which is currently being tried in California. The other options, as mentioned above, are a cap-and-trade system (which British Columbia has implemented) and a floor price on imported petroleum. The LCFS is created for the sole purpose of reducing carbon emissions and stimulating advances to the transportation sector to meet state or regional climate goals. California implemented its LCFS in 2010, with the goal of reaching a 10% reduction in transportation GHG emissions for the state by 2020 (Farrell and Sperling 2007; Andress, Dean Nguyen, and Das 2010). An LCFS strategy can vary and measurements of the fuel consumption can be implemented at any level along the supply chain. A general LCFS has three goals: 1) increasing efficiency of vehicles, 2) reducing GHG emissions in the transportation sector, and 3) decreasing the use of vehicles and fuel consumption by promoting alternative transportation opportunities (Mosey and Kreycik 2008).

The main challenge with the LCFS that both Farrell and Sperling (2007) and Mosey and Kreycik (2008) acknowledge is the uncertainty of environmental impacts. The LCFS, while it attracts investment and trading, can ignore the issues of land-use change and the carbon that is emitted during industry growth and transition. Ideally though, as seen in California, the LCFS can introduce renewable fuels into an economy by helping to direct investments away from carbon-intensive fuels (Farrell and Sperling 2007).

The cap-and-trade system, exhibited by British Columbia, is another policy alternative to the RFS. The cap-and-trade system develops a maximum level of pollution, a “cap,” and issues emissions permits among companies that generate emissions. A company then must have a permit that corresponds and accounts for every unit of emissions they produce. If the company goes over its allocated permits or under they can trade their permits with other companies. This form of policy ensures that the maximum pollution is set and never exceeded by putting a price on pollution (British Columbia Ministry of Environment 2014; British Columbia Parliament 2008).

The final alternative to an RFS is a carbon tax, which was introduced to British Columbia in 2008. The tax creates an incentive to produce fuels that have fewer and cleaner emissions. The tax is supposed to be neutral as the legislature each year creates a plan that demonstrates how the revenue from the tax will be redistributed to the taxpayers. The redistribution is done through a reduction to other taxes such as personal or corporate income taxes (Andress, Dean Nguyen, and Das 2010; British Columbia Ministry of Environment 2014; British Columbia Ministry of Finance 2008).

## Methods of Evaluation

Methods for assessing an RFS are limited and few, since it is a newer form of policy developed within the last decade. Since there are few methods of assessment the majority of the assessments take an environmental or economic approach. Economic forms of analysis can differ for the RFS, but generally take on a cost-benefit approach or a lifecycle assessment, the latter being used because an RFS is dealing with energy and environmental factors. To summarize the literature, a majority of the state and federal RFS evaluations use a combination of environmental impacts with economic analyses as an approach to quantify the results of RFS policies (McCullough et al. 2011; Nobles 2009; Schnepf and Yacobucci 2013). A combination of analysis occurs because it can strengthen the validity of the analysis and appeal to a larger interdisciplinary audience, which is necessary in crafting policy. Another notable aspect of analysis to keep in mind regarding RFS evaluation—specifically environmental—is that there is no standard protocol for biofuels life-cycle evaluations, which can weaken an LCA if it is not coupled with other forms of analysis (Mosey and Kreycik 2008). Finally, evaluation for policy is not just done for economic and environmental assessments, but also for social costs. Assessments of social costs help to determine how the policy will alter society. The following pages will discuss environmental, economic, and social evaluations in more detail.

### *Environmental Analysis*

Environmental analysis methods for Renewable Fuel Standards and energy policy generally take an approach that involves either life-cycle assessments of renewable energy or emissions analysis. In the case of the federal government, the Environmental Protection Agency (EPA) generally does the analysis and designs the evaluation so that it answers the concerns that legislators have about the policy. For instance the EPA, in 2007, issued an initial report on the impacts of the RFS, which assessed emissions of vehicles using biofuels, equipment used to produce such fuels, and biofuel production facilities. In the same report, the EPA assessed air quality, life-cycle impacts, estimated costs of renewable fuels vs. petroleum-based fuels, agricultural sector impacts, and business impacts (U.S. Environmental Protection Agency 2007). Notably, most environmental evaluations now address some or all of the following factors:

emissions, water quality, soil degradation, and land-use change. Emissions and land use are the only evaluations discussed in this thesis as the LCA method used for emissions and land-use can have inputs that assess water quality and soil degradation.

*Emissions*

The emissions from biodiesel production are generally assessed through a life cycle assessment (LCA). The LCA method was originally created by The Society of Environmental Toxicology and Chemistry and the International Organization for Standardization in 1990. An LCA is defined as a “cradle-to-grave” assessment of how a product affects the environment and human life (Curran 2006). As the Environmental Protection Agency’s adopted definition, this analysis looks at each process in the life cycle of the product, from manufacture and maintenance to the materials used to produce the product. Figure 6, from Curran’s 2012 EPA study, shows what is assessed and inventoried to determine the LCA for a product.

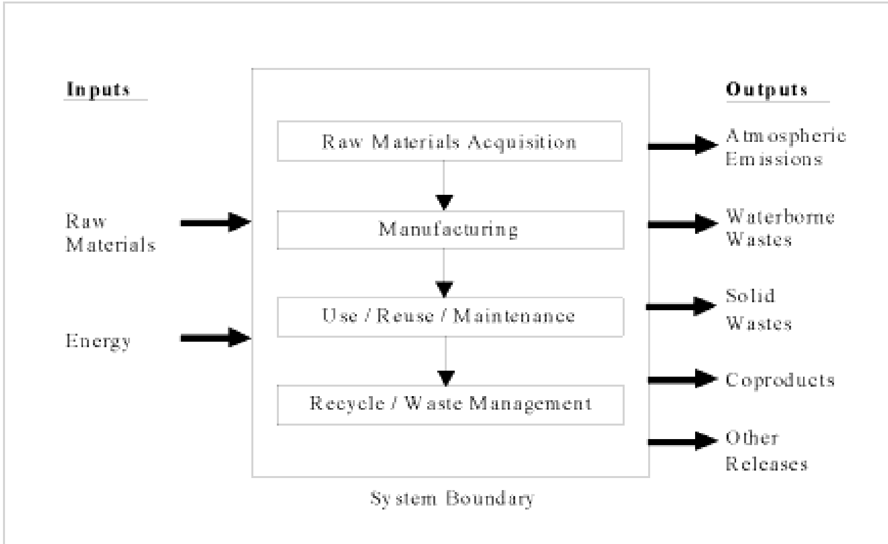


**Figure 6: Life Cycle Stages (Curran 2006)**

In terms of a biodiesel LCA, the raw materials would consist of feedstock and the acquisition would be through agricultural crop extraction methods, fertilizers, water, transportation, etc. The manufacturing would consist of the production process, including transportation from facilities to retail sale. The energy use would account for crop production, manufacturing, and energy use after retail sale. The waste and outputs would consist of emissions, waste in production, recycling of materials, tool maintenance, and other products that can be created from biodiesel waste during production. As illustrated, assessing an LCA for biodiesel is extremely complicated, with many factors to consider. For this reason, it is not surprising that there is significant uncertainty about the actual environmental impacts of biodiesel. However, LCAs have been criticized for a number of reasons, including 1) failure to include land-use change; 2) failure to track impacts of GHGs; and 3) failure to account for the impacts of fertilizers or to underestimate their use (Larson 2006).

In 2007, as part of the Energy Policy Act of 2005, the EPA released a rulemaking that required a new set of guidelines be crafted to determine lifecycle greenhouse gas emissions from biofuels (Yacobucci and Bracmort 2010). Debates over these regulations are ongoing, as certain factors such as time frame, inputs, outputs, and indirect land-use change can alter the overall assessment of an LCA. Some studies in particular find that the largest debate over LCAs lies in the indirect land-use change that can cause “carbon debt” (U.S. House of Representatives Committee on Energy and Commerce 2013c; Yacobucci and Bracmort 2010). The carbon debt idea is that there is such a significant change when clearing land, that an immediate release of a carbon pool will occur, which can take decades to centuries to overcome (Farigone et al. 2008).

A research group from the University of Maine highlighted that LCAs provide a methodological approach to assessing environmental impacts and consumption but, as already seen, there are several ways to conduct an LCA. The type of LCA used by the University of Maine research group was a flow analysis model, analyzing flows and stocks of a single product. Two types of flow analysis models are energy flow analysis (EFA) and substance flow analysis (SFA), but they essentially examine the same thing. This research group found that most LCA studies fall into the same common trap of forgetting other environmental impacts and only focusing on energy and greenhouse gas emissions, and this generally occurs when the LCA is motivated by energy efficiency and climate change mitigation policy that promote renewables (Manik and Halog 2013). The most unique aspect of this study was that it broke the LCA model into five steps of biodiesel production, using palm oil as an example. The five steps are 1) land preparation; 2) oil palm plantation (or other biodiesel crop); 3) palm oil mill (crusher); 4) conversion to biodiesel fuel; and 5) use of biodiesel fuel. From these five steps, depending on how an LCA or flow analysis categorizes processes in its assessment, the LCA can be classified into four distinct categories. The LCA is broken into four categories to bring attention to the idea that an LCA may not in fact cover all aspects of the life cycle and, therefore, limits the assessment's credibility.

The first of these groups is cradle-to grave, which includes all five steps of production and usage. The next category is cradle-to-gate, which starts with step one, but does not necessarily get to the end (step five). The third category and LCA can fall into is called gate-to-grave, which starts at step five, use of biodiesel fuel, but never looks at the actual production of the crop. The final category that an LCA can fall under is gate-to-gate, which looks at a combination of a few of the steps, but does not assess all of them.

It is interesting to note that an LCA may not in fact analyze the full life-cycle of a product, but each one of these categories has their own merits because they allow researchers to focus or target certain aspects of the life-cycle and therefore address concerns within that step better. From this categorization, Manik and Halog found that 60% of the LCA studies they reviewed fell under the gate-to-gate category, showing just how incomplete an LCA can be, especially when it's driven by policy motivations (Manik and Halog 2013).

*Land-Use Change*

For assessments of land-use change due to biodiesel production, LCAs are the common form of assessment because they can determine all the factors that will be affected and the results from change in land use. These factors tend to include emissions, soil degradation, and water consumption along with construction and land clearing impacts. In addition, Geographic Information Systems or other mapping programs are typically used to determine the amount of land that will be converted for biodiesel production to gain a holistic view of the acreage that is converted.

Although LCAs are the common model of choice, another model to use is the global computable general equilibrium (CGE). A CGE model is an economic model that predicts how the economy will react to a change in policy or technology and incorporate environmental parameters and factors into the model to assess impacts. CGE models are made up of "a set of theoretical equations designed to determine the economic behavior of a) consumers, b) producers, c) government, d) the rest of the world and to model 1) corporate financial decisions, 2) household financial decisions, and 3) government financial decisions" (Charney and Vest 2003). CGE models are a useful model for a biofuel industry because it can evaluate a complex system, which other models can only evaluate one market at a time (Inter-American Development Bank 2014; The World Bank 2003). Lastly, CGE models are data intensive and can take a few months to a year to construct and run, causing them to be employed less in policy evaluations (Timilsina et al. 2010).

Authors of the report, “The Impacts of Biofuel Targets on Land-Use Change and Food Supply” utilized this model in particular as it can help evaluate and compare land use impacts of different forms of policy (Timilsina et al. 2010). Timilsina et al. found that the CGE indicated that expansion of biofuel production in the European Union (EU) would lower GDP globally and cause re-allocation of land to biofuel feedstocks. The CGE is applicable for land-use change policy evaluation as it encompasses competition between industries, for example biofuels and food industries, which in some ways compete for a product. In general, the CGE analyses can provide a holistic assessment of a biofuels industry and its emergence into an economy by running a model that has numerous, complex inputs and equations from each aspect of the economy that is being evaluated to determine how the economy will react. The disadvantage of this form of analysis is that the model cannot forecast because it is based on data from a specific year. In addition, while the model does provide an idea of the economic impact of the policy, a CGE model cannot give the time frame or context in which that impact will occur. Lastly, a lot of the data inputs needed for the model are not provided by departments or census data, much of it is estimated reducing the credibility of the models outcomes and results (Charney and Vest 2003).

In a report completed one year after the Timilsina et al. (2010) report, Laborde (2011) focused more on land-use change by using an updated CGE model that concentrated on land-use changes resulting from the EU’s National

Renewable Energy Action Plan. This report highlighted the same concerns about using a CGE, but found that emissions from land use change caused by all twenty-seven EU member states' biofuels mandates would eliminate two-thirds of the emissions savings that biofuels have when used in the transportation sector as a cleaner burning fuel. The report also indicated that, due to a level of uncertainty that exists with the utilization of the CGE model, additional types of analyses should be run and trade policies that help control land use change should be enacted.

Authors of the article, "Economic and Environmental Impacts of Washington State Biofuel Policy Alternatives," one of the few articles regarding Washington state's biofuel industry policies also utilized this CGE to evaluate policy options (McCullough et al. 2011). The authors evaluated policies based upon how they would complete the five goals that were also used in this thesis. As noted by the authors, this type of analysis is suited for analyzing impacts of different policies, but only provides a unique output that is characteristic to the base year and therefore not acceptable for forecasting (Charney and Vest 2003).

The study found that while taxes on emissions such as carbon taxes are the most effective in lowering carbon emissions, the CGE model results should not be interpreted as definitive answers since renewable energy markets are constantly changing. In fact, the results from the study should be viewed as a comparison among policies more than anything else. The primary contribution to literature and using CGE models to evaluate land-use change and renewable energy market policy is that none of the policy options the authors chose to study would achieve all five goals, but rather only achieve one goal successfully (McCullough et al. 2011). As seen from the literature, land-use change models and LCAs are effective in determining some key land-use impacts of this emerging market, but are limited in their scope, often overlooking key inputs. Debate over correct application and evaluation of an LCA and CGE models causes lots of opposition towards biofuels, leading most policy evaluations to take a more economic approach.

*Economic Policy Analysis*

Economic analyses are common, but they differ in approaches, depending on the outcomes wanted and the legislative mandates. Most of them quantify industry value, job creation, gross state product (GSP), and value of land (Mosey and Kreycik 2008). Economic impacts of an RFS hinge largely on production of the alternative fuels, which causes a highly complex level of analysis to be employed.

An analysis common to the federal government uses a model called Jobs and Economic Development Impact (JEDI). This model is "an input-output, spreadsheet-based model," which estimates the project costs, impacts from jobs created and lost, earnings income, and output through entry of basic project information. This model's default inputs have been established through interviews with industry experts and analyses from Minnesota's IMPLAN group, a company that develops state and national level databases and tools for analysis. The model was constructed for ethanol, but has expanded across biofuels except biodiesel, and is common in federal biofuel analyses (National Renewable Energy Laboratory 2013b; Mosey and Kreycik 2008). This model is referenced because state and federal level agencies employ this model for other biofuel evaluations and there is potential for this model to be expanded to evaluate biodiesel as production increases. In addition, the model has been tested and is widely acceptable in the industry despite its limitations. The limitations of the model are that it reports only gross impacts, not net impacts and is sensitive to base year data and therefore is not a forecasting model. Lastly, results are dependent on the accuracy of the data and vary based on geographic location and project specifics. An example of the JEDI model output is exhibited in Table 4, in which ethanol is used as the fuel of choice.

**Table 4: Annual Economic Impacts of Meeting Incremental Ethanol Capacity for State-Level RFS, Construction Year 2008 (Mosey and Kreycik 2008)**

| State | Incremental Ethanol Capacity Required for RFS (million gallons) | Annual Jobs | Annual Earnings $M (2006) | Annual Output $M (2006) |
|---|---|---|---|---|
| Hawaii | 107 | 1,000 | 33 | 59 |
| Iowa | 218 | 1,321 | 27 | 128 |
| Louisiana | 95 | 714 | 14 | 55 |
| Minnesota | 1,000 | 6,526 | 151 | 598 |
| Missouri | 376 | 3,581 | 54 | 226 |
| Montana | 4 | 30 | 1 | 2 |
| Washington | 100 | 568 | 17 | 56 |
| Oregon | 224 | 1,392 | 38 | 130 |
| Total | 2,124 | 15,133 | 334 | 1,256 |

Table 4 indicates that if each of the states meets its RFS mandate for ethanol, then each will create jobs, total earnings, and annual production output in million dollars for the state. Take Washington State, for example. According to the JEDI model, if Washington State met its RFS requirement of 100 million gallons of ethanol produced in-state, then roughly 568 jobs would be created, leading to an estimated annual earnings generated by the industry within the state of 17 million dollars and a total output of 56 million dollars. Now, this is modeled on a yearly basis; therefore, this is projected to occur each year that Washington State meets or exceeds its RFS requirement for ethanol. Unfortunately, since the policies are so new, the information available regarding factors that affect the success of the RFS is limited. States' experiences with the RFS are dependent upon location, feedstock, infrastructure, market, and goals; and therefore, can significantly differ.

An analysis that is great for one state might not be the best for another, which causes legislators to call for different forms of evaluation. As mentioned in studies already highlighted, scale is a real issue, especially with LCAs, but economic analysis can have the same concern. Often analyses are not strict enough in acquiring data and variables, or the studies are too broad, causing uncertainty to arise. Scale is a huge issue that needs to be addressed in every type of evaluation.

*Social Evaluations*

As seen from the review of literature above, a policy evaluation can take many different approaches, but the one that is often forgotten is a social evaluation. Policymakers commonly seek research about environmental and economic impacts, but often fail to assess how specific policies may have altered society in other ways. Policy shifts can be hazardous for society and, therefore, social evaluations of policy are a necessity. These tend to take the approach of surveys and interviews (e.g., Delshad et al. 2010; Johnson, Halvorsen, and Solomon 2011). Evaluations from the social science disciplines help to tease out how certain policies and social aspects such as attitudes, beliefs, and morals can change the industry and the environment.

A study of the effectiveness of biofuel policy in the U.S. Midwest by Johnson, Halvorsen, and Solomon (2011) highlights a typical model used for social evaluations. This study of consumers' beliefs about climate change and decisions about purchasing ethanol was conducted through surveys and utilized multivariate methods and the statistical package called Statistical Package for the Social Sciences (SPSS) to evaluate societal impacts of biofuel policy. This methodology was utilized because it can evaluate policy while acquiring both qualitative and quantitative data.

Another model that can combines different factors to assess policy was developed by the author Jadwiga R. Ziolkowska, who proposes a multi-objective decision analysis as a form of evaluation that, although well-recognized in environmental and economic evaluation theory, is rarely used. The author highlights that most forms of policy analysis—such as CGEs, LCAs and cost-benefit analysis—do not address both tangible and intangible objectives of biofuel policy, making a multi-criteria analysis a necessary tool for examination of policy. The multi-criteria framework the author suggests combines the Preference Ranking Organization Method for Enrichment Evaluations method (PROMETHEE), and an expert elicitation approach and fuzzy set theory (Ziolkowska 2013). The PROMETHEE helps policymakers find the right alternative policy to achieve their goals through a mathematical model that values inputs and outputs to rank actions such as objectives. The author chose this combined framework because it addresses the issue of uncertainty in decision-making that the PROMETHEE could not do alone. The framework allows for the inclusion of decision maker inputs in the evaluation process, and can be used on any policy scale, with inputs consisting of goals, measures, limitations, budget, etc. The downside to this model is that, as it is interdisciplinary, it requires a large amount of both quantitative and qualitative input data, which can be hard to acquire, especially in the case of an emerging industry such as biofuels.

The final evaluation model to be considered here, with respect to biofuel policy, is the MARKAL model (Sarica and Tyner 2013). This model was developed by the Energy Technology Systems Analysis Programme (ESTAP) and has been used by the EPA to study international and national cases of energy policy.  Sarcia and Tyner's article is the only one to utilize the MARKAL to assess the federal RFS and technologies that can contribute to the targets of the policy. The MARKAL model uses Reference Energy Systems (RES) to assess current and future technologies in biofuel production. A simplified version of an RES can be viewed in Figure 7. This study determined that the MARKAL model, although efficient in its analysis, could have setbacks because it has difficulty adapting to changing costs from land and production. In addition, the evaluation found that few or no biofuels would be produced without the federal RFS, and that subsidy costs and the cost of the RFS are variable, depending upon technology (Sarica and Tyner 2013).

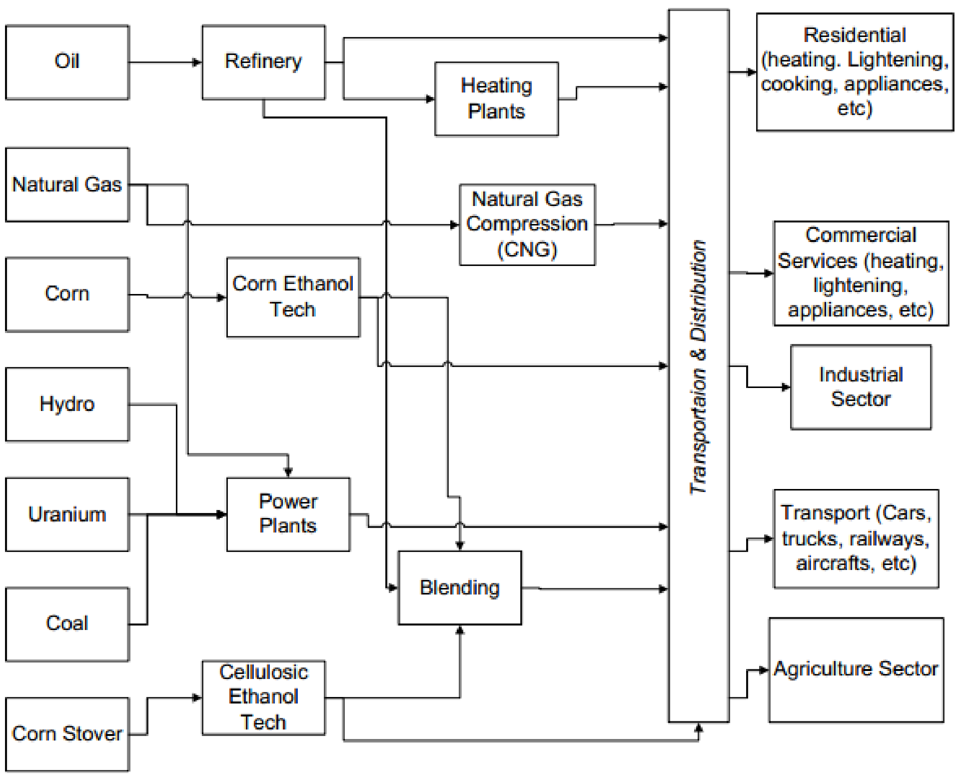


**Figure 7: Simplified RES Utilized in the EPA MARKAL Model (Sarica and Tyner 2013)**

From a review of the literature it is evident that there are numerous ways to evaluate biofuel policy. Each policy has its benefits, such as a multi-objective framework analysis that can incorporate policymaker inputs, to a cost-benefit analysis, which determines economic outcomes of policy. Regardless of the benefits, each one has shortcomings that cause its validity to be questioned by policymakers. In addition, the review of the literature did highlight that social impacts, stakeholder beliefs, and consumer attitudes are often forgotten in policy analysis, causing a large gap in the biofuel policy evaluation literature.

## Conclusion

Biodiesel is gaining increasing recognition around the globe as a renewable fuel source with lower emissions than its petroleum competitor. Despite the growth of the industry, the environmental uncertainty surrounding biodiesel has been cause for alarm. Fortunately, through environmental regulation and policy initiatives, the industry has established itself in the United States and across the globe. Policies such as Renewable Fuel Standards, at the federal and state levels, have continued to encourage this growth. As seen from the literature review, the federal RFS is the United States policy that promotes biofuel production. Unfortunately, it has implementation issues such as blend walls, price competiveness, and environmental impact uncertainty, which have led to debate about the RFS and about biofuels in general. Regardless of the implementation issues, nine states have followed the federal government's example and introduced their own forms of biofuel policy through state RFSs, LCFSs, and subsidy and incentive programs. Of these states, Washington State introduced its own RFS for biodiesel in 2008, mandating that for all of the diesel sold in the state, 2% must be biodiesel.

The Washington State biodiesel RFS mandate went into effect in 2008, but since then has had little success, as the mandate has been found to be non-binding, since no accountability system was put in place by the state. Since the mandate's creation, little review of the mandate has been done except for by the Biofuels Advisory Committee as discussed in Chapter 1, Section: Washington State Biodiesel Policy (see page 33). In addition, the academic literature of Washington State's RFS is limited consisting of only two studies done in December of 2008 and 2011 which are discussed in Chapter 1, Section: Washington State Biodiesel Policy (see page 33) and Chapter 2, Section: Environmental Analysis (see page 58). This gap in the literature should be addressed to properly assess the RFS and determine possible replacement policies. This thesis aims to fill that gap, by producing an evaluation of the Washington State biodiesel RFS that assesses how different sectors evaluate the mandate.

In order to determine what type of policy evaluation was applicable for this study, a review of biofuel policy evaluation methods was necessary. From the review of the literature, policy evaluations were categorized into three categories—environmental, economic, and social. The environmental evaluations of policy consisted of LCAs and CGEs, both of which had their own merits and pitfalls. With any evaluation, scope is a huge issue in determining inputs and outputs, and this is especially the case for LCAs and CGEs.

The economic evaluation consisted of the JEDI model, a form of cost-benefit analysis. The JEDI model, which was created by the NREL, is an input-output model of costs, job creation, and overall production. However, its use is currently limited because data are still fairly new or non-existent in the field of biodiesel. This model although unable to assess biodiesel currently, has been essential in creating renewable energy markets and assessing renewable energy policy in the country and is employed by the National Renewable Energy Laboratory (NREL).

The final form of evaluation falls under the category social, which employs social science to gain knowledge about social impacts of biodiesel policies. This form of evaluation is strong in gaining insight into sector beliefs and attitudes toward a policy, but limited because it does not provide quantitative data that most policymakers like to see when making policy decisions. Also in this category are the multi-objective analysis framework and the MARKAL model. This multi-objective framework captures many different inputs using a mathematical model and can incorporate both qualitative and quantitative data, but can be time consuming, while the MARKAL focuses solely on technology and land-use evaluation of policy disregarding social impacts.

A review of the literature found that disregard for social factors other than economics is common in most forms of evaluation. As mentioned above, Washington State biodiesel RFS lacks a formal written evaluation and the most effective way to do this would be through a formative evaluation that would contribute to the literature by providing sector insight into the RFS. This would fill the gap in literature surrounding the revisions of Washington State's biodiesel RFS and provide a unique method of evaluation that is not often found in the literature.

# Chapter 3: Methods

## Introduction

The present thesis aims to address the question of how policy experts and stakeholders assess the performance of the Renewable Fuel Standard mandate for biodiesel in Washington State. Since the RFS was passed, there have been few studies done on the RFS and its effectiveness in implementation. Therefore, this study sought out twenty-one individuals from different sectors (i.e., government, academic, private, and non-profit) for interviews, of which seven agreed. Two of the individuals interviewed work for the state government, two are from academic institutions, two work in the private sector, and the final interviewee works for a non-profit. In addition, 107 individuals from the same sectors listed above were contacted to complete an online survey; seventeen completed the survey, with some respondents skipping questions. The transcribed interviews were analyzed through a multistage data analysis technique (per Ryan & Bernard, 2003), to identify themes. The survey data were analyzed in three separate programs PCORD, JMP, and Excel, through a Multiple Response Permutation Procedure (MRPP), resampling ANOVAs, and Levene's and Tukey's tests. This chapter begins with an overview of the data collection, interview structure, and study design. Following this, are the descriptions of the state policy regarding biodiesel in Washington and detailed descriptions of each sector chosen to participate in the study. Lastly, the methods of analysis are discussed.

**Data Collection**

This study is designed to be a formative analysis of the Biodiesel Renewable Fuel Standard Requirement for Washington State. A formative evaluation is conducted while a policy is in effect, and is generally done for the purpose of improving the policy and making corrections or additions, if needed. A summative evaluation is the opposite of formative; a summative evaluation seeks to determine the outcomes of the program once it has been completed (Burns 2008; Chen 1996; Scriven 1996). This study chose a formative evaluation, as the RFS for Washington State is still in effect. A formative evaluation was chosen as the most practical way to assess the Washington State RFS because it allows for questions to be tailored to how the program is succeeding or failing as well as what additions or alterations are needed to improve the policy. In order to answer an interdisciplinary research question, a mixed methods research approach was developed.

This study aimed to interview experts in sectors such as government, academic, private, and non-profit, about their experiences and opinions of the mandate. Surveys and interviews were essential to this type of study because they addressed formative questions by asking parties directly how they interact with the policy, their concerns moving forward, and effects of the policy on their position, business, etc. The interviews and surveys will help fill the gap of knowledge that currently exists regarding how the RFS is being implemented and what would be the next step for alterations to the policy. Survey data and interview transcriptions will help policymakers gain a stronger understanding of their constituents and opposition parties' beliefs surrounding the RFS. Greater understanding of how different stakeholders view the RFS can help with policy formation and lessen the possibility of conflict or opposition.

In order to identify potential participants of the study, an Internet search was completed, along with an intensive review of state policy documents from the Revised Code of Washington, House Bill report, and the Washington State Biofuels Advisory Committee. These documents, along with federal websites that highlight biodiesel producers by state, helped create a list of the biodiesel network that has been established in Washington. In order to reduce redundancy, typically only one person from each organization, department, or company answered the survey.

With the intention of creating a large, formative evaluation encompassing each sector's knowledge and opinions, 107 experts were identified and contacted by phone and/or email to participate in the surveys, based upon their relationship with and knowledge of the state's biodiesel industry. Out of the 107 individuals who were contacted, seventeen responded and completed the survey. A distribution of the sectors represented by survey participants can be viewed in Figure 8.

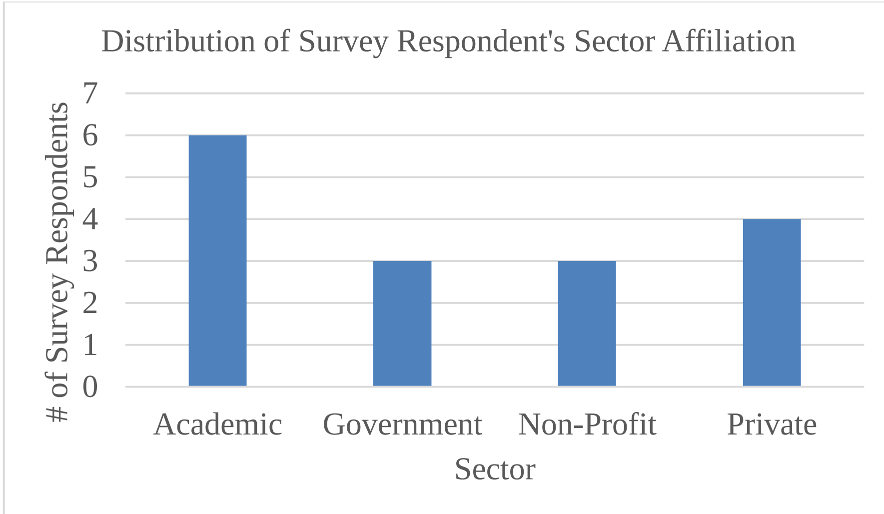


**Figure 8: Distribution of Survey Respondent's Sector Affiliation (n=17)**

By survey design, individuals had the opportunity to skip questions and answer with a range of options such as matrix, multiple choice, and open-response styles. Due to the nature of the questions this study is attempting to answer, a mixed-methods study design was chosen. The survey was formulated to collect both quantitative and qualitative data regarding different sectors' knowledge and views of the mandate. The surveys were created on SurveyMonkey and the average time to take the sixteen-question survey was fifteen to twenty minutes (see Appendix for survey). Accompanying the surveys, unstructured interviews were conducted to gain further qualitative data regarding the implementation, goals, and structure of the mandate. Unstructured interviews were chosen so as to not steer interviewees toward certain responses or themes, but to explore what they view to be the most significant aspects—such as implementation, revision, etc.—pertaining to the state RFS. Data produced from the interviews were categorized into themes, while the surveys produced quantitative data about sectors' values, beliefs, and economic and political concerns. A total of four of the survey respondents participated in the interviews.

The interview subjects were chosen based upon their willingness to participate in an unstructured, recorded interview. Initially, contacts were chosen based upon their connection to the mandate such as involvement in crafting the policy or their company is directly affected by the mandate, but some were contacted based upon suggestions from participating interviewees. The suggested contacts were warranted, as they were current private industry representatives that may have been missed in initial contact due to a change in management within the companies. Twenty-six individuals were approached to participate in the interview. A total of seven individuals completed the interview. Interviews were unstructured, but interviewees were provided with a list of the following questions below prior to the interview that would be suggested questions to answer. Prior to the interview, information was sent to the interviewees regarding the Washington State RFS, the bill that passed it (SB 6508), and the Revised Code of Washington in addition to the questions below. The interview was designed to investigate experts' views of the following sorts of questions:

1. What happened as a result of the policy?
2. Has this bill fulfilled its goal of increasing in-state production of biofuels?
3. Has this bill fulfilled its goal in increasing in-state biofuel feedstock supply?
4. Has this bill fulfilled its goal in reducing petroleum dependence?

5. Has this bill fulfilled its goal in reducing carbon emissions?
6. Has this bill fulfilled its goal in fostering environmental sustainability?
7. How could this policy have been better designed to accomplish goals?
8. What factors caused the program to fail? Or succeed?
9. How much of failure/success of the RFS is contributed to gasoline prices?
10. How much do you see the failure/success being contributed to incentives?
11. How much of the failure/success to meet the 2% biodiesel in state diesel fuel supply is contributed to technology?
12. Has the failure of this RFS caused the industry to stop growing? Did the RFS help/hinder certain parties/organizations?
13. Does the skepticism about biofuels by the general public factor into the industry growth? What are your thoughts on the public opinion in regards to the RFS?
14. How much does the clause that the governor can pull the plug if he deems necessary affect the position of your organization/your opinion surrounding biofuel mandates?
15. Do you have any additional comments or ideas at this time that you would like to share regarding the Washington State Renewable Fuel Standard mandate of 2% of the diesel sold in the state must be biodiesel?

Of the seven interviewees, two were affiliated with the state or federal government, 1 was affiliated with non-profits, two were in the private sector, and two were academic professors in the field of environmental economics. The questions were designed to get a formative understanding of the mandate as mentioned above; formative questions are designed to ask questions about the program, its purpose, and initial results of the program, so that improvements and corrections can be made. To ensure anonymity of all the participants in both the surveys and interviews, individuals were only associated with their occupational sector (i.e., government, private, academic, non-profit). Lengths of interviews ranged from ten to sixty-eight minutes. The typical length for an interview was fifteen minutes.

## **Data Analysis**

### *Interview Data*

Data were manually transcribed from computer and phone recordings without software. Themes were extracted from the interviews using a data analysis technique from authors Ryan and Bernard (2003). The first stage of analysis involves reading through the interviews and identifying repetition of topics and keywords, and color-coding them. This stage can also filter out themes by identifying metaphors and transitions, which might have underlying messages. The second stage is the processing stage, in which cutting and sorting occurs; this involves the researcher sorting the highlighted phrases into natural themes. The final stage, referred to as metacoding, assesses the piles and determines what themes and sub-themes exist from the original research question. Due to the small number of interviewees and the unstructured interview set up, themes were found based on the number of responses as well as the sector of employment. The open-ended questions from the surveys were scrutinized using the technique mentioned above, and served as a supplement to the interviews, while the quantitative data were analyzed by sector.

*Survey Data*

The main purpose of the survey analysis was to determine the different sectors' responses and to see if there were any similarities amongst sectors. A Multiple Response Permutation Procedure (MRPP) was run along with ordination, Monte Carlo pairwise comparisons, and resampling to determine the relationships across sectors and their responses. The MRPP, ordination, and pairwise comparisons were run in a program called PC-ORD, while the remaining tests were run in JMP and Excel. After an MRPP was run, resampling ANOVAs were run per question to test for significant differences among the sector responses. The final form of analysis, to create visual representations, was done in a combination of Resampling Excel Add-in Package and JMP.

# Chapter 4: Results and Discussion

## Introduction

Analysis of the data revealed few significant differences in sector choices regarding formative questions of the Washington State Biodiesel Renewable Fuel Standard. There were several unexpected data discoveries but, overall, the response sample size was small; which could have hindered the significance of the findings. The survey data are discussed first in this section, followed by the interview data. The interview data teased out themes across the sectors regarding the Washington State Renewable Fuel Standard. Across the sectors, the general responses illustrated a lack of enforcement and implementation of the mandate, and a need for revision. Lastly, restrictions and benefits to restructuring the mandate are discussed and the chapter closes with a brief section on the future outlook of Washington State's Renewable Fuel Standard and the biodiesel industry.

## Survey Results

The initial analysis that was run, a Multiple Response Permutation Procedure (MRPP), broke the survey questions into three themes. Each of the themes was determined based upon their placement in the survey, as certain pages have themes such as environmental justifications, implementation, mandate evaluation, mandate goals, mandate design, and mandate alterations. From these page themes, three themes were created for evaluation using MRPP: 1)

Environmental Justifications, 2) Mandate Evaluation and Implementation, and 3) Mandate Design.

The Environmental Justifications theme is composed of one question, Q4: Do you believe that the following are significant environmental justifications for the RFS mandate (see appendix for environmental justifications)? It was chosen as the only question for this theme as no other questions fit within this topic. The theme was created to investigate why different sectors may believe the creation of the Washington State biodiesel RFS was necessary from an environmental standpoint.

The second theme named, Mandate Evaluation and Implementation, consisted of the following questions:

Q6: How effective was the implementation of this mandate?

Q7: How much do you see the following factors hampering the success of the RFS 2% biodiesel mandate (see appendix for factors)?

Q8: How much do you see the following factors contributing to the success of the RFS 2% biodiesel mandate (see appendix for factors)?

This theme was created to help determine answers to formative questions surrounding evaluation and implementation of the mandate. Answers to these questions will help to evaluate the next steps in revision or alteration of the state legislation.

The last theme, Mandate Design, was created to encompass questions that deal with mandate success and goals, and is composed of questions nine, twelve, and sixteen. Question nine asks respondents, “Of the goals listed below for the

RFS mandate, which do you believe have been successful and not successful to date (see appendix for goals)?" Question twelve asks, "In your opinion, how successful has the Renewable Fuel Standard Mandate been to date (i.e., that 2% of the diesel sold in Washington State must be biodiesel)?" The final question in this theme, question sixteen, inquires about the design of the mandate by asking, "How much does the fact that the governor has the authority to suspend certain RFS requirements 'based on determination that such requirements are temporarily technically or economically infeasible, or pose a significant risk to public safety' affect the goals of the mandate and your confidence in the mandate?"

*Theme Design and Results*

For each of these themes, the hypothesis was that there would be a difference in responses to the questions across the sectors. Across these three themes, only one showed a significant difference amongst sector responses when run as an MRPP and ordination, in the program PCORD. The data in the theme Mandate Evaluation and Implementation consisted of Questions six through eight in the survey (see Appendix for survey). Figure 9 illustrates the ordination distribution among the sectors for Theme Two: Mandate Evaluation and Implementation. The MRPP determined that there was a moderate significant difference among the sector responses (A=0.080067; p-value= 0.044509). The differences are shown in the image according to the grouping patterns that you see with the academic and non-profit sectors. This finding illustrates that there are differences between sectors responses regarding the mandate's evaluation and implementation. The importance of this finding is that it highlights how differing opinions in policy making are important and must recognized to craft effective and strong policy.

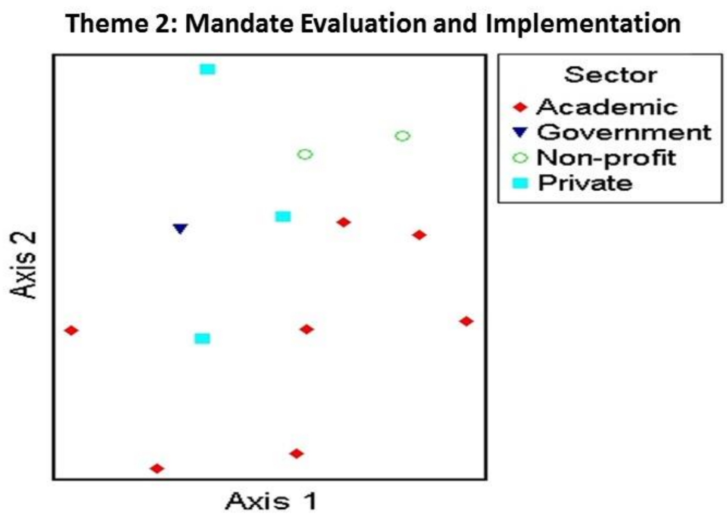


**Figure 9: Theme 2 NMS Ordination Showing key Differences in Distribution of Survey Responses**

NOTE— Axis 1 and Axis 2 are just spatial references that allow us to visually see the patterns in the opinions of the different sectors.

*Environmental Determinants*

Since the remainder of the themes showed no significant differences in sector responses, resampling ANOVAS were run to determine significant differences in sector response by question. The questions that showed significant differences are question seven (How much do you see the following factors hampering the success of the RFS 2% biodiesel mandate?) and question eight (How much do you see the following factors contributing to the success of the RFS 2% biodiesel mandate?) For question seven, the factor that showed a significant difference among sector responses for whether or not it hinders the success of the RFS is the

Feedstock Supply (p-value= 0.035). Figure 10 indicates the mean response from each sector.

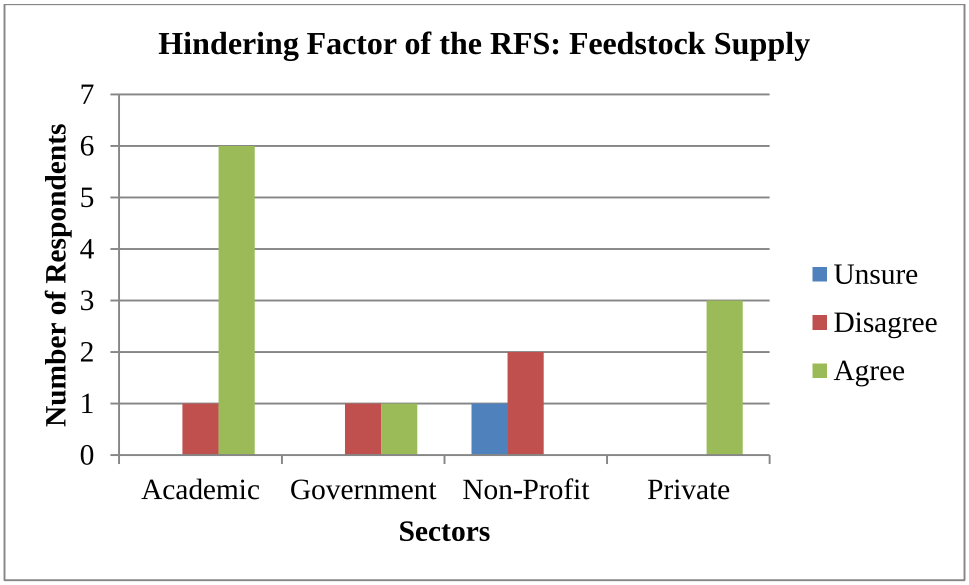


**Figure 10: Hindering Factor of the Washington State Biodiesel RFS: Feedstock Supply (p-value=0.037; n=15).**

NOTE—Measured on a Likert scale (1=unsure; 2= Strongly Disagree; 3= Disagree; 4= Agree; 5= Strongly Agree).

As seen from Figure 10, the sectors could not agree regarding the feedstock supply as a possible hindrance to the Washington State RFS. The academic and private sectors tended to see feedstock supply as a large hindering factor. As seen from a review of the literature the reasoning for the selecting feedstock supply as a hindering factor could be because accessibility to feedstock causes investors to deter from entering the biofuel market. The non-profit and government sectors disagreed with the academic and private sectors, as they cited feedstock supply as a non-issue in hindering the mandate success. These sectors could have chosen this choice because they view feedstock supply as a non-issue since the RFS was created to increase in-state feedstock supply of biodiesel and currently the state agencies biodiesel needs are being met through contracts that require state fleets to use a certain percentage of biodiesel. What this issue really boils down to is whether or not accessibility to feedstock supply could hinder the success of the Washington State RFS for biodiesel.

The remainder of the factors that hinder the success of Washington State's RFS had no significant difference among sector responses. As seen in Table 5, a majority of the fifteen people surveyed, from all sectors, agreed that feedstock price, policy uncertainty at the federal and state levels, production costs, and infrastructure investments were factors that hindered the RFS's success. Agreement over feedstock price affecting the RFS is consistent with the literature, as higher commodity prices can drive up the cost of production leading to less or limited capital investment. Agreement across the sectors on uncertainty in federal and state policy hindering the state RFS was also expected as federal policy is what mandates the overall targets of biodiesel production capacity per year. In addition, state and federal policies dictate incentives and tax breaks, which can alter production and capital investment.

| **Table 5: Sector Responses about Factors that Hinder the Washington State Biodiesel RFS (N=15)** | | | |
|---|---|---|---|
| Factors | Unsure %(N) | Disagree %(N) | Agree %(N) |
| Diesel Prices | 20 (3) | 33 (5) | 47 (7) |
| Feedstock Price | 0 | 27 (4) | 73 (11) |
| Feedstock Supply** | 7 (1) | 27 (4) | 73 (11) |
| Policy Barrier Blend Wall | 13 (2) | 53 (8) | 33 (5) |
| Policy Uncertainty- Federal | 20 (3) | 27 (4) | 53 (8) |
| Policy Uncertainty- State | 27 (4) | 20 (3) | 53 (8) |
| Production Costs | 20 (3) | 20 (3) | 60 (9) |
| Infrastructure Investments | 7 (1) | 20 (3) | 73 (11) |
| Environmental Barriers- Greenhouse Gas Emissions | 13 (2) | 53 (8) | 33 (5) |
| Environmental Barriers- Feedstock Water Consumption | 27 (4) | 53 (8) | 20 (3) |
| Consumer Knowledge | 13 (2) | 40 (6) | 47 (7) |

**Only factor for which the responses differed significantly based upon sector response.

As mentioned in the literature review, production costs are extremely dependent upon capital investment, infrastructure and feedstock price. Since all of these expenses are closely linked, any increase in cost along the production chain can affect the success of a state-mandated RFS, particularly those that operate on a production percentage outcome or per gallon percentage blend as in the state of Oregon. Lastly, if infrastructure is not available or is limited for distribution of biofuels, it can raise costs of distribution to the market place and can inadvertently make RFS mandate goals less attainable. Fortunately, biodiesel is a liquid fuel and therefore the infrastructure changes are minimal when substituting it for petroleum-based products. As mentioned in the review of the literature, the main concern with infrastructure is the initial installation costs and upgrades to existing systems.

On the other hand, the majority of sectors also answered that a blend wall, greenhouse gas emissions, and feedstock water consumption were not factors that deterred the success of the RFS in Washington State. The response that a blend wall is not a factor that deters the success of the RFS was to be expected as biodiesel does not have a blend wall issue, but rather ethanol does. The response regarding feedstock water consumption was a bit unexpected as it is a large concern of the federal RFS, but it may not be a concern at the state level.

Water consumption may not be viewed as a concern at the state level for hindering the RFS because agricultural industries and the EPA have certain restrictions and guidelines that are more enforceable on a statewide level. Lastly, emissions, as expected, would not hinder the success of the state biodiesel RFS, as the goal of the RFS is to in fact decrease emissions directly by increasing production of cleaner renewable fuels. In actuality, it would be expected that greenhouse gas emission reduction goals will help contribute to the success of the state RFS by driving consumers and producers to use a cleaner burning fuel.

The remaining factors of consumer knowledge and diesel prices did not have a certain response that claimed a majority. For the factor diesel prices, the result of no clear decision on whether it affects the RFS success was to be expected, as there is still discrepancy over price effects in the literature. This discrepancy in part stems from the fuel vs. food debate, as price is constantly volatile and changing due to the market demand and production costs. This raises a huge question as to what needs to be done to involve the public in the RFS and consumption and promotion of biodiesel within the state.

There were significantly different responses by sector to question eight (How much do you see the following factors contributing to the success of the RFS 2% biodiesel mandate?) Factors that contributed to the success of the biodiesel RFS, as expected, were different from those that hindered the mandate. A resampling ANOVA determined that there were significant differences between sectors regarding the roles of production costs, infrastructure investments, and consumer knowledge in contributing to the success of the mandate.

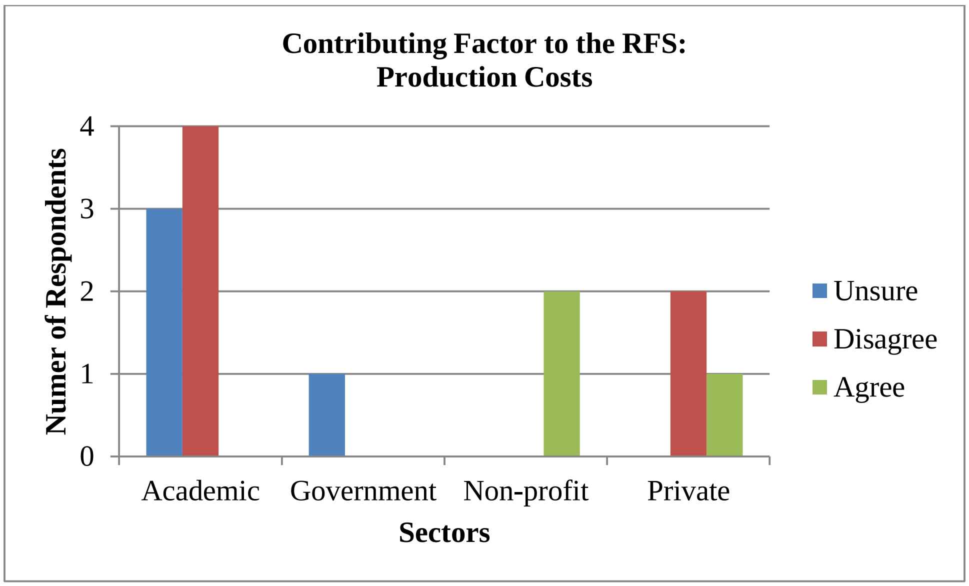


**Figure 11: Contributing Factor to the Washington State Biodiesel RFS: Production Costs (p-value=0.01; n=13).**

NOTE—Measured on a Likert scale (1=unsure; 2= Strongly Disagree; 3= Disagree; 4= Agree; 5= Strongly Agree).

Production costs can either contribute to the success of biodiesel production or hinder it. Production costs showed a significant difference among sector responses for whether or not it contributed to the success of the RFS (p-value= 0.01). As seen from Figure 11, the academic and government sectors reported that they were unsure or disagreed that it contributed to the success of the mandate, while the non-profit and private sectors reported that it does. A review of the literature found that production costs and capital investment can severely change an industry depending on how much funding is available and how inexpensive the technology is for production. If production costs are high, it can make biodiesel uncompetitive against petroleum-based diesel products, which then leads to a decrease in demand and production that, in turn, threatens the success of a mandate.

Infrastructure investment also showed a significant difference in sector responses, with the academic and government sectors indicating they did not view the factor as contributing to the success ($p=0.023$). On the other hand, the non-profit and private sectors indicated that infrastructure investment does contribute to the success of the RFS (see Figure 12).

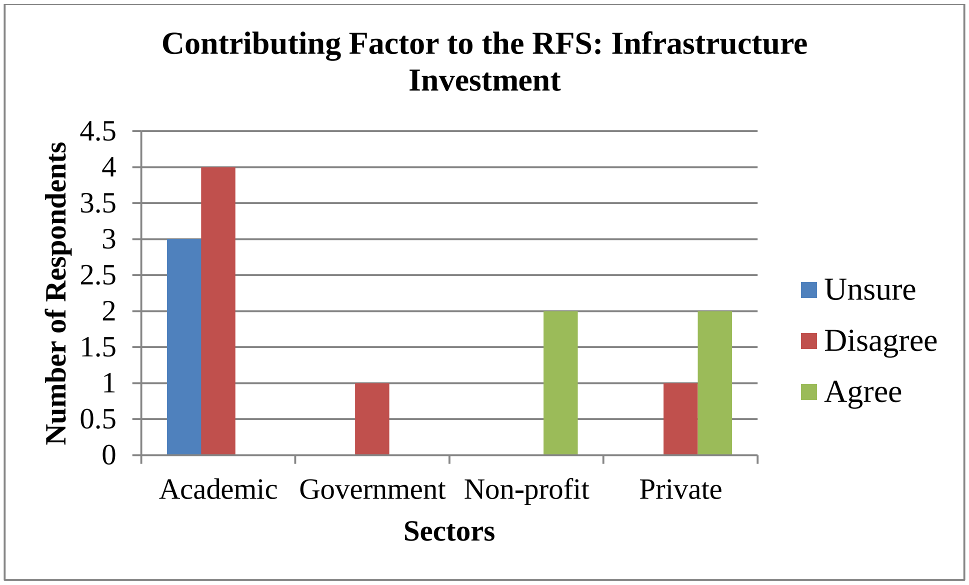


**Figure 12: Contributing Factor to the Washington State Biodiesel RFS: Infrastructure Investment (p-value=0.023; n=13).**

NOTE—Measured on a Likert scale (1=unsure; 2= Strongly Disagree; 3= Disagree; 4= Agree; 5= Strongly Agree).

Infrastructure investment is similar to that of production cost in its indirect affect altering the success of the mandate. If the infrastructure is not already in place, distributors and producers have to incur even higher capital costs to get their product to the market. This additional cost can raise production costs, but if companies can use or alter existing infrastructure—such as pumps, holding tanks, and shipping systems—then this can have the reverse effect on production costs as well. Therefore, since this factor can alter biodiesel product cost, it was expected that a split response would occur, but the pairing of the non-profit and private against government and academic was not expected.

The final factor that showed a significant difference in responses among sectors is consumer knowledge (p=0.017). The academic sector disagreed that consumer knowledge was a contributing factor in the success of the state RFS, while the government, non-profit, and private sectors agreed it was (see Figure 13).

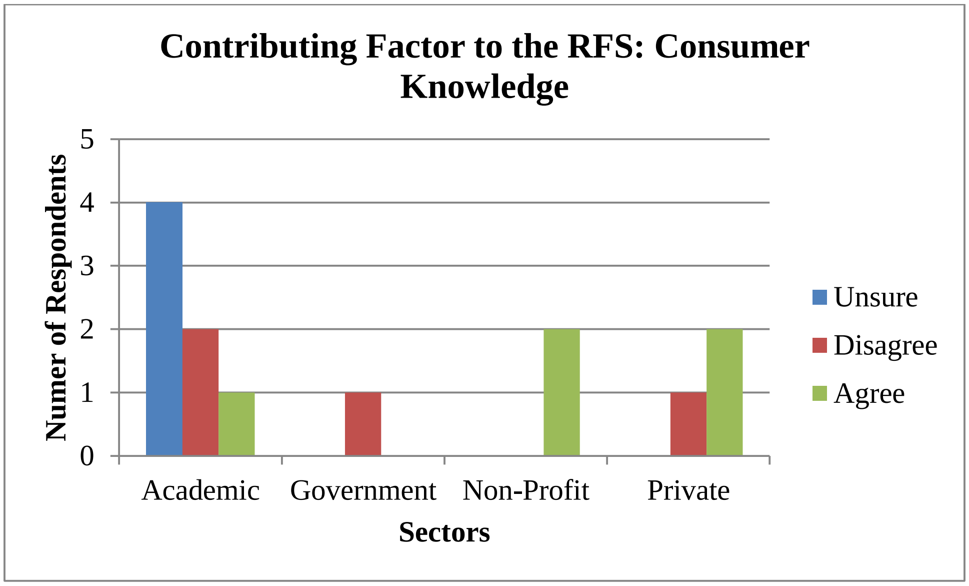


**Figure 13: Contributing Factor to the Washington State Biodiesel RFS: Consumer Knowledge (p-value=0.017; n=13).**

NOTE—Measured on a Likert scale (1=unsure; 2= Strongly Disagree; 3= Disagree; 4= Agree; 5= Strongly Agree).

The pairing of sectors in regards to consumer knowledge is quite unique as the non-profit and private sectors predominantly indicated that consumer knowledge is a contributing factor in the success of the RFS, while the government sector respondent disagreed. Meanwhile, the academic respondents predominately were unsure or disagreed whether or not consumer knowledge contributes to the success of the RFS. The overall results from questions seven and eight; regarding consumer knowledge indicate that sectors view consumers differently. As seen from the literature, production costs, infrastructure investments, and consumer knowledge can contribute to the mandate's success through loans, incentives, and outreach. Programs for the state that fit this profile are producer facility loans, incentives for farmers, and outreach done by both the state and academic research programs.

The remainder of the factors, did not have significant differences among sector responses, but did indicate overall agreement for or against their contribution to the state mandate's success. A majority of the sectors responded that diesel prices, feedstock price, feedstock supply, policy uncertainty at the federal and state levels, and greenhouse gas emissions are not factors that contribute to the success of the RFS (see Table 6).

**Table 6: Sector Responses about Factors that Contribute to the Success of the Washington State Biodiesel RFS (N=15)**

| Factors | Unsure %(N) | Disagree %(N) | Agree %(N) |
|---|---|---|---|
| Diesel Prices | 23% (3) | 46% (6) | 31% (4) |
| Feedstock Price | 15% (2) | 54% (7) | 31% (4) |
| Feedstock Supply | 8% (1) | 54% (7) | 38% (5) |
| Policy Barrier Blend Wall | 31% (4) | 54% (7) | 15% (2) |
| Policy Uncertainty- Federal | 23% (3) | 54% (7) | 23% (3) |
| Policy Uncertainty- State | 23% (3) | 54% (7) | 23% (3) |
| Production Costs** (p-value=0.01) | 31% (4) | 46% (6) | 31% (4) |
| Infrastructure Investments** (p-value=0.023) | 23% (3) | 46% (6) | 31% (4) |
| Environmental Barriers- Greenhouse Gas Emissions | 15% (2) | 46% (6) | 38% (5) |
| Environmental Barriers- Feedstock Water Consumption | 46% (6) | 38% (5) | 15% (2) |
| Consumer Knowledge** (p-value=0.017) | 31% (4) | 31% (4) | 38% (5) |

**Only factors for which responses differed significantly based upon sector response.

*Mandate Goals*

As mentioned in the literature review, the Washington State biodiesel RFS initially started out with five goals to achieve: increase state biodiesel feedstock supply, increase state production of biodiesel, decrease petroleum dependence, decrease carbon emissions, and foster environmental sustainability. The survey addressed these issues by asking survey participants which goals they viewed as the most and least important. The survey responses, shown in Figure 14, show that none of the sectors seemed to be on the same page, which is not effective when formulating policy to push for growth of the industry. The most important goal, seen by the four sectors, was the reduction of carbon emissions, but was closely followed by the goal an increase in state biodiesel production.

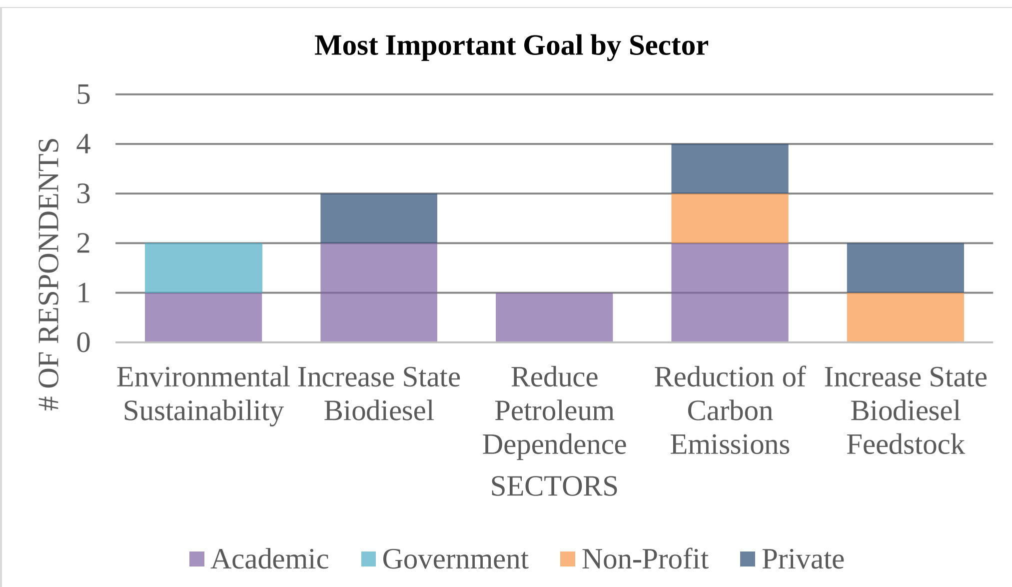


**Figure 14: Most Important Washington State Biodiesel RFS Goals (n=12)**

As shown in Figure 15, the survey participants indicated that the least important goal was to be increasing state biodiesel. This is surprising, because the renewable fuel standard was constructed to increase state biodiesel, but perhaps participants viewed this as the least important because, with an increase in feedstock, a market will arise for in-state biodiesel production, especially since state agencies are required to use a certain percentage of biodiesel and state contracts were passed by the legislature that require Washington State agencies to buy 51% of their biodiesel in-state. Since these other laws are being effectively implemented, the sectors could view this goal as a non-issue, essentially.

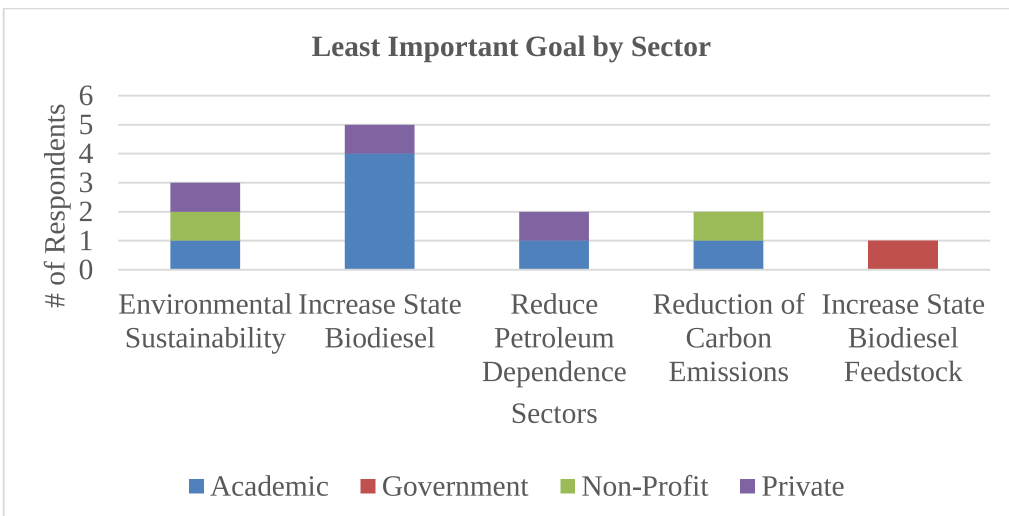


**Figure 15: Least Important Washington State Biodiesel RFS Goal (n=13)**

*Additional Survey Questions*

Additional survey questions helped to apply a holistic approach to answer all formative questions necessary for an evaluation of the Washington State Biodiesel Renewable Fuel Standard. The additional questions were analyzed through resampling ANOVAs and found no significant difference among sector responses. The first question asked individuals to identify if certain environmental factors were a consideration to implement and put in place a mandate. The responses indicated that the sectors agreed that air quality was the sole environmental factor to justify creating the state mandate, while the remaining factors of water quality and consumption, soil quality, biodiversity and land use change were not (see Table 7). This question did measure responses based upon a Likert Scale (1=unsure; 2= Strongly Disagree; 3= Disagree; 4= Agree; 5= Strongly Agree).

Table 7: Responses from Surveys about Importance of Environmental Factors as Justifications for Washington State Biodiesel RFS **(N=16)**

| **Factors** | **Unsure % (N)** | **Disagree % (N)** | **Agree % (N)** |
|---|---|---|---|
| Air Quality | 6% (1) | 19% (3) | 75% (12) |
| Water Quality | 38% (6) | 25% (4) | 38% (6) |
| Water Quantity Consumption | 31% (5) | 44% (7) | 25% (4) |
| Soil Quality | 31% (5) | 25% (4) | 44% (7) |
| Biodiversity | 31% (5) | 31% (5) | 38% (6) |
| Land Use Change | 13% (2) | 50% (8) | 38% (6) |

When asked which agency is currently responsible for implementation and who should be responsible for implementing and tracking usage and production, none of the survey respondents reported the correct agency, i.e., the Washington State Department of Licensing. The respondents, on the other hand, listed a myriad of agencies that they thought should be in charge of implementation, such as the Washington State Departments of Commerce, Ecology, and Enterprise Services. This indicates that, not only was the RFS weak initially, but even those in the private sector who have to submit reports to the state are unsure who exactly is supposed to track its implementation.

The next question in the survey asked participants whether they believed that the biodiesel RFS for Washington State was effective in its implementation or not and, as expected, a majority—53% across all sectors—reported the mandate as ineffective to date.

Questions that targeted the issue of revision asked survey respondents what the best alteration or revision to the RFS might be, and then based on the current state of the industry what the most appropriate revision or alteration to the RFS for the state was to achieve the five goals. The first question, which indicates the best revision, showed a division among four answers in which none had a clear majority of the responses. The four responses chosen were incremental increase (based on Oregon's mandate percentage by the gallon), stronger incentives for consumers, less or limited government incentives and mandates, and no alterations to the mandate (see Table 8).

The options for the future can fall into different categories, but the first as mentioned is for Washington State to move towards implementing a percentage by the gallon mandate, which is currently what Oregon State has implemented. This form of mandate allows for policy makers to measure biodiesel usage as it is blended and sold at the pump. In addition, the way the mandate is measured, by the gallon, allows for policy makers to create goals and targets for the state to meet. Once those goals are met then the percentage required will be ramped up. For example, in Oregon State, all diesel fuel was required to be B2 and then once it reaches at least 15 million gallons produced annually the mandate will then bump up to use B5 (Oregon State Government 2014).

The next option that was chosen for revisions by the sectors is stronger incentives for consumers. This can come in many forms whether it is through incentives or tax breaks that draw people to purchase vehicles that will have lower emissions because they run on biodiesel. The other option is to incentivize fleets to use biodiesel so that their emissions are lower and they are abiding by EPA regulations. The fleets to target can be public transportation, construction, and marine vessel fleets (Alternative Fuels Data Center 2013d). Another option is a more hands off approach, in which the government has less or limited incentives and mandates. This is an option because it can, in some ways, help to determine exactly how the market will react to biodiesel, rather than creating false markets through incentives. With fewer incentives it could help or hurt the biodiesel industry because it could drive investment away or attract more investment. Driving investment away is the largest concern with this option because less investment could lead to the industry falling apart. Currently, the incentives put in place by the state regarding its fleet's requirement to use biodiesel are what is continuing production in the state. Without that incentive, the demand for biodiesel could go down. This option has its merits and pitfalls, and therefore if pursued by the state it must be fully evaluated to prevent the industry from deteriorating (Mosey and Kreycik 2008).

The final recommendation that participants chose was no alterations to the mandate. This option entails that no revisions be made and basically that the legislature should let the mandate eventually be forgotten or replaced by a law that supersedes the RFS. This suggests that the RFS failed in its intent, but can be revived with a completely new policy that is constructed to meet the goals and shortcomings of the RFS. If this option were pursued by the legislature, the next policy that could be implemented would be either a clean fuel standard or a cap and trade system. A clean fuel standard is essentially the same policy of a low carbon fuel standard; just the title is changed so that it is more marketable and appealing to the public. A clean fuel standard or LCFS mandates fuel suppliers to slowly reduce the carbon intensity in their products over time. This form of policy is gaining support because it does not favor certain alternative fuels and technologies over others, and essentially lets the market determine the outcome and solutions to reduce carbon in the current supplied fuel. This form of policy is becoming more common across the United States as California enacted one in 2011. In addition, eleven states in the Northeast and Mid-Atlantic signed a Memorandum that agreed to collaborate and develop a clean fuel standard for the region in 2011. Lastly, British Columbia currently has an LCFS, which has been in place since 2008 (Ceres 2012).

| Table 8: Survey Participants Recommend Alterations or Revisions of Mandate to Achieve the Five Goals (N=11) | |
|---|---|
| **Revision Options** | **% of Respondents (N)** |
| **Incremental increase of mandate percentage based on production** | 18% (2) |
| **Yearly increase of mandate percentage** | 0% |
| **Stronger incentives for producers** | 0% |
| **Stronger incentives for farmers** | 0% |
| **Stronger incentives for consumers** | 36% (4) |
| **Less or limited government incentives and mandates** | 36% (4) |
| **No alterations to mandate** | 9% (1) |

The final question illustrated what the sectors view to be the most appropriate or politically feasible alteration due to the current state of the biodiesel industry in Washington State. The academic sector, for the most part, selected a revision of the goals and mandate, while the remaining sectors chose incentives and a non-profit chose education and outreach. This indicates that there is disagreement among the sectors as to what may be the most appropriate revision, but they do acknowledge that revisions need to be addressed (see Table 9).

| Table 9: Survey Participants Views of Most Appropriate Alterations or Revisions of Mandate to Achieve the Five Goals **(N=11)** | |
|---|---|
| **Revision Options** | **% of Respondents (N)** |
| **Incentives for consumers** | 36% (4) |
| **Incentives for technology in the industry** | 9% (1) |
| **Incentives for producers** | 0% |
| **Leave mandate as is** | 0% |
| **Public education and outreach** | 9% (1) |
| **Revision of goals/ mandate** | 45% (5) |

## Interview Themes

Analysis of the seven interviews revealed similar themes across the sectors, highlighting a lack of enforcement of the state's RFS, a need for new policy, and barriers to industry growth that should be addressed through education and outreach. There were several unexpected themes that developed from the interviews, such as all sectors advocating a new policy, even though they did not agree on a preferred policy path. The similarities in the interviews demonstrate that the sectors all share common ground on what they are trying to achieve (i.e., reduction of carbon emissions) but they lack information, knowledge, and political cooperation to get there.

*Theme 1: Not Enforceable*

Across the board, all the individuals interviewed for the purpose of this study indicated that the Washington State Biodiesel RFS was not enforceable. State agency individuals (categorized as the government sector) noted that the RFS was designed this way, as Governor Gregoire announced it in her 2006 legislative package and left the agencies scrambling to figure out how to craft appropriate policy responses in one legislative session. They went on to remark that the language was rushed, and crafted in a way that made it enforceable, in order to appease all sectors, including petroleum companies who had a history of advocating against this form of policy. Lastly, they noted that the RFS was designed to be the weakest portion of the bioenergy campaign, as the state's main focus was to expand feedstock, supporting agriculture and producing in-state biodiesel, while providing incentives and loans to the producers, which would eventually give momentum to expand the industry statewide. The state government and agencies had been leading the way in this effort by requiring all agencies and state ferries to use a certain percentage of biodiesel. Unfortunately, since the RFS was designed to be weak, in this view, the implementation and reporting issues for general public use of 2% were never ironed out, leaving the policy to be almost ineffectual in the state.

*Theme 2: Discrepancy over Price*

Regardless of the questions asked in the semi-structured interviews, all interviewees highlighted that cost of production and cost at the pump is a concern in producing and selling biodiesel. Most identified that the cost of petroleum products is low with hidden subsidies, while biodiesel is still getting off the ground and has limited support from the state, causing it to be uncompetitive with petroleum-based fuel. State agency interviewees disagreed with the remark that petroleum products were cheaper by stating that, “[the] price of biodiesel doesn’t make a difference anymore, there is a big perception that it does.” From the literature review done for this study, this idea that biodiesel is more expensive is dependent on region or economic situations, as the price of biodiesel on the West Coast, according to the reports done by the U.S. Department of Energy, are comparable to that of diesel. On the West Coast, as of January 2014, biodiesel was priced at $4.07/gallon of B20, while diesel was priced at $4.02/ gallon (DOE 2014). The same source reports that, nationally, biodiesel costs an average of 8¢ more than diesel at a B20 blend, and 39¢ more than diesel at a blend of B99/B100. This is just the cost at the pump, and does not factor in production costs but, as highlighted from the interviews, even among professionals that work in the industry or have influence in the industry policy, there is uncertainty regarding price. This alone can cause tension when it comes to creating appropriate policy and legislation at the state level regarding biodiesel, which many of the sectors admitted need to be addressed by Theme 6—outreach and education.

*Theme 3: Food vs. Fuel Debate*

An ongoing global debate in biofuels production is the concern that fuel production from agricultural crops will diminish the food supply. The interviewees of this study had differing opinions on this debate, but each one brought it up of their own accord. An academic interviewee remarked that, "in Washington State, the agricultural land produces a lot of high-valued crops already, and so it's [biodiesel] got tough competition." The point of this quote is to highlight that this academic interviewee did not view biodiesel crops as a direct threat to food crops because food crops will essentially take precedence over biodiesel. This means that he valued food over fuel when it comes to the debate of whether or not to produce fuel on agricultural land if a situation arises in which they will be competing for the same land.

A private sector interviewee mentioned the fuel vs. food debate in a different light, by highlighting the concerns surrounding the sustainability of the feedstock and the impact it could have on the environment and land that it employs. He stated, "if we don't have feedstocks that are harvested in a sustainable manner then you've got the potential to something that's harmful." To clarify the statement, he noted that if biodiesel feedstock is not harvested sustainably it could in fact damage the fields, which in rotation are used for food crops and therefore moving forward, biodiesel feedstock production needs to proceed with an err on the side of caution to ensure that they do not destroy the land and make it no longer arable.

This debate was rounded out by a response from state government professionals who claimed that not only was this a non-issue for Washington State, but the fuel vs. food debate was denounced through research and outreach done by the Washington State University. The state, according to the interview participants who work in state agencies, provides funds every year—ranging from $500k to $300k—for research surrounding bioenergy. The interviewees reported that researchers and farmers alike had found that, if farmers in the state of Washington grew canola during an off period in which the field would be fallow, their next crop of wheat would have a higher yield. The canola crop increases yield because it has a "deep tap root… so your canola can go into the soil and scavenge nitrogen… that got too deep for your wheat to utilize." In Washington State, canola is grown on non-irrigated dry land where there are lower water and pesticide costs and during a time when the field would in fact be fallow. So, instead of letting their fields sit idle in between rotations, farmers can actually make an income off the canola and increase the wheat yield in the next cycle, which causes it to not compete with food crops (Hang, Collins, and Sowers 2009).

Although interviewed state officials noted that this is becoming a non-issue in Washington State, it still exists in other regions and the perception that it exists in Washington State is still evident amongst the professionals in the industry and the public.

*Theme 4: Policy Uncertainty*

The interviewees also chose to address the issue of policy uncertainty, as it answers some of the formative questions that help to tease out issues in the implementation of the Washington State RFS. Between the survey participants and interview participants, there was consistency regarding this theme. Each viewed uncertainty in policy as a major barrier to investment and to the growth of the state's biodiesel industry. An academic interviewee noted that stability in the future would be essential for biodiesel growth, while a private sector interviewee stated that uncertainty is harmful because, "when people build a business model off this they are way out on a limb and in many cases they can't weather it through the policy changes." One private interviewee even claimed that the uncertainty and weakness in the RFS has pushed state biodiesel producers to sell their product out of state. Lastly, the interview responses of state government officials agreed that uncertainty may be a deterrent in entering the industry, but those who have weathered the recession are stronger businesses because they have, "business model(s) that are viable almost absent of any consistency in government policy." In actuality, the government officials find that uncertainty has been able to, in a way, help weed out the winners and losers and ultimately focus on the true concerns over feedstock supply and in-state production. The uncertainty in policy leads to the next theme of revision and whether or not revision should happen.

*Theme 5: To Revise or Not?*

Revision is a big question that looms over and ultimately determines the outcome of Washington State's Biodiesel RFS. Across the board, in surveys and interviews, participants indicated that a revised or new policy is needed for the state to move forward in achieving its goals. In the seven interviews, there was a combination of different answers regarding this subject. A private industry interviewee favored a straightforward solution like the gallon requirement found in Oregon's RFS, which was evident in their statement, "We've got to find something that works that doesn't cost the tax payers any money and has economic benefits [and] that's found in the Oregon State RFS. I think we should copy what Oregon has done, its' been tried, its' had success, and its' worked." In addition the state government interviewees articulated that Oregon is a perfect example of the success of a well-crafted RFS for biodiesel mandated by the gallon, but despite this currently there is "more of an emphasis on a Clean Fuel Standard."

In addition, a private interviewee noted that, "the failure and success depends on a properly written regulation. An LCFS is very desirable for a lot of reasons, but even if we are just continuous with our neighbors it would be a very positive step forward." By mentioning this, the interviewee was getting at the idea that if Washington State, works together with its neighboring states and follows similar policies that they have enacted this is better than the current unenforceable RFS for the state of Washington. A non-profit interviewee agreed that a new policy was necessary, but recognized that a regional approach would be more fitting, as that would keep everyone on the same standard with the same goals in mind, as well as maintaining competitiveness at the borders.

An academic interviewee advocated an “income-neutral tax.” The interviewee claimed that British Columbia has provided a great model for dealing with the crux of the issue (carbon emissions) through a carbon tax, but it needs to be presented in a way that all sectors will respect. This statement makes it evident that the issue of biodiesel is not just an environmental concern, but also a complex political issue.

The other academic interviewee stated that, “people should take seriously what has been and is probably the most well designed climate policy in the world right now, which is BC’s carbon tax, revenue neutral carbon tax. That carbon tax if implemented well will provide producers with incentives for investing in renewable fuel production to the extent that it is economically viable.” It was interesting to note that both academic interviewees agreed that the best option for replacement of the Washington State Biodiesel RFS was British Columbia’s carbon tax system.

In regards to subsidies and incentives, it was intriguing that across the board, all interview participants were against subsidies as they are, “very costly ways of inducing investments” and they direct people into unrealistic markets. On the other hand, most sectors favored incentives in different forms. Government sector interviewees praised the current state incentive program, contributing biodiesel producers’ success to the state loans and incentives program. Academic sector respondents agreed more or less with incentives being a positive and viable market for increasing in-state biodiesel production. However, private sector respondents thought incentive programs could be strengthened in a way similar to Oregon's, where growers receive a certain monetary amount per pound of feedstock crop grown—an incentive for growers to keep producing in Oregon. The idea is that this would expand the biodiesel market within the state and makes products more competitive outside the state.  However, expiration of incentives was raised as a concern. If incentives have a short life span, then it creates uncertainty and can discourage investment in the industry.

Besides the topic of revision, respondents addressed their frustrations with the policy from its initial introduction as a bill and after it was passed in the state legislature in 2006. One academic respondent noted in irritation that the RFS crafted in 2006, was the "wrong policy instrument" from the start. Another academic noted that it was "the wrong policy instrument to meet the stated outcomes," because it did not have incentives to attract firms to the market, there was no form of enforcement, and limited or no general public knowledge of the policy

As mentioned in previous themes, the interviewees insinuate or allude to a need for outreach and education when discussing policy revisions, the food vs. fuel debate, and the discrepancy over price. This leads to the final theme of outreach and education that is essential both within the industry and outside it.

*Theme 6: Outreach and Education*

The interview analysis indicated that there was widespread acceptance from all sectors regarding a need for education and outreach targeted at different levels. A private sector interviewee summed up the importance of education by stating that, "if we truly believe that we want sustainability and if we truly believe that $CO_2$ emissions are affecting our environment and if we truly believe that we are seeing climate change. If we truly believe in those things then how are we going to get people to do it? Through education." To this interviewee, education is the foundation that needs to be laid first to move forward in replacing the RFS and creating appropriate policy that will help mitigate and adapt to climate change in the state. The other private sector respondent noted that the general public does not pay attention to or care about the RFS. This response was consistent with the state officials who were interviewed and noted "people in Washington, no one is aware that there is an RFS."

An academic interviewee noted that "it's really important to figure out how to get more outreach" and that the field as a whole needs more outreach education at different levels because people in the industry still have misconceptions about certain policies and debates mentioned in the themes above. The non-profit interviewee noted that when it comes to outreach and education, "you just can't do one thing, you need to do a series of different things and we need to first of all do some reflecting." This interviewee highlighted a key component in outreach and education, which is that of reflection on the current state of the industry and policy and how they have or have not succeeded in their missions. In terms of outreach and education for the industry in the state of Washington, there are different ways to approach this component, but it cannot just be a top-down approach. Each sector needs to take the initiative to educate its own constituents and then reach out to their communities, because if biodiesel production increases in the state of Washington that will create jobs and lead to more investment.

## **Discussion**

This study found that for some of the formative questions, sectors showed common responses regarding the mandate; while in others there was clear disagreement. Regardless of the disagreements, the surveys and interviews highlighted a need for outreach and education regarding biodiesel production in Washington State, and a new policy to achieve the goal of lower carbon emissions. This study suggests that all sectors should begin to formulate educational campaigns regarding biofuels and that state agencies should consider looking into a carbon tax, as most sectors viewed it as effective if implemented properly. Additionally, survey and interview subjects suggested that since all sectors have a goal of reducing carbon emissions, the Governor should take a stronger stance on the issue and start to work towards a regional policy that will keep Washington State's biodiesel market competitive at the borders.

These findings will help fill the gap that currently exists regarding assessments and revisions for the state of Washington biodiesel RFS. Not only is this study unique in that it reviews a policy that is in significant need of assessment, revision, and possibly replacement, but also it highlights the differences in sector beliefs. This is an integral piece in policymaking, since different parties have to understand their opponent's needs, wants, and goals before they can move forward with policy creation or revision. Since this method of evaluation is different than the typical environmental and economic evaluations, it is unique and will contribute to the literature by shedding new light on how different sectors view integral components that affect the RFS.

The thesis investigated how policy experts and stakeholders assess the performance of the Renewable Fuel Standard Mandate on biodiesel for Washington State. From the interviews and surveys completed, the simplified answer is that all four sectors—academic, government, non-profit, and private—agreed that the biodiesel RFS was not successful, due to the fact that it is not being enforced and there are no clear legal provisions for enforcement. Regardless of the fact that it was non-binding and unenforceable, the sectors' views on certain contributing and hindering factors with respect to the RFS can be used in later discussions on how to craft the RFS's replacement or revision. In addition, the sectors did come to agreement, both in interviews and surveys, that the state needs to craft policy that gets at the real concern, which is carbon emissions, whether that is through promoting biodiesel or not. The largest concern and the reason the RFS was created were to alter the state's carbon emissions and the state needs to get back to that idea first and foremost.

Currently the state has become more aggressive about targeting and reducing carbon emissions, which is evident in the Governor's (Jay Inslee)

Executive Order 14-04 Washington Carbon Pollution Reduction and Clean Energy Action signed on April 29, 2014, which created a Carbon Emissions Reduction Taskforce to provide recommendations on policy and market mechanisms for Washington State that will reduce GHG emissions. The first annual report will be due to the governor in November 2014. With this executive order the Governor hopes to target 7 key areas: carbon emission, coal- fired electricity from other states, clean transportation, clean technology, energy efficiency, state government operations, and carbon pollution limits (State of Washington Office of the Governor 2014).

This report builds on the already existing knowledge and reports that the Climate Legislative and Executive Workgroup (CLEW) created under the Substitute Senate Bill 5208 in 2013 gave to the state legislature in October 2013 (Leidos 2013). In addition to this, RCW as of 2008, includes a section (70.235.020) that acknowledges Washington State's greenhouse gas emission reduction goals, starting with a goal in 2020 that requires that the state reduce its' levels back to levels that were present in the 1990s (Washington State Legislature 2009).

As seen from recent legislation and executive orders, the governor of Washington is trying to make reduction of GHG emissions a priority, but now it is up to the legislature and industry leaders to get on board, which could prove to be a challenge. An education and outreach campaign could be beneficial in helping to gain greater acceptance and support of this priority, but it needs to be done at different levels such as statewide, county, and city levels to be successful and reach a greater population. Lastly, more collaboration needs to continue at the regional level, similar to that which was done by the previous governor, Christine Gregoire, who signed the Western Climate Initiative. The Western Climate Initiative was an agreement signed by five Western state governors in 2007 that stated they would work to “identify, study, and implement ways to reduce GHG emissions” (Western Climate Initiative 2007).

*Data Limitations*

The limitations to the data are numerous, especially considering the fact that only 16% of the individuals identified as working in or contributing to the biodiesel industry in the state responded to the surveys. Since the response rate was so low, the results do not depict overall attitudes of the sectors studied but, rather, those of a few eager and active individuals. Despite having a low response rate, the individuals that did respond are some of the most active contributors to policy in the state and were very willing to share their views and goals for the industry and their particular sector. Interpretations of the data can also lead to limitations, such as having to break the responses into themes for the ordination analysis. In some ways, this can be viewed as data manipulation if the themes had not already been broken up on the survey. Since not all of the respondents answered all of the survey questions, breaking it into themes was necessary in the analysis. Without breaking the data into themes, the participants’ results would have to have been limited to a total of nine respondents from three sectors, which significantly reduces the available data. Lastly, because error is inevitable in statistical analysis, a bonferroni correction was run for pairwise comparisons in the MRPP to correct for error, but this does not mean that error could not have incurred somewhere along the way. The bonferroni correction was used to minimize error as much as possible. In addition, interpretation of the interview data is subject to error as well because a theme system was created but, since this required constant interaction and familiarity with the interview transcripts, some points could have been overlooked.

In addition, the respondents who agreed to this study were those in favor of revisions and more active in changing the policy in the legislature. Parties that are against revisions of the current RFS or crafting new policy to target greenhouse gas emissions were contacted to participate in this study, but declined the invitation. This in fact limits the data and credibility of the study because it could not fully encompass those in the industry who are strongly against revising the state RFS. Therefore, further research needs to be done to fully encompass those who are completely against revisions of Washington State's RFS and promoting biodiesel production within the state.

*Future Research*

Further socio-economic and policy analysis studies are needed to inform a greater response by various sectors of society, along with a greater understanding of the costs involved in altering policy to the types suggested by the interview and survey participants. Lastly, a survey regarding consumer knowledge and beliefs would be beneficial to address the revisions to the RFS that will target the general public's consumption.

While this study addressed many of the formative questions necessary to evaluate a policy, it was limited in that it could not address summative questions. Summative questions address what occurs at the completion of the program, and aid in determining whether to extend or terminate the policy. It is suggested that the state conduct a summative evaluation after the change in Washington State's Department of Licensing permits for the RFS in July 2015. Although there will be limited numerical results, some numbers on production have been reported by producers. A summative evaluation, coupled with this study, and a cost-analysis of policy options would provide the state with the best platform in moving forward with biodiesel. Further research into Washington State's RFS revision options would expand our understanding of sector views and limitations, and may encourage cooperation for a new policy that benefits the biodiesel industry in Washington, such as a carbon tax, clean fuel standard, or an RFS gallon mandate. Ultimately, the choice in policy will depend on the state's policy priorities.

If the state wants biodiesel production to remain a priority, then revisions need to be made to the current RFS so that the 2% mandate is implemented and companies are held accountable to production goals. This could be achieved through a system similar to Oregon's RFS, where the percentage is by the gallon and is tracked and enforced. If this is to happen, the state would also need to create a system to make the mandate enforceable, possibly through the

Department of Licensing, which was originally intended to track production and consumption.

In addition to this, if the state determines that promoting biodiesel production on the state level is not worth its investment and time, then policymakers need to let the RFS be forgotten and move to create other policies that would achieve the goals set forth by the RFS such as environmental sustainability, reduction of petroleum consumption, and decreasing carbon emissions. Policy options to address these concerns can come in the form of carbon taxes, an RFS similar to Oregon's, or a clean fuel standard.

# Chapter 5: Conclusion

This research began by answering the question of how relevant sectors of society assessed and viewed the Washington State Renewable Fuel Standard for biodiesel. Washington State is one of five states that have some form of biodiesel RFS or biodiesel incentive program. Since Washington State is on the forefront of policy for biodiesel, it was essential to assess its mandate and determine why RFS mandates in general are appropriate moving forward for creating biodiesel industries and mitigating climate change. While Washington State's biodiesel RFS may not be enforceable currently, it is a crucial step in the movement towards promoting biodiesel and alternative fuels as a way to reduce carbon emissions and mitigate climate change.

This thesis began with an extensive introduction to the topic followed by a review of past literature about federal and state RFS policy. In order to understand the context of this question, this review began with research that examined how and why the federal RFS was created and the current implementation issues it is having. A key concept in this body of research is the idea that the federal RFS promotes biodiesel and alternative fuels as ways to reduce the country's greenhouse gas emissions and reliance on foreign petroleum products. From this, the review then shifted to addressing the implementation issues that the federal RFS currently has and how states are addressing the shortcomings of the federal RFS with their own RFS mandates. As part of this review, it was noted that currently nine states have state-mandated RFS policies. Other policy approaches were then highlighted, such as California's Low Carbon Fuel Standard (LCFS) and British Columbia's carbon tax system. From this review of literature, it was shown that RFS mandates were given similar attention as compared to other policy options, but both federal and state mandates are still being evaluated through a variety of policy assessments. In particular, Washington State's biodiesel RFS has had few assessments done leading to a gap in this field of research.

The review of past research then turned to the process of evaluating and assessing policy. The literature revealed that policy evaluations of biofuel policies take either an environmental or economic approach. The environmental evaluations focus on greenhouse gas emissions, soil degradation, water quality, and land use change assessments. Economic assessments take the form of a cost-benefit analysis for the most part. Unfortunately, as determined by the literature review, both of these types of evaluation can, in part, leave out the social costs of policy and implementation. Social costs include, but are not limited, to how the policy can alter the community's perception of the government, policy, or product (biodiesel).

To help fill the gap in literature that there is no formal written evaluation of the Washington State RFS for biodiesel, this thesis then turned to how to fill this gap by assessing the Washington State biodiesel RFS. Using a mixed methods approach, interviews were conducted and surveys distributed to assess how different sectors view the state RFS. The results of this study suggest that, while sectors may have disagreed on a variety of factors surrounding the RFS's implementation, they did agree that it was not being enforced. Based on the results, the sectors determined that the mandate needs to be revised to be enforced or to replace it with new legislation that targets the main concern of carbon emissions. This study suggests that new policy can be formulated, if all sectors work to promote better public relations within their areas of expertise and to the general public regarding biodiesel because, as evident from the results, professions across the board exhibited limited knowledge of policy, but were understanding of the goals it aimed to achieve. For immediate options for policy reform, stronger public relations by the state to promote biodiesel production and usage in the state is essential and could help to alter perceptions and lead parties to actively seek out a change in policy.

As the Washington State biodiesel RFS demonstrates, biofuel industries and policies are complex and intertwined in many ways, but policies such as the RFS are created to help promote in-state production, decrease dependency on foreign petroleum products, foster sustainability, and ultimately reduce greenhouse gas emissions to help mitigate the state's impacts on climate change. This thesis provides an important addition to existing literature by informing future efforts to alter or revise the biodiesel RFS so that it can achieve these goals. Through revision or replacement, the mandate biodiesel production in the state can limit greenhouse gas emissions and ultimately mitigate climate change. With revisions and alterations to the Washington State RFS, the state can become one of the leaders in the country in promoting biofuels, and provide a successful model for other states to follow. The more effectively we revise and create policy to promote biodiesel and alternative fuels, the greater our chances are of mitigating climate change and reducing harmful emissions.

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# Appendix: Survey Given to Participants

## WA State Biodiesel Minimum Fuel Requirement

### 1. Washington State Biodiesel Renewable Fuel Standard Requirement

You are being invited to participate in a research study titled "A Formative Evaluation of Washington State's Biodiesel Renewable Fuel Standard Requirement." This study is being done by graduate student, Jennifer Dunn from The Evergreen State College. You were selected to participate in this study because of your connection to Washington State's Biofuel Industry.

The purpose of this research study is to gather information about experts' opinions regarding the success/failure of the Renewable Fuel Standard and produce a thesis and presentation about my findings. If you agree to take part in this study, you will be asked to complete an online survey/questionnaire. This survey/questionnaire will ask about the Washington State Renewable Fuel Standard and it will take you approximately 15 minutes to complete.

You may not directly benefit from this research; however, we hope that your participation in the study may aid legislators in evaluating the RFS and making alterations and additions to help the state achieve its biodiesel goals.

Risks to you are minimal and are likely to be no more than mild discomfort with sharing your opinion. To the best of our ability your answers in this study will remain confidential. With any online related activity, however, the risk of a breach of confidentiality is always possible. We will minimize any risks by keeping password protected files, only sharing the files with my faculty adviser, Dr. Edward Whitesell, and deleting all files upon completion of the study.

Your participation in this study is completely voluntary and you can withdraw at any time. You are free to skip any question that you choose.

If you have questions about this project or if you have a research-related problem, you may contact the Jennifer Dunn at 832.423.1724 or jennymsutx@gmail.com.

***1. By choosing "I agree" below you are indicating that you are at least 18 years old, have read and understand the consent form above and agree to participatein this research study.**

- ◯ I AGREE
- ◯ I DO NOT AGREE

Page 1

## WA State Biodiesel Minimum Fuel Requirement

### 2. WA State Biodiesel Renewable Fuel Standard Requirement

This survey intends to ask participants questions regarding their expert knowledge of the State of Washington Renewable Fuel Standard requirement.

According to the Revised Code of Washington 19.112.010, 19.112.110, and 19.112.180:

In the state of Washington, at least 2% of all the diesel fuel sold must be biodiesel or renewable diesel fuel. This mandate is required to increase to 5% exactly 180 days after the WA State Department of Agriculture (WSDA) determines that state feedstocks and oil crushing capacity can meet a 3% requirement.

"Biodiesel fuel" according to the WSDA is defined as "monoalkyl esters of long chain fatty acids derived from plant or animal matter that meet the registration requirements for fuels and fuel addititves established by the federal environmental protection agency" (RCW 19.112.010).

***2. In which sector do you work?**

- ◯ Government (State)
- ◯ Government (Federal)
- ◯ Private
- ◯ Non-Profit
- ◯ Academic
- ◯ Other (please specify)

**3. If you are willing, please write a few sentences on your views regarding biofuels, Washington State biodiesel, and the industry growth.**

## WA State Biodiesel Minimum Fuel Requirement

### 3. Environmental Justifications

**4. Do you believe that the following are significant environmental justifications for the RFS mandate?**

| | Strongly Disagree | Disagree | Unsure | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Air Quality | ○ | ○ | ○ | ○ | ○ |
| Water Quality | ○ | ○ | ○ | ○ | ○ |
| Water Quantity and Consumption | ○ | ○ | ○ | ○ | ○ |
| Soil Quality | ○ | ○ | ○ | ○ | ○ |
| Biodiversity | ○ | ○ | ○ | ○ | ○ |
| Land-use Change | ○ | ○ | ○ | ○ | ○ |

## WA State Biodiesel Minimum Fuel Requirement

### 4. Implementation

**5. In your opinion, what agency is or should be responsible for implemtation of this mandate? For your answers label them as:**
**1. agency currently responsible**
**2. agency that should be responsible.**

**6. How effective was implementation of this mandate?**

- Highly Effective
- Effective
- Unsure
- Ineffective
- Highly Ineffective

## WA State Biodiesel Minimum Fuel Requirement

### 5. Mandate Evaluation

**7. How much do you see the following factors <u>hampering</u> the success of the RFS 2% biodiesel mandate? *The answers will be scaled for statistical analysis unsure=1, Strongly Disagree=2 through to Strong Agree=5**

| | Strongly Disagree | Disagree | Unsure | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Diesel Prices | | | | | |
| Feedstock Prices | | | | | |
| Feedstock Supply | | | | | |
| Policy Barriers- Blend Wall | | | | | |
| Policy Uncertainty (federal) | | | | | |
| Policy Uncertainty (state) | | | | | |
| Production Costs | | | | | |
| Infrastructure Investments | | | | | |
| Environmental Barriers- GHG Emissions | | | | | |
| Environmental Barriers- Feedstock Water Usage | | | | | |
| Consumer Knowledge, Attitudes, and Values of Biodiesel | | | | | |

# WA State Biodiesel Minimum Fuel Requirement

## 6. Mandate Evaluation

**8. How much do you see the following factors <u>contributing</u> to the success of the RFS 2% biodiesel mandate? *The answers will be scaled for statistical analysis unsure=1, Strongly Disagree=2 through to Strong Agree=5**

| | Strongly Disagree | Disagree | Unsure | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Diesel Prices | | | | | |
| Feedstock Prices | | | | | |
| Feedstock Supply | | | | | |
| Policy Barriers- Blend Wall | | | | | |
| Policy Uncertainty (federal) | | | | | |
| Policy Uncertainty (state) | | | | | |
| Production Costs | | | | | |
| Infrastructure Investments | | | | | |
| Environmental Barriers- GHG Emissions | | | | | |
| Environmental Barriers- Feedstock Water Usage | | | | | |
| Consumer Knowledge, Attitudes, and Values of Biodiesel | | | | | |

## WA State Biodiesel Minimum Fuel Requirement

### 7. Mandate Goals

**9. Of the goals listed below for the RFS mandate, which do you believe have been successful and not successful to date?**

| | Not Successful | Successful | Not Significant Effect to Date |
|---|---|---|---|
| Increasing State Production of Biodiesel | ○ | ○ | ○ |
| Increasing State Feedstock Supply | ○ | ○ | ○ |
| Reducing Petroleum Dependence | ○ | ○ | ○ |
| Reducing Carbon Emissions | ○ | ○ | ○ |
| Fostering Environmental Sustainability | ○ | ○ | ○ |

**10. Which goal do you believe to be the <u>most important</u> to achieve?**

- ○ Increasing state biodiesel production
- ○ Increasing state feedstock supply
- ○ Reducing petroleum dependence
- ○ Reducing carbon emissions
- ○ Fostering environmental sustainability

**11. Which goal do you believe to be the <u>least important</u> to achieve?**

- ○ Increasing state biodiesel production
- ○ Increasing state feedstock supply
- ○ Reducing petroleum dependence
- ○ Reducing carbon emissions
- ○ Fostering environmental sustainability

## WA State Biodiesel Minimum Fuel Requirement

### 8. Success/Failure of Mandate

**12. In your opinion, how successful has the Renewable Fuel Standard Mandate been to date (i.e., that 2% of the diesel sold in Washington State must be biodiesel)?**

- Highly Successful
- Successful
- Unsure
- Unsuccessful
- Highly Unsuccessful

**13. If you are willing, please write a few sentences below as to why you chose your answer regading the succes or failure of the WA State Renewable Fuel Standard Mandate for Biodiesel**

## WA State Biodiesel Minimum Fuel Requirement

### 9. Alterations to the Mandate

**14.**

1. **Which do you believe to be the best alteration or revision of the RFS Mandate in order to achieve the goals?**

- Incremental increase of mandate percentage based on production
- Yearly increase of mandate percentage
- Stronger incentives for producers
- Stronger incentives for farmers
- Stronger incentives for consumers
- Less or limited government incentives and mandates
- No alterations to mandate

**15.**

1. **What do you view to be the most appropriate way for achieving the goals of the mandate?**

- Incentives for consumers
- Incentives for technology in the industry
- Incentives for producers
- Leave mandate as is
- Public education and outreach
- Revision of goals/mandate

# WA State Biodiesel Minimum Fuel Requirement

## 10. Mandate Design

**16.**

1. **How much does the fact that the governor has the authority to suspend certain RFS requirements "based on determination that such requirements are temporarily technically or economically infeasible, or pose a significant risk to public safety" affect the goals of the mandate and your confidence in the mandate?**

- Strongly Agree
- Agree
- Unsure
- Disagree
- Strongly Disagree

**17.**

1. **Please note below any additional comments or ideas you may have regarding the Washington State Mandate that 2% of the diesel sold in the state must be biodiesel.**

# WA State Biodiesel Minimum Fuel Requirement

## 11. SURVEY COMPLETE

Thank you for agreeing to complete this survey to help me collect information about the Washington State Renewable Fuel Standard for biodiesel. The data gathered from this survey and interviews will help me to complete my thesis. This study is significant to Washington State because no formal evaluation has been done regarding the RFS. From this study, legislators can view how different sectors see the RFS succeeding or not and can then call for alterations to the mandate or more in depth analysis of its effects. As mentioned in my email and survey introduction, the survey will remain anonymous, as the only affiliation will be by occupation sector (i.e. government, non-profit, private, and academic). Only my advisor and I will have access to it and you will remain anonymous in my thesis and my presentation. Pease feel free to contact me by email (jennymsutx@gmail.com) if you have any questions regarding the survey or my research or would like to attend my thesis presentation in late May 2014.

Sincerely,

Jennifer Dunn

**18. As this study is mixed methods, I am conducting interviews as well as distributing surveys. If you would like to participate in an audio-recorded unstructured interview (your answers will be anonymous), please provide your contact information below.**

| | |
|---|---|
| **Name** | |
| **Occupation Sector** | |
| **Email Address** | |
| **Phone Number** | |