AN ABSTRACT OF THE ESSAY OF

Ian T. Davidson for the degree of Master of Public Policy presented on 10 December 2014.

Title: A Sticky Problem: Identifying the Barriers to the Adoption of Fats, Oils, and Grease as an Energy Feedstock in Oregon

This study investigates the barriers faced by fats, oil, and grease (FOG) as an energy feedstock in the state of Oregon. FOG, which typically originates in food service establishments (FSEs), historically has been treated as waste, yet it also has the chemical make up to be an energy feedstock in anaerobic digesters. Despite this potential, Oregon currently experiences a low level of FOG adoption. Important barriers to this adoption are identified using Painuly and Reddy's (2004) framework for renewable energy technology (RET) barrier identification. Under this framework, barriers are established by analyzing the literature and vetted through a stakeholder engagement process. Stakeholders include those familiar with FOG and biogas energy in Oregon, specifically wastewater treatment technicians; representatives from interested non-profits; and managers of commercial biogas plants. These stakeholders were interviewed and asked questions concerning the barriers to FOG adoption, and their insights serve as the basis of this research. Lastly, policy recommendations to increase the adoption of FOG as an energy feedstock in Oregon are made.

Keywords: Fats, Oils, and Grease; Renewable Energy Technologies; Biogas; Biomass; Renewable Energy;

A Sticky Problem: Identifying the Barriers to the Adoption of Fats, Oils, and Grease as an Energy Feedstock in Oregon

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Ian T. Davidson, Author

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

1.0 Introduction

Oakley Taylor identifies herself as "the grease queen" of Bend, Oregon not because she loves fried food but because she runs the FOG (Fats, Oils, and Grease) program for the city of Bend. FOG is a waste that typically originates in food service establishments (FSEs) and has the potential to become a commodity as an energy feedstock. Taylor is one of many in Oregon who are working to prevent what the *Wall Street Journal* called a "municipal heart attack." Restaurants, food processors, and individuals send their fats, oils, and grease down the drain where they cool, congeal, and sit. "The grease is very corrosive to the sewer lines, especially when it sits in there," Taylor said. "It can accumulate and cause sewer blockages." Like a clogged artery in the human heart, a clogged sewer pipe can have catastrophic results.

The grease beneath our feet costs cities across the nation billions annually. In Taylor's perfect world, no one would put grease down the pipes. Instead, they would find other alternative destinations for the grease, such as the dump, farm fields, and anaerobic digesters. Others in the industry are more selective about their destinations, preferring that FOG end up only in an anaerobic digester, where the waste is broken down into methane, carbon dioxide, and fertilizer. The fertilizer, predictably, can be used on farmlands, while the methane and carbon dioxide can be either burned in a conventional boiler and used as heat for surrounding buildings or burned in a gas engine to generate electricity.

Despite this potential, turning grease into energy is easier said than done, and the State of Oregon, among many others nationwide, currently experiences a low level of FOG adoption, or usage levels of FOG as an energy feedstock. Why is this the case? Part of the lack of adoption is likely due to the well established fact that renewable energy technologies (RETs) of all types typically require promotion policies and/or some kind of incentive in order to convince people to adopt renewables because they are typically more costly than conventional energy technologies (Menanteau, Finon, and Lamy, 2003). But incentives and active promotion through government policies are also unlikely to be sufficient unto themselves in producing high levels of renewables use, especially with an out-of-the-box energy form based on animal fats and grease. This is because there are often significant barriers standing in the way of adoption that are unrelated to incentives. Typical examples include unfamiliarity with the RETs, financial hurdles, regulatory red tape, and behavioral barriers like resistance to change or constraints on time (Painuly, Reddy 2004). To date, however, there has been little academic research investigating barriers to the adoption of FOG as an energy feedstock in the U.S., let alone Oregon, or FOG management in general.

This study intends to begin filling that gap by developing a more comprehensive analysis on why FOG adoption rates are low in Oregon with a primary focus on barriers to the adoption of fats, oil, and grease as an energy feedstock in Oregon. In doing so, this research will provide decision makers in Oregon with information and recommendations for the design and implementation of policy that has a better chance of success in taking deleterious FOG out of our sewers and turning it into a productive renewable energy resource.

This essay uses a qualitative methodological approach and employs Reddy and Painuly's (2004) framework for identifying renewable energy technology barriers, which built upon Painuly's (2001) framework for the analysis of barriers to renewable energy penetration (described in greater detail below in the Methods section), to engage a broad cross-section of key stakeholders and experts through semi-structured interviews. The key stakeholders are those who have been involved with the conversion of FOG and other biomass feedstocks into biogas energy, specifically wastewater treatment technicians, state and local regulators, farmers with anaerobic digesters, and managers of commercial biogas plants. These stakeholders relied on their years of experience with FOG, regulation, and policy to offer insights regarding the most important factors in and barriers to FOG adoption in Oregon.

In addition, the interviews gleaned information about possible solutions for overcoming the identified barriers and increasing the use of FOG. These solutions, along with lessons learned from the academic literature on policy adoption, helped to inform the policy recommendations found in the later parts of this paper. In short, realizing high adoption requires new policies designed to overcome the many existing barriers to use.

1.1 Renewable Energy Technologies

In the literature, the term RETs, or Renewable Energy Technologies, provides a broad umbrella for dozens of types of technologies ranging from solar and wind to biomass and geothermal, with several variations in each of these subcategories.

Meeting increasing energy demands with available and affordable resources is a challenge facing every nation in the world. Civil unrest and even war can be symptoms of energy insecurity and attempts to secure increasingly difficult-to-find resources. The use of, and reliance on, traditional energy technologies from fossil fuels has contributed to global warming and may well result in "severe, pervasive and irreversible impacts for people and ecosystems" (United Nations, 2014) such as rising sea levels, widespread food shortages (Gallucci, 2014), dangerous heatwaves, additional and more intensive flooding, more human health problems (e.g., spread of malaria), and, in some cases, violent conflicts (Godsen, 2014).

Additionally, every U.S. president since Richard Nixon, whether Democrat or Republican, has listed "energy independence" as a national goal (Yergin, 2011). For these reasons, a growing number of elected officials, policymakers, scientists, and citizens are promoting Renewable Energy Technologies (RETs) as an alternative for the future. RETs have the potential to both reduce our dependence on fossil fuels, thus decreasing damage to the environment, as well as serving as a reliable source of energy in a sometimes-uncertain market. FOG, a material made up of energy-rich biomass, is one of these RETs.

Despite the unifying rhetoric of energy independence and looming threat of global warming, the U.S.'s movement toward energy independence is riddled with partisan conflict because the current energy debate revolves around how to best balance competing values such as economic growth and environmental protection and how to best balance the demands from organized interests, such as those from the fossil fuel industry, newer businesses in the renewable energy sector, as well as environmentalist groups (Weber et. al., forthcoming).

In addition, the transition from fossil fuels to RETs, whether FOG or otherwise, has involved a series of booms and busts, with strong support and increased usage for short periods followed by abrupt declines as policy and market conditions changed. An early example occurred during the late 1970s with a strong push by the Carter Administration to increase the use of solar energy. President Carter approached the nation with “an unpleasant talk” of the U.S.’s dependence on foreign oil and proposed legislation to decrease the nation’s reliance on foreign fossil fuels (Carter, 1977). Two years later President Carter made history by holding the first ever press conference on top of the White House to announce that the water in the executive mansion would be partially heated by the solar panels (Port, 2004). President Carter announced and launched a sweeping drive with a goal of harnessing the sun, the wind, and other renewable resources to generate 20 percent of America's electricity by 2000. President Carter vigorously supported the Solar Energy Research Institute, indicating that it would be “a major thrust of DOE's program in 1980” (Carter, 1979).

President Carter’s vision for the Solar Energy Research Institute, however, was not achieved. Soon after President Reagan’s inauguration, Denis

Hayes, head of the fledgling Solar Energy Research Institute, was told by a colleague as he walked down a hallway at the DOE, "They're (the Reagan Administration) going to kill your study" (Allen, 2000). The study, part of President Carter's vision for a solar-powered America, showed that alternative energy could easily surpass the former president's goal of 20 percent of America's electricity by 2000. In fact, the study indicated that they could easily meet 28 percent of the nation's power needs by 2000. All solar and wind power needed, according to the study, was a push–"the same research funding and tax credits provided to other energy industries, and a government committed to lead the way to reduced reliance on fossil fuels" (Allen, 2000). No push came. Unlike his predecessor, President Reagan gave renewed emphasis to oil and gas production. The warning Hayes received proved to be prophetic as President Reagan slashed the fledgling institute's budget from $124 million in 1980 to $59 million in 1982 (Allen, 2000). By the end of 1985 Congress and the administration allowed tax credits for solar homes to lapse, and shortly thereafter the Reagan administration took the symbolic solar panels off the roof of the White House, a poetic end to the dream of a renewable era.

This dream was only began to be revived at the end of the Clinton administration when there was some momentum for reducing carbon dioxide emissions from power plants; however, the momentum soon faded after George W. Bush took office. The Bush administration decided against EPA rules for capping carbon dioxide and actively pursued a delay of their implementation later until in his term in spite of a 2007 Supreme Court ruling (*Massachusetts v.*

EPA) that decided CO2 was a covered pollutant under the Clean Air Act which maintained the status quo for RETs.

In 2002, President Bush promoted the *Clear Skies Initiative*, which called for a market-based approach to CAA goals, which would necessarily weaken the requirement that coal-fired plants reduce mercury emissions. President Obama, in contrast, took a top-down, command-and-control approach to air pollution and viewed the EPA as one of his most powerful tools for fighting climate change. Under this mentality, he used the CAA "major source" rule to cover almost 90 percent of industrial GhG emissions (Adler, 2014)[1]. When 2014's congressional gridlock stymied climate change legislation the EPA announced a plan to reduce industrial carbon emissions by 30 percent by 2030. Obama's efforts were accompanied by the placement of solar panels once again on top of the White House, symbolically telling the U.S. that solar, and by extension RETs, are "available, reliable, and ready for millions of Americans across the country" (White House, 2014).

In an effort to help meet the goal of a more diversified national energy portfolio the Obama administration has given higher priority to the growth of RETs utilizing the Investment Tax Credit and the Production Tax Credit, but the government, under Obama, has also started to make public lands available for RET development.

About twenty eight percent of all US territory, or about 640 million acres

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[1] Note on June 23, 2014, in *Utility Air Regulatory Group v. Environmental Protection Agency* (*UARG v. EPA*), the Supreme Court overturned the Obama Administration's GhG rule, while also affirming the substance of *Massachusetts v. EPA*.

of land, is owned directly by the US government. These lands are home to national parks and forests, wildlife reserves, military bases, energy production and water management (Congressional Research Service, 2012). While energy development on federal lands has traditionally involved the extraction of coal, oil, and natural gas, President Obama has placed a high priority on high priority on RET development on federal lands, while reducing the focus on fossil fuels. For example, during President Bush's second term the Bureau of Land Management (BLM), which resides in the U.S. Department of the Interior and has taken led the development of energy resources on federal lands, issued 13,175 oil and gas leases on federal public lands. In comparison, during President Obama's first term, the BLM issued 7,297 leases for oil and gas, a decrease of 45 percent (US Department of the Interior).

Renewable projects, however, have seen an increase in the number of projects on federal lands under the Obama. Prior to 2009, the BLM had approved no solar projects, 942 MW of geothermal power, and 566 of wind power. From 2009 through 2013 the BLM authorized 51 projects to provide over 13,000 MW of power which included 28 solar facilities generating a combined 8,586 MW, 11 wind farms generating a combined 5,557 MW, and 12 geothermal plants generating 1,500 MW combined (US Department of the Interior).

The benefits of generating renewable energy on public lands are significant. Approved solar power projects on BLM lands provide enough electricity to power roughly 2.6 million homes, while wind and geothermal projects each supply enough electricity for 1.5 million homes (US Department of the Interior, *New Energy for America.)*. These RET developments on federal lands translates into millions of tons of avoided carbon dioxide emissions every year. Presently the BLM has pending applications to build dozens more renewable energy projects on public lands, so the environmental and energy benefits are expected to increase considerably in the coming years.

Additionally, the increased adoption of renewable energy generation, whether on federal or private land, is having an impact on the U.S. workforce. One study found that every megawatt of solar photovoltaic (PV) power installed can create up to 30 "job years," (the equivalent of 30 people working for one year). The Solar Foundation (2014), which conducts a regular census of solar workers in the U.S., found that the solar industry employed more than 142,000 people in 2013, an increase from 93,000 in 2010. Organizations supportive of wind and geothermal energy, respectively, estimate that every megawatt installed results in four new jobs (American Wind Farms, 2012; Geothermal Energy Association).

Despite the recent advances, RETs in today's energy market cannot compete with fossil fuel-derived energy and its existing, albeit aging, infrastructure. Additionally, the current economic landscape does not include negative external costs such as anthropomorphic greenhouse gas emissions, and this exclusion only decreases the economic competitiveness of various RETs, thus giving fossil fuels a market advantage. For example, researchers led by Paul R. Epstein of Harvard Medical School determined that a more accurate total of economically quantifiable costs, based on a conservative weighting of many factors, would add 17.8¢/kWh to the price of coal, making it prohibitively expensive for current consumers (Epstein et al, 2011).[2] Given this situation, the introduction and subsequent adoption of an RET becomes very difficult. Recognizing the disadvantage RETs have, governments at all levels across the nation are creating various policies to assist RETs in gaining a foothold and eventually maturing in the market.

The focus on costs also helps us to understand why, at times, the market price of different energy types, renewable and otherwise, is more influential than public policy in determining which fuels get developed and used. For example, since 2000 the U.S. supplies of natural gas, because of the innovation of hydraulic fracturing, have grown at an alarming rate, and the prices, thought still dynamic, have correspondingly seen an overall decrease (EIA, "Natural Gas Prices"). The fallen prices have influenced adoption more than any policy ever could, contributing to a dramatic increase of natural gas's share of the U.S. energy portfolio, from 16 percent of all electricity generated in 2000 to 27 percent in 2013. In contrast, the corresponding share of coal use has dropped

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[2] Epstein et. al (2011) noted that while their assessment robust it was not comprehensive, "Still these figures do not represent the full societal and environmental burden of coal. In quantifying the damages, we have omitted the impacts of toxic chemicals and heavy metals on ecological systems and diverse plants and animals; some ill-health endpoints (morbidity) aside from mortality related to air pollutants released through coal combustion that are still not captured; the direct risks and hazards posed by sludge, slurry, and CCW impoundments; the full contributions of nitrogen deposition to eutrophication of fresh and coastal sea water; the prolonged impacts of acid rain and acid mine drainage; many of the long-term impacts on the physical and mental health of those living in coal-field regions and nearby MTR sites; some of the health impacts and climate forcing due to increased tropospheric ozone formation; and the full assessment of impacts due to an increasingly unstable climate" (p. 93).

from 51 percent to 39 percent of electricity generation as companies retrofit old facilities and build new ones to take advantage of lower prices (EIA, 2014).

Not all RETs are created equal, and as such a multitude of factors must be considered when determining whether an RET will become a viable energy source or efficiency tool. How will this RET affect the energy supply? How will this RET affect the environment? The most persistent question when considering an RET is, "how will this work economically?" The economic considerations must cover all aspects of an RET, including production, installation, and use. While an individual can sympathize with the idealistic goals of an RET, a consumer has a much more difficult time paying for an RET's higher cost. Consumers, regardless of the market they are in, are economic creatures and often make value-based purchases, deciding, in the case of energy, if an RET is "worth it." Investments in RET either need to have a significant return on investment or a limited payback period.

RET is a broad category, and as such each technology or resource faces unique challenges. While some challenges are universal, such as economical barriers, most are not and must be treated with context-specific measures. FOG, like many other RETs, lacks the market maturity to secure a prominent foothold in the market. Within the broad field of various RETs, the utilization of FOG is certainly lesser known and faces many barriers.

1.2 Overview of Fats, Oils, and Grease

Roots, corroded pipes, cave-ins, and bottles are among the common culprits of clogged pipes and diverted sewage on its way to the treatment plant. Less common causes of clogged pipes, as documented by City of Portland workers, include rats, beavers, a .357 Magnum, wedding rings, syringes, teeth, spoons, a large duffel bag full of marijuana, and even a "live [and naked] man" (Jacquiss, 2010). However, the overwhelming cause of blocked pipes is FOG.

An EPA Report to Congress on Combined Sewer Overflows (CSOs) and Sanitary Sewer Overflows (SSOs) stated that "grease from restaurants, homes, and industrial sources are the most common cause (47%) of reported blockages." The old adage "out of sight, out of mind" does not apply to grease because it "solidifies, reduces conveyance capacity, and blocks flow" (EPA, 2006), creating sometimes very visible problems, as in the case of combined sewer overflows and sanitary sewer overflows.

In 2001, Barry Newman of the *Wall Street Journal* took a tour of New York's sewer system to understand the "national sewer-fat crisis" and was startled at what he discovered. Don Montelli, a City employee and Newman's tour guide, took the reporter over to a manhole in Brooklyn, which he described as a "notorious grease spot." After a brief explanation, Montelli lowered a robot hooked to a wire into the sewer and showed Newman the attached video screen. "What you're looking at right now," Montelli explained, "is grease down the sewer." Newman's disgust was only dwarfed by his amazement, which is evident in his description of his view:

> With colonoscopic clarity, the camera shows a pipe with a drippy coating of fat. Fat won't pollute; it won't corrode or explode. It accretes. Sewer rats love sewer fat; high protein builds their sex drive. Solids stick in fat. Slowly, pipes occlude.

> Sewage backs up into basements -- or worse, the fat hardens, a chunk breaks off and rides down the pipe until it jams in the machinery of an underground floodgate. That, to use a more digestible metaphor, causes a municipal heart attack.

"Municipal heart attacks," as the name suggests, have devastating consequences to the city coffers, personal property, and the environment even in smaller municipalities than New York City.

In 1999 Georgia's Environmental Protection Division (EPD) discovered numerous violations in Atlanta's wastewater treatment program, many of which were a result of FOG. Georgia's capital city was fined for NPDES permit violation and forced to take action to improve its wastewater treatment system. According to the EPD, Atlanta has spent more than $2 billion in repairs and fines since the discovery was made. A representative from a wastewater treatment district in the Portland, Oregon metro area explained that Atlanta's repairs and fines are exactly the kind of situation he wants to avoid in his district.

Atlanta's troubles, while severe, are not uncommon. A 2010 article in the *Willamette Weekly*, an alternative weekly publication serving Portland and the Willamette valley, written by Nigel Jaquiss covered the growing FOG problem in Portland. Jaquiss' reporting, smartly entitled "A Fecal Matter," acknowledged that, "Although cop shootings and personnel issues attract more media attention, sewer backups are responsible for more damage claims against the city than any other cause." In fact, almost 300 property owners sought compensation from 2007 to 2010 for sewer backups. Jacquis noted that Portland has paid out more than $500,000 for those claims, with more pending at the time of writing his article.

While a portion of the FOG found in sewers comes from individual homes, this is only a fraction; the majority of FOG comes from what professionals call Food Service Establishments (FSEs). While all restaurants are FSEs, not all FSEs are restaurants. Unlike the title "restaurant," FSEs encompass bars that have their infamous fried "bar food," bagel shops, full-service hotel kitchens, and a wide variety of other companies that are in the food business.

Disposal of FOG into a sewer system may seem benign, especially in small quantities, but as time passes the "benign" grease expands, collects, and adheres to the walls of the sewers, thus blocking flow and causing overflows. If Publicly Owned Treatment Works (POTWs) cannot stay the introduction of FOG into their system, they must clean their pipes more frequently, which is a cost to the public. A representative from Gresham, OR explained that they typically clean sewers every 3-5 years, but in an area they commonly call "restaurant row," maintenance is required every 3-6 months because of the sheer quantity of FOG being disposed. The increased frequency of maintenance temporarily shuts down essential infrastructure, produces unpleasant smells, and costs local governments.

The 1998 Urban Waste Grease Resource Assessment study determined that the average annual grease production of FOG is 13.37 pounds per person, but this number was calculated using the FOG caught by the grease traps that are becoming required by law in most FSEs—the actual amount of FOG created is likely much higher since FOG is also poured down drains and thus wasn't measured in this study. By applying even this conservative national average to the 3.93 million residents of Oregon, it is estimated that 52.5 million pounds of FOG exist in Oregon.

There is, however, a silver lining to the fat- and grease-filled clouds that loom over cities and counties nationwide: this same FOG that is clogging sewers can be used to produce clean renewable energy in an anaerobic digester. A typical anaerobic digester is a sealed, warmed vessel, or series of vessels, in which the bacteria act anaerobically, i.e. without oxygen, to naturally break the FOG down into fertilizer and biogas, which consists of around 70% methane and around 30% carbon dioxide (Syrus Energy, 2014). The carbon dioxide and other trace gases are removed using a process known as upgrading or scrubbing, leaving behind methane, which is then known as Renewable Natural Gas or Biomethane. Virtually identical to natural gas, Biomethane has a variety of uses, but it is generally burned either in a conventional boiler to be used as heat for surrounding buildings or in a gas engine to generate electricity (Syrus Energy, 2014).

According to the Pollution Prevention Resource Center, FOG has an energy value of 12,000 British thermal units (Btu) per pound (Burgess, 2010). In comparison, gasoline has an energy value of 17,630 Btu per pound and liquefied natural gas (LNG) has 11,738 Btu per pound. With at least 52.5 million pounds of FOG in the state of Oregon, there is considerable energy potential in this otherwise bothersome waste.

FOG has been used in anaerobic digestion and biogas production for some time, but as Painuly (2000) observed, “Despite technological developments and economic viability for several applications, renewable energy [in this case, FOG] has been tapped only to a small fraction of its potential.” Presently only three of the nine biogas facilities in Oregon use FOG as a feedstock. Despite its abundance, FOG is an underutilized energy feedstock, and this research attempts to understand why and how Oregon can overcome the barriers to its adoption.

2.0 Literature Review

Before reporting the results of this research, key concepts in the literature used in the study are provided. The barriers to the adoption of FOG will be examined at length and then several case studies will highlight how barriers can be overcome.

2.1 Barriers

The barriers facing RETs are many and diverse according to Reddy and Painuly (2004), but six common themes, or barrier categories, stand out. They include a lack of awareness and information, economic and financial constraints, technical risks, institutional and regulatory barriers, market failures, and behavioral or cultural barriers. Which of these barrier categories matter to the adoption of FOG as an energy feedstock in Oregon? The short answer is that only three barriers--economic and financial constraints, institutional and regulatory barriers, and behavioral or cultural barriers—appear to matter in the case of FOG adoption in Oregon.

2.1.1 Awareness and Information

In the years leading up to the 1990s, it was commonly thought that few alternatives existed to traditional fossil fuel sources except nuclear power (Jacobsson, Johnson, 2000), but the rapid growth of wind and solar energy installations in recent years have brought a more diverse portfolio of RETs to the national forefront. However, some RETs, including biogas, are still relatively unfamiliar to policy makers, investors, and the public at large. According to Reddy and Painuly (2004), this "lack of information or knowledge on the part of the customer, or a lack of confidence in obtaining reliable information" slows, and sometimes prevents the adoption of such RETs. (p. 1,435)[3]

It stands to reason that an RET will struggle if awareness is limited. The probability of an RET's adoption is thus significantly decreased if potential consumers, or those buying the RETs, and investors and government officials, who sponsor the RETs, are unfamiliar with the merits of a particular RET, its respective incentive programs, or even its existence (Reddy and Painuly 2004; Thiruchelvam 2003). Presently, households, small firms, and commercial establishments face difficulties in obtaining information on RETs because the market is already so saturated with competing information for fossil fuel derived energy (Reddy and Painuly 2004). Paul-Georg Gutermuth's (1998) research also acknowledges that a general awareness of an RET is necessary for market

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[3] Reddy and Panuily (2004) follow Kempton and Linda (1994), who assessed the range and depth of energy consumers' analysis of various aspects of the energy process including billing, utility overtime, and a comparative cost analysis, and found that "consumer weakness in data analysis and collection distort market decisions" (p. 1,435).

penetration, but explained that awareness alone is not sufficient for high rates of adoption.

2.1.2 Economic and Financial

Painuly's "barriers" framework for RET adoption (2001), the first of its kind, and the basis for the Painuly and Reddy's work in 2003, places great weight on economic and financial barriers. He indicates that it is "crucial" to address financial issues to enable the widespread adoption of RETs but gives no indication why. Instead, he directs readers to Gutermuth's work, which evaluates financial measures taken by the state to assist RETs. Gutermuth (1998) identifies several financial barriers, which include: the present low price for non-renewable energies, a lack of full cost-pricing when determining the cost of energy, subsidies and other support for fossil fuels, excessive profit anticipation from investors, and very high prices for system integration and capacity backups in the electricity field. For these reasons, Gutermuth, and by extension Painuly, believes that these barriers can only be overcome by government intervention, typically in the form of grants, subsidies, or tax credits.

2.1.3 Technical Risks

Technical risks, as explained by Reddy and Painuly (2004), refer to the technical performance of the various RETs and the unreliability of their performance. Since technical risks are specific to a particular technology, few general observations of RETs can be made. While most RETs are well proven, some technical risks still remain (ibid). For example, solar power, while abundant on sunny days, is an ineffective power source on cloudy days. Existing battery technology, which cannot store and preserve excess energy generated on sunny days for sunless days, is limited (Wile 2013). The same challenges face wind power, which offers little utility on a windless day.

The unreliability of solar and wind power is a considerable hurdle to either's continued growth. This dilemma has been particularly pronounced in Germany under Chancellor Angela Merkel's *energiewende*, which can be translated as energy transition or revolution. While Germany's new energy policies sought to curb CO2 emissions, emissions have actually increased 1.8% in 2013 (Waterfield, 2014). One reason for the failure is Germany's reliance on solar and wind power, which are erratic and crippled by inadequate storage capabilities. The scarcity in the electrical supply pushed Germany to rely more on heavy oil and coal power plants, which are reliable power sources, and increased the amount of CO2 released into the atmosphere from 2011 to 2012. (Waterfield 2014).

The potential side effects of drilling processes required for hydraulic fracturing and geothermal energy extraction also pose significant risk. In 2006 in Basel, Switzerland, Markus O. Häring led a project with high hopes: tapping into a vast, clean, renewable source of energy. Häring and his team drilled a hole three miles deep, fracturing hard rock with the end goal of using the naturally occurring geothermal energy to power homes and businesses. Unexpectedly, on December 8, 2006 the project set off an earthquake, "shaking and damaging buildings and terrifying many in a city that, as every schoolchild learns, had been devastated exactly 650 years before by a [similar] quake" (Glanz, 2009). After the quake, the project was hastily shut down and is frequently brought up as a warning of the dangers of harnessing geothermal energy. It is not a question of "if" an earthquake will occur because of geothermal drilling, but "how large" the inevitable earthquake will be (Harmon, 2009). Talk of human-induced earthquakes, particularly runaway earthquakes, understandably makes the public uneasy about RET projects with this risk.

Geothermal energy and other RETs are not the only ones with this particular side effect. Using data from 1970 to 2013 a team of USGS scientists determined that an increase in seismicity "has been found to coincide with the injection of wastewater in deep disposal wells" which is a byproduct of hydraulic fracturing, more commonly known as "fracking" (USGS). However, the USGS also notes that fracking does not appear to be linked to the increased rate of earthquakes that rank a magnitude three or higher on the Richter scale.

Fracking's technical risks, however, are not limited to earthquakes. Fracking has frequently been accused of contaminating local groundwater. A recent study published in the *Proceedings of the National Academy of Sciences* found that bad fracking techniques included failures in the cement that should have sealed the pipe transferring the water necessary for fracking, faulty production casings, and underground gas well failure. Whatever the cause, fracking can release methane "directly into drinking-waters aquifers" (Mufson, 2014).

While not all RETs face technical risks like those tackled by solar, wind, fracking, and geothermal power, all RETs, FOG included, face issues with appropriate siting according to available resources, population characteristics, available installation location, and regional weather patterns (Chang et. al. 2011), which can only be addressed on a case-by-case basis.

2.1.4 Institutional and Regulatory

Reddy and Painuly (2004) identify institutional and regulatory barriers as the fourth main obstacle to the adoption of RETs. These barriers occur when there are "insufficient government regulations and/or incentives to stimulate the adoption of RETS by businesses and industries" (Reddy and Painuly, 2004). These impediments include insufficient national policy for RETs, a lack of application of modern management skills in energy development agencies, and inadequate access to credit for RETs in the economy (this is particularly true for nonmainstream RETs like biomass).

Reddy and Painuly's assertion that an insufficient national energy policy is a barrier is corroborated by the literature; however, in order to adequately address the challenges posed by institutional and regulatory barriers to RET adoption, a quick review of the present political landscape is needed. As initially pointed out by Mayhew (1974), politicians prefer to write laws and claim credit for addressing public problems at the front end of the policy process because this plays better with voters. Politicians reach for the political low-hanging fruit found at the front end of the policy process and have little incentive to devote limited political resources to regulatory or bureaucratic reform designed to save money or increase compliance (Weber and Davidson, 2014). RET adoption is not a quick process and frequently requires long-term buy-in from elected officials. As noted by Lowi (1979) bureaucrats and regulators have long been scapegoats for elected officials when regulations or incentives fail to bring promised results. In such situations, politicians tend to write vague laws and then blame regulators for mistakes in rule writing or implementation, thereby distancing themselves from the results of their laws. In fact, getting too deeply involved in regulatory reform makes it more difficult for politicians to avoid responsibility when things go wrong (Weber and Davidson 2014). In Reddy and Painuly's (2004) language, this scapegoating and insufficient authority of the agencies shows a lack of "modern management skills in energy development agencies" (p. 1,436).

The costs and benefits of RETs are the focal point of the politics and political divide of energy in the U.S. Political opposition to RETs tends to focus on its higher economic cost relative to fossil fuels, like coal and natural gas. Principal opponents to RETs include fiscal conservatives and Republicans, industries with high energy demands, and "labor unions involved in energy infrastructure and energy intensive manufacturing enterprises" (Weber, Bernell, and Boudet, forthcoming).

On the other side of the debate, proponents of RETs include environmental and climate change advocates, public sector unions, industries with low energy needs, political liberals, and Democrats. RET proponents focus on the negative "social"–typically health and environmental–costs of fossil fuels, which are largely externalized; the long-term benefits of weaning society off fossil fuels; and the expectation that RET costs will, with time, become competitively priced, especially as technological innovations continue to reduce the costs of RETs and once the true social costs of carbon are factored into the market prices of energy (Weber et. al., forthcoming).

Al-Badi, Malik, and Gastli (2011) observed, "Development of renewable energies is dependent mainly on political support. As long as renewable energies are not financially and economically competitive on the liberalized market, there is a need for a political support." Institutional barriers can include existing regulations or regulatory frameworks that favor conventional energy resources over RETs, leading to a lower level of support (Reddy and Painuly 2004; Sovacool 2008). A study conducted by the International Monetary Fund (IMF) assessed present levels of energy subsidies through out the world, including the U.S. According to the IMF study, which evaluated 176 nations, the United States is the largest subsidizer of energy derived from fossil fuels, spending $502 billion annually (IMF 2013). The market failure, stemming from unaccounted external costs of fossil fuels, is exacerbated when the government subsidizes the market, particularly to this extent. The United States' existing regulations overwhelmingly support conventional energy resources over RETs.

2.1.5 Market Failures

Reddy and Painuly (2004) note that in order to use resources effectively, markets must be competitive. Inefficiencies stem from imperfections or failures in the market. The energy market is a textbook example of a market failure, which occurs when there is an inefficient allocation of resources, or, in other words, there is another possible distribution of resources that would leave some participants better off without make others worse off. By not attaining an optimal allocation of resources, there is waste. These wasted resources can be accounted for if and when the social costs of a given market are accounted for. When social costs are not accounted for, market failure exists.

While we typically think of cost as the sticker price of an item, additional—social—costs must be accounted for to prevent market failure. For example, the health and environmental impacts of coal (whether from the mining, the transportation, the pollution produced, or the disposal of hazardous waste afterwards) cost society even if that price is not a line item on an electricity bill. Pollution from coal affects all major body organ systems and contributes to four of the five leading causes of death in the U.S.: heart disease, cancer, stroke, and chronic lower respiratory diseases (Physicians for Social Responsibility, (2009). Additionally, large quantities of water are typically needed to remove impurities from coal once mined. When coal-fired power plants remove water from a river or a lake, fish and other aquatic life, as well as other animals and humans that depend on these water resources, can be affected. This same displaced water sometimes returns to its place of origin but brings with it heavy metals from the coal, such as arsenic and lead (U.S. EPA, "Coal"). Additionally, the cost of military action to secure access to oil, like the protracted conflicts in Iraq and the larger Persian Gulf region, while not included in the price of oil, are certainly significant factors (Weber et. al., forthcoming).

Presently, RETs are at a price disadvantage because the social costs of anthropomorphic greenhouse gas emissions, which are not included in the market price of energy, derive from fossil fuels. However, if environmental externalities were internalized, then RETs, at least in some cases would have a competitive advantage (Owens, 2006). For example, a 2011 study by three prominent economists (Muller, Mendelsohn, and Nordhaus 2011) determined that if the social costs of six major air pollutants emitted by coal power plants were accounted for, the cost of coal would be adjusted by adding 2.8 cents per KwH.[4] Include the social costs of carbon, using a relatively conservative estimate of $27 per ton, and another 0.8 cents per KwH is added (Muller et. al, 2011). These adjustments make the levelized cost[5] of conventional coal rise to 13.4 cents per KwH, roughly 13 percent more expensive in terms of KwH than photovoltaic solar energy (Weber et. al, forthcoming).

2.1.6 Cultural and Behavioral

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[4]Sulfur dioxide (SO2), nitrogen oxides (NOx), volatile organic compounds (VOCs), ammonia (NH3), fine particulate matter (PM2.5), and coarse particulate matter (PM10 –PM2.5).

[5] The levelized cost of electricity represents the per-Kwh cost of building and operating a generating plant over the full life of the facility.

Reddy and Painuly (2004) note that adoption of RETs is "generally influenced by the consumer perceptions of the quality and usefulness of these items when compared to conventional technologies" (p. 1,437). Consumers, which in this case include governments, which subsidize or incentive RETs use, and investors who fund ventures, are resistant to change because that change is seen as a "sacrifice" or discomfort (Reddy and Painuly, 2004, p. 1,437). Rather than being viewed as providing equivalent services at a cheaper price and with less energy, RETs are seen as more costly and not energy efficient, thereby deterring consumers from embracing RETs.

While renewable energy, as a field, is viewed in a positive light, the same cannot be said of every type of renewable energy, especially lesser-known types such as biogas (Wüstenhagen, Wolsink, and Bürer 2007). Up until the early 2000s, "most developers, including energy companies, authorities, and private local investors thought that implementation was not a problem" because the first surveys revealed very high levels of support for the RETs broadly (Wüstenhagen, Wolsink, and Bürer 2007). However, public apathy and general misunderstanding, misconceptions of consumption and abundance, and psychological resistance to new technologies are pervasive in the RET industry, which influences the slow adoption (Reddy and Painuly 2004; Sovacool 2008; Srinivas 2009; Sidiras and Koukios 2004).

The positive picture for renewable energy as a group has misled policy makers to believe that social acceptance is not an issue. In order to move from general support for technologies and policies to effective positive investment, policy, and siting decisions, one has to acknowledge that there is indeed a problem (Bell et al., 2005). However, policy makers are not the only ones that influence the RET market. The adoption of RETs is generally influenced by consumer perceptions of the quality and usefulness of these items when compared to conventional technologies (Johnson, 1994).

2.2 Overcoming Barriers

As demonstrated above, there are many barriers that impede or prevent the adoption of RETs. However, there are ways for these barriers to be overcome, and two examples will be examined. The first case study focuses on Solar City and its stunning growth in the market share of solar energy, of which the whole has grown astronomically in recent years. The second case study examines the effect of the tax credits for biodiesel. While these two cases in no way identify every way barriers to RET adoption can be overcome, they do provide substantial examples of how it has been done and show how the barriers to FOG adoption can be overcome.

2.2.1 Solar City

Solyndra was a promising solar panel company until it defaulted on a $535 million loan guaranteed by the Department of Energy in 2011 and now survives only as a politically charged euphemism for the failures of government (e.g. we don't want another Solyndra). Solyndra's failure, however, is not an isolated instance. Other DOE loan guarantees were given to the electric car company Fisker and the solar company Abound, both of which went also bankrupt in a very public way (Brady, 2014).

BrightSource Energy, the California solar thermal power plant builder, with support from the likes of Google, NRG Energy, Morgan Stanley and other heavy-hitters, appeared ready to break the mold but suddenly pulled its initial public offering on the eve of its debut in April 2012 citing “adverse market conditions” (Woody, 2012). BrightSource Energy, which was the recipient of a $1.6 billion federal loan guarantee and was well capitalized, shocked many with the announcement of its canceled IPO because it seemed to be one of “the few solar thermal startups left standing” (Woody, 2012).

As other private RET companies have been fraught with canceled IPOs, poor earnings reports, and bankruptcies, one company in particular has been able to buck the trend: SolarCity. Unlike previous RET companies, SolarCity does not try to outdo competitors with the latest, greatest technology, but rather they try to make their money by “deploying existing solar technology with a novel approach to financing” (Bullis, 2012). Solar City has also benefited from the recent higher tariffs, which were set by the Department of Commerce because of Chinese “dumping” practices. The DOC is encouraging Chinese manufacturers to build solar panel factories elsewhere, whether in the U.S., South America, Africa, or the Middle East (Chakravorty, 2014). From reports, it appears that SolarWorld, a competitor of SolarCity, has been the driving force behind higher tariffs, but SolarCity has benefited nonetheless and has plans to build the largest solar factory in the U.S. (Thrill, 2014). Despite SolarCity’s more subtle play in influencing the Department of Commerce, Solar City has spent considerable amounts of money on lobbyists in recent years. Beginning initially in 2009, Solar City, according to OpenSecrets.org, paid only $180,000 to lobbyists at DOE and on Capitol Hill but has ramped its investment in lobbying and in 2014 paid $520,000 annually. As one commentator observed, "You get what you pay for and politics is no exception." SolarCity has made a sizeable return on investment in terms of grants and guaranteed loans, bypassing financial and regulatory barriers that plague other RETs (Copperfield Research, 2013).

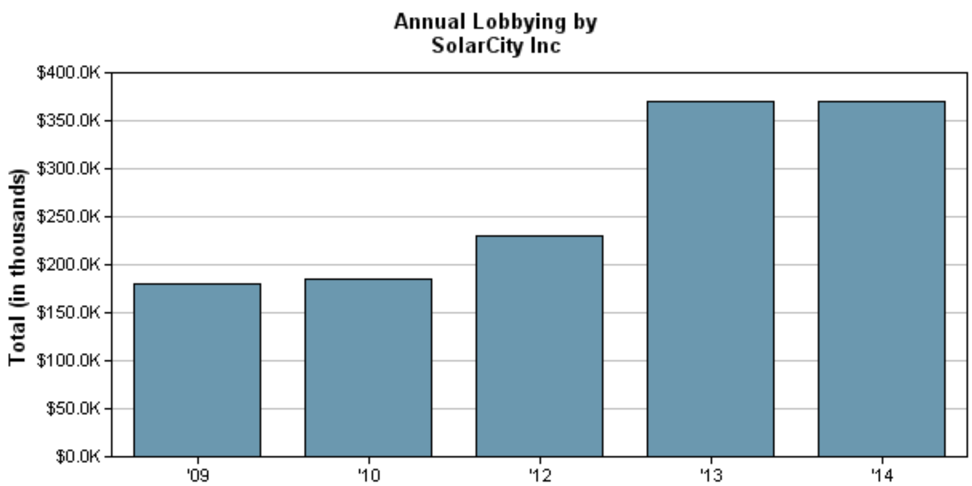

Figure 1: Annual Lobbying by SolarCity Inc

Unlike its competitors, SolarCity's business model doesn't ask for large upfront payments for their solar system but rather retains ownership and simply leases their systems to their customers. Once online, the panels produce electricity and surplus power is sold back to the local utility. The savings that result from using less power from the grid "typically reduces the homeowner's bill to offset the lease payments" (Bullis, 2012). SolarCity saw that most of the money to be made in the solar industry did not come from the production and sale of solar panels, which only account for 20% of the overall cost. The remainder is comprised of the cost of the hardware to connect the systems to the grid and electrician fees.

SolarCity's approach has also been aided by a dramatic decline in the price of solar panels, which since the 1970s has dropped 99% (see Figure 2), making SolarCity the most powerful company in the market (Shahan, 2014). GTM Research estimates that SolarCity had as much as 13 percent of the market in 2011,"more than double the next biggest player" (Bullis, 2012).

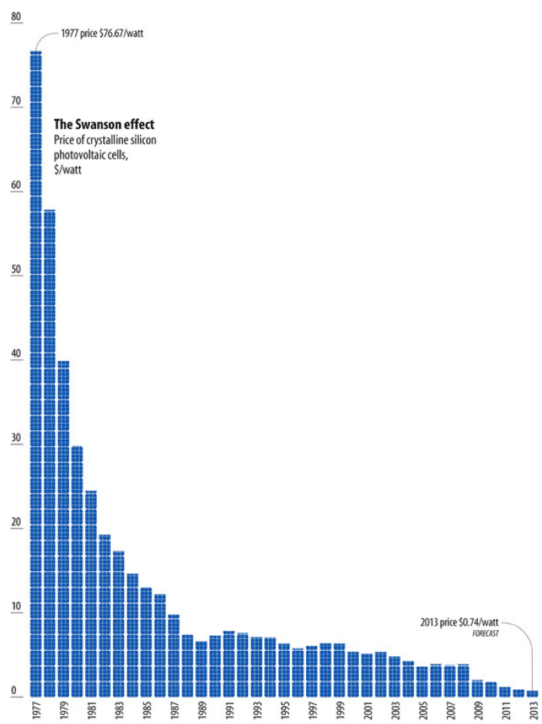

Figure 2: The Price of Solar Energy (1977-2013)

SolarCity's financing options depend upon their customers' ability to sell excess electricity back to the grid, which not all states allow. Major power producers discourage the practice because it disrupts their business model and creates unlimited new competitors since every homeowner can now potentially produce and sell electricity, but existing policies support the continuation of SolarCity's unique place in the electricity market.

As will be demonstrated below, FOG encounters some of the same challenges SolarCity faces, namely financial and regulatory barriers. SolarCity's unique business model has, of course, helped it succeed where others failed, but as demonstrated above, SolarCity's success can also be credited to substantial financial assistance from the U.S. government and beneficial policies put in place by the Department of Commerce, the Department of Energy, and Congress.

2.2.2 Biodiesel Tax Credits

The 2004 American Jobs Creation Act, commonly known simply as the "Jobs Bill", awarded biodiesel a fuel tax credit. Biodiesel burns cleaner than petroleum diesel, thereby reducing the emission of harmful air pollutants (EPA, 2014). Furthermore, used cooking oil can be recycled to produce biodiesel; billions of gallons of waste grease can be diverted from landfills and municipal water pipes, improving the quality of both air and water. The 2004 law took effect the following year, awarding biodiesel blenders a tax credit of $1.00 for each gallon of biodiesel made from animal fats and oil crops and a $0.50 per gallon credit for biodiesel made from recycled fats and oils.

The effect on the industry was immediate. Keith Collins, who in 2006 was the Chief Economist of the U.S. Department of Agriculture, and James A. Duffield, a Senior Agricultural Economist at the USDA at the time, observed, "The biodiesel tax credit has already had a major impact on the emerging biodiesel industry. Largely due to this tax credit, biodiesel production increased from about 25 million gallons in 2004 to over 90 million gallons in 2005" (Choices Magazine, 2006). The preliminary data for 2013 indicates that the U.S. produced over 1.3 billon gallons of biodiesel, a 5,200% increase from 2004 (EIA 2014). Since 2005, additional state and federal laws added strength to biodiesel incentives included in the Jobs Bill by way of mandates or tax credits, bolstering the astronomical growth of biodiesel in the U.S., but the size of biodiesel's market share is still nowhere near that of traditional diesel or gasoline. Thus we see that even with government tax credits or subsidies, renewable energies remain at a disadvantage.

As noted above, there are six main categories of barriers that prevent or hamper the adoption of RETs; however, only three barriers–-economic and financial constraints, institutional and regulatory barriers, and behavioral or cultural barriers–appear to matter in the adoption of FOG. These barriers were determined using Painuly (2001) and Reddy and Painuly's (2004) frameworks and they are explained in greater detail below.

3. Methodological Approach

3.1 Research Goals and Research Question

This study aims to identify the most important barriers that exist for the adoption of FOG as an energy feedstock in the state of Oregon and inform policy to address these issues. Naturally, the research question becomes: What are the most significant barriers to the adoption of FOG as an energy feedstock in

Oregon? Following from that, what are the most appropriate policy measures to address the identified FOG barriers and successfully promote FOG adoption going forward? In order to succinctly answer these questions, both barriers and policies must be identified and analyzed to determine and subsequently recommend appropriate courses of action. Common RET barriers have been identified in the literature review of this study, using Reddy and Painuly's (2004) work. The current policy landscape describes the promotion strategies currently in effect, but it leaves unanswered this research's problem of low adoption of FOG as an energy feedstock.

Painuly's (2001) recommendation of using three different yet complimentary measures to identify barriers–literature survey, site visits, and interaction with stakeholders–informs this study.

Qualitative studies are of particular interest in cases where there is a need to develop detailed descriptions and to learn about a topic that the researcher is not able to see in person, integrate multiple perspectives, and describe how events occurred (Weiss 1995).

3.2 Survey of the Literature

An extensive survey of the literature was conducted, starting during my time at the Oregon Department of Energy. News articles chronicling Oregon's problems with combined sewer overflows, various FOG programs, and the growing biogas industry feature prominently in this study. Numerous case studies from across the country that dealt with biogas energy and FOG as a feedstock were also examined. This research of the literature helped mitigate the potential problems and challenges of reflexivity. As defined by Yin (2011, p. 150), reflexivity occurs when the questions the poses influence the research participants' answers or when the research participants influence the researcher.

3.3 Site Visits

Painuly explained, "Site visits should be made, wherever possible, to study the projects closely" (2001, p. 78). Four site visits were conducted in 2014 at three wastewater treatment plants and one merchant biogas plant. During these site visits, I saw firsthand the infrastructure used to process FOG into biogas for energy consumption. The on-site understanding of process and the insights obtained in the field were valuable later in identifying barriers.

3.4 Informal Interviews

Interaction with stakeholders began when I interned with the Oregon Department of Energy, where I held informal interviews with various representative stakeholders. These individuals were informed members of the wastewater treatment community in the state of Oregon who provided contextual information about current initiatives surrounding FOG in the state that were not easily available in the literature or current policy design because of the on-going development of this nascent field of study. Foundational knowledge about the wastewater industry's dealings with FOG in Oregon was acquired and has been presented in this paper.

3.5 Formal Interview Design and Execution

The purpose of these formal interviews was to help the stakeholders identify the most significant barriers to the adoption of FOG as an energy feedstock—barriers that, when removed, most greatly facilitate the adoption of FOG as an energy source.

This approach is crucial to the identification of barriers because the stakeholders' perception of barriers may reveal the lacunae in existing policies and help to identify measures to overcome barriers.

As observed by Robson (2011, p. 134), a researcher needs to be able to "interpret information during the study, not simply record it." This kind of on-the-fly interpretation requires preparatory study, so I thoroughly reviewed the literature and studied my notes from the previous informal interviews to familiarize myself with the jargon before conducting formal, unstructured interviews. Unstructured interviews, sometimes referred to as intensive interviewing, (Lofland, Anderson, and Lofland, 2006), use open-ended questions to create an open dialogue between the researcher and the interviewee that proved to be invaluable during the interview and allowed me to interpret information as Robson advises (Yin, 2011, p. 134-135).

Interviews began with the participant briefly talking about his or her experience in the field and familiarity with FOG. In order to create an environment where "intense listening" could occur, I made a "systematic effort to really hear and understand" (Rubin and Rubin, 1995, p. 17). To account for the "1,000 Page Question," as described by Kvale and Brinkmann (2009, chapter 11) as many interviews as possible were recorded so that the recording could be consulted when needed instead of consulting a 1,000 page transcript of the interview. Instead of transcribing the interviews, notations of tape counter numbers were made over the course of the interview to allow for quick consultation (Yin, 2011, p. 301).

Face-to-face interviews were conducted as often as possible, enabling me to see visual cues, which provide helpful information and at times "suggest further explanation, or the need to change the topic." These visual cues were particularly helpful at interviews conducted during site visits (Yin, 2011, p. 290).

I strove to create an environment where the participants used their own words to answer the questions posed to them and did not regurgitate a script (Yin, 2011, p. 135). I tried to enter into the world of the interviewee by using the jargon of the field (Yin, 2011, p. 135).

The interview design addressed common barrier categories. The literature review helped to identify the most common barrier categories for RET adoption, and input from the best literature was synthesized to determine the barrier categories around which to frame the analysis for this study. Four barrier categories were chosen: *(1) Awareness and Information (2) Cultural and Behavioral; (3) Economic and Financial; and (4) Institutional and Regulatory* (Painuly, 2004). By isolating these barrier categories, I was able to call attention to all possible barriers no matter how negligible they might have seemed to the interviewees, whom I suspected might only focus on the most obvious or significant barriers.

Seven of these semi-structured, open-ended interviews were conducted in 2014. Interviews lasted 30-60 minutes each. Of the seven interviews, five were conducted in person and two over the phone. Each participant was an expert in the field of wastewater treatment, biomass, or FOG, and the stakeholders included representatives from publicly owned wastewater treatment plants, a merchant biogas plant, and the non-profit sector.

4. Findings

While FOG remains a costly nuisance to publicly owned treatment works it continues to be an underutilized feedstock for renewable energy. So long as barriers to adoption remain in place, FOG will continue to plague city sewers and its full energy potential will be untapped. In the case of FOG adoption in the state of Oregon, the data show that only four of Painuly's six barriers are critical to understanding the current status of FOG. The four barriers in Oregon are: Awareness and Information, Cultural and Behavioral, Economic and Financial, and Institutional and Regulatory, which are explained in greater detail in the Literature Review.

4.1 Awareness and Information

As previously explained, a lack of awareness and information on the part of the customer–whether the end-user or government officials–slows and sometimes prevents the adoption of RETs (Reddy and Painuly, 2004, p. 1,435).

This is particularly true with lesser-known RETs like FOG, which are much more unfamiliar to the public than solar or wind. A lack of awareness and information is a problem on a general level, as with the public and with some policy makers, who interviewees indicated are simply not aware of the possibility of using FOG as an energy feedstock, thereby decreasing the likelihood of adoption. A lack of information and awareness is also a problem on a much more specific level, as with grease haulers who are unaware of the state tax credit they could be eligible for if their grease were used for energy, which will be covered in more depth in the Economic and Financial section. Additionally, interviewees, particularly those from wastewater treatment plants, indicated that many FSEs were unaware of the government regulations on FOG and its disposal, leading them to dump FOG down the drain, a violation of local and federal laws. Because of this, wastewater treatment districts must devote resources to outreach campaigns, informing the FSEs of what is expected from them. Until policymakers, grease haulers, and FSEs, and to a certain extent the public in general, become familiar with FOG's potential and associated incentives, FOG will not be adopted on a large scale in Oregon.

4.2 Cultural and Behavioral

In order to more clearly identify the various cultural and behavioral barriers at work in this case, the analysis is organized according to the various groups of major stakeholders: wastewater treatment operators and policy makers.

4.2.1 Wastewater Treatment Operators

Wastewater treatment operators are in a position to significantly affect the adoption of FOG in Oregon since WWTPs are the primary beneficiaries of FOG's energy potential. However, wastewater treatment operators create barriers to the adoption of FOG because their industry culture prioritizes their responsibility to meet government-mandated permit requirements above potentially cost-saving innovations. Although these values pervade the industry from top to bottom, this culture is beginning to change and experiment with new technologies.

Unprompted, many of the interviewees described the wastewater industry as "fairly conservative"—meaning that they are slow to innovate and experiment—and even those that required more prompting through direct questions agreed with that characterization.[6] This conservative culture is shown in the leaders hesitation to use public funds on unproven technology and their hyper-focus on meeting the requirements for their required National Pollutant Discharge Elimination System (NPDES) permits, thus giving them a myopic view that precludes the implementation of potentially cost-saving innovations like FOG.

One wastewater treatment manager explained that this industry-wide conservatism comes from organizational leaders' desire to be responsible with public resources. He went on to explain that in the 1970s with the passage and implementation of the Clean Water Act there was a huge influx of wastewater treatment engineers and that 40 years later, these engineers are now running wastewater treatment plants across the nation. These "elder statesmen" possess a

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[6] It should be noted that this risk aversion is not limited to Oregon or the Pacific Northwest. One wastewater treatment operator with experience in various other parts of the country indicated that this is a national characterization.

"if it ain't broke, don't fix it" mentality and are consciously slow to "gamble" with public resources (Interview, 29 May 2014).

This cohort that entered the industry in the 1970s at a time when meeting the permit requirements detailed in the Clean Water Act and subsequent legislation, which were brand new at that time, was the sole purpose of their employment. They have carried this permit-first culture with them to the present day as they now lead the WWTPs. The leaders require substantial proof of efficacy before investing time and resources into a new and possibly experimental initiative. This proof comes to WWTPs by way of consultant firms like CH2M Hill, which frequently use the success of overseas WWTPs, especially in Europe, which have successfully implemented new initiatives. Further, as more and more domestic WWTPs successfully implement a new technology, other WWTPs sometimes receive pressure to do the same. For example, in 2004, there were only four WWTPs participating in the regional preferred pumper program, which will be explained in greater detail later on, but now there are 12.

The interviewees agreed that WWTP leaders tend to be slow to innovate both because of their responsibility to use public resources wisely and to qualify for NPDES permits, but, interestingly, those interviewed are split on whether or not lower-level wastewater treatment workers are as conservative as their bosses. In several interviews, those familiar with the industry indicated that wastewater treatment operators are conservative because they focus on the short-term. They have learned from their bosses to focus on the permit requirements mandated by the EPA and the NPDES. For the majority of WWTP workers, their eight-hour shifts revolve around permit compliance. One interviewee in particular explained that many of the workers view new projects and innovations as “continually upsetting the apple cart with new initiatives”, so innovations get in the way of their ability to do the tasks for which they were hired. In fact, one respondent explained that it is not a mischaracterization to say that the “engineers are on the clock 24/7/365” working for the NPDES permit (Interview, 3 June 2014). One interviewee adopted a football analogy and commented that WWTP workers work towards a “Reg Endzone,” meaning that their final goal was to meet the regulations (Interview, 30 May 2014). One engineer simply said, “That’s why we’re here” (Interview, 10 June 2014). They do not have time or the desire to explore pet projects, such as FOG, which are not central to the organization’s core mission of meeting NPDES requirements.

On the other hand, other interviewees believed that WWTP workers are more open to innovation than their superiors are; these interviewees are quick to point out that whether WWTP employees admit it or not, WWTPs are “in the energy business” (Interview, 30 May 2014) because three to four percent of all energy use in the nation is used to transport water (EPA, “Water and Energy Efficiency”). In addition to maintaining an NPDES permit, WWTP operators have an obligation to their ratepayers to keep their rates as low as possible, and some innovations, like using FOG as an energy feedstock in on-site biogas energy production, can cut their energy costs. By reducing the cost of energy for the WWTP, they are able to pass on savings to their customers, the public. Given the energy conservation mandate, it would seem that WWTP workers would be interested in cost-saving innovations, and, for that matter, their bosses would be as well, but, as shown above, the majority of WWTP leaders appear to focus solely on permits and consider potentially cost-saving initiatives too risky to justify.

4.2.2 Policy Makers

Policy makers carry significant clout in the adoption of RETs like FOG; however, certain aspects of political culture make adoption difficult. In order for an RET project to succeed, an energy champion must take on the project and policy makers must be willing to invest political capital into a long-term project with delayed payoffs.

While not addressed by Reddy or Painuly (2004) and only tangentially addressed by others (Bulkeley & Kern, 2006, McCormick & Kåberger, 2007) one interviewee stressed the importance of having an "energy champion," or someone who spearheads a project and uses political clout or persuasion to see a project to completion (Interview, 30 May 2014). The need for one or more energy champions is particularly important for publicly owned treatment plants, which not only need someone to lead the project logistically, typically a WWTP engineer, but also need someone to back it politically, usually an elected official with oversight of a WWTP like a city councilor. When asked why some municipalities went forward with FOG projects and others didn't, one wastewater treatment manager quickly said, "Some municipalities have no vision," referring to both political leaders and city wastewater treatment plant operators (Interview, 30 May 2014). However, the prevailing culture of politics makes it unlikely for many political leaders to take the risks necessary to implement a FOG program. As noted previously, some did not even know about the potential of FOG, however, few were easily convinced once they learned of the possibility from a local champion.

Many other policy makers needed more convincing, especially with regard to the financial viability of the project. Projects of this nature require a long payback period, which is at odds with the culture of in which political leaders are interested in short-term deliverables for their constituents. As initially pointed out by Mayhew (1974), politicians prefer to write laws and claim credit for addressing public problems at the front end of the policy process because this plays better with voters, whereas long-term political actions are not as easily seen or appreciated by voters. Within this culture, policy makers are unlikely to see the value of giving support to long-term, costly projects like FOG.

4.3 Economic and Financial

As previously explained, RETs like FOG sit at a financial disadvantage to traditional energy sources because of several financial barriers, which for FOG include: the present low price of existing energy sources, high-cost of capital construction of RET projects, unpredictable amounts of FOG, a lack of governmental or nonprofit financial assistance, and weak incentives for grease haulers. The most frequent barrier cited by interviewees was financial and, as will be demonstrated below, it comes as no surprise.

Compared to other regions in the US, energy prices throughout the Pacific Northwest are relatively inexpensive. For example, in Oregon, average utility rates are 0.0829/kwh while California and New York have rates higher than 0.16/kwh (EIA, 2014). The decreased rates mitigate the economic incentives to invest in and utilize cost-saving renewable energies like biogas. This regional difference is even starker when one takes into account that most WWTP receive a reduced industrial rate, which WWTP managers peg around 0.058/kwh, compared to the residential average of 0.0829/kwh mentioned previously. Because of the low cost of existing energy, much of which comes from hydropower, there is not a pressing need to expand RETs like biogas in Oregon.

Another factor working against the adoption of FOG is the high capital construction cost of outfitting a plant to receive and digest FOG, which costs millions of dollars. Gresham, a suburb to the east of Portland, was able to construct a FOG receiving unit and new holders for a cost of $1.35 billion (Energy Trust, 2006). However, Gresham, unlike many other cities, was unusually lucky because they already had a cogeneration system, a building to house it, and anaerobic digesters. Other cities would have to purchase these in addition to building dedicated receiving and storage, scrubbers, etc. Pendleton, Oregon, which did have to upgrade their facility, went forward with the FOG project with little concern for the financial aspects. When asked about the need for outside assistance in the form of federal, state, or non-profit grants to fund the project, the city official interviewed said the project would have been "iffy" without grants but could have continued without them (Interview, 18 June 2014). Even with a relatively low capital construction cost like Gresham's or political support like Pendleton, no city or investment group can convert FOG into energy independently and instead must take out loans with long payback periods. One city employee explained that as a rule of thumb, if any proposed project has a payback period of longer than 10 years it is unlikely that the plan will proceed, indicating that ten years seems to be an unofficial barrier for many public officials. High capital costs constitute a large barrier to the adoption of FOG as an energy feedstock if the infrastructure is not already in place.

Even after the infrastructure needed to receive, process, and transform FOG into energy has been put into place, serious barriers to full-scale adoption remain. Foremost among them is the inherent uncertainty of FOG: it is hard to estimate how much FOG exists and, therefore, hard to predict how much a biogas plant, private or public, will receive. A 1998 NREL-funded study recognized the inherent difficulties of averages when it pointed out that even within a small niche of fast food burger restaurants, there was a considerable disparity between the amounts of FOG produced (Wilstee, 1998). For example, Jack in the Box restaurants "generate two to three times as much grease as McDonald's." The researcher expanded the McDonald's comparison, explaining that Denny's restaurants generate about 2/3 as much grease as McDonald's does and a "typical small family restaurant" generates about 1/3 as much grease as a McDonald's does (Wiltsee, 1998). The most recent thorough analysis of the amount of FOG produced was conducted in 1998, which determined that the average annual grease production of FOG is 13.37 pounds per person in metropolitan areas greater than 80,000 across the country (Wilstee, 1998). While comprehensive for its time, the data is out of date and far too generalized to be helpful for individual cities or businesses in Oregon.

While estimating the amount of available FOG is always difficult, it is especially hard in rural areas. As mentioned above, Pendleton, Oregon is a city with policy makers supportive of renewable energy technologies. The city already has solar panels, a hydropower turbine, and anaerobic digestion facilities. One city employee joked that the city just needed to get wind power to round out the city's renewable energy portfolio (Interview, 18 June 2014). In spite of this political support, Pendleton struggles with maintaining a consistent flow of FOG. Located in Eastern Oregon just north of the Blue Mountains, Pendleton is a rural city and as such has a smaller number of FSEs to draw upon for FOG. Pendleton's circumstances are complicated further by Baker Commodities, a private pumper that collects FOG in town to be used in their facility in nearby Sunnyside, Washington. These factors make it difficult to estimate the amount of FOG available in Pendleton and other rural towns like it.

Even if the amount of FOG produced in an area can be estimated, a biogas production facility may not be able to rely on that figure as an input. The best pre-treatment programs, which prevent the FOG from entering the sewers by using grease traps and grease interceptors, cannot prevent all FOG from entering the sewers or winding up in a landfill and thus escaping processing by anaerobic digesters because, as explained in the Cultural and Behavioral barrier section on grease haulers, it may not be in a grease hauler's economic interest to dispose of the grease at a processing facility.

Aside from the unreliability of the FOG supply, it is much more difficult to institute a FOG project now than it was even 3-5 years ago because of several financial assistance programs that have now lapsed. Every facility I spoke with acknowledged receipt of government grants and support. With rare exception, all facilities received money from the now defunct Business Energy Tax Credit (BETC) and American Recovery and Reinvestment Act (the Stimulus Package). However, when these funds ran out, creation of additional facilities halted. Additional support came from the Energy Trust of Oregon in the form of grants amounting to millions of dollars. Some cities, like Pendleton, could have self-funded the capital costs, but the majority needed outside money to make projects viable. A representative from JC Biomethane, the only merchant biogas plant in the state, explained that even with the grants they received, a similar project could not be replicated because of the reduced rates utilities are offering for power now. JC Biomethane has a power purchase agreement with Portland General Electric that pays them somewhere between 6 and 7 cents for every kwh produced; however, if a similar plant was to go online today, their rate would be only 3 to 4 cents per kwh produced—a substantial decline. Since the construction of the JC Biomethane plant in 2013, market conditions have declined, cutting the rates of a power purchase agreement in half and making similar construction financially unfeasible. These market conditions and the lack of outside funding stand in the way of further FOG adoption.

Poorly designed government incentives for grease haulers present another financial barrier. Grease haulers are an essential component of an effective FOG-to-energy marketplace. Once a grease management system is filled at an FSE, a grease hauler is called to pump out the FOG. When the hauler's tank is full of grease, he or she seeks out a disposal location, and because FOG, despite its energy value, is still a waste product, a tipping fee is charged at most disposal sites. While no census has been conducted to determine where pumpers dispose of the collected FOG, stakeholders indicate that the two most frequent locations are either the dump or an energy facility that accepts FOG, like a WWTP.

Pumpers, with rare exception, have no affiliation with biogas facilities and dispose of their cargo wherever they believe is in their best interest—sometimes illegally. In 2005, a Tacoma, WA-based company, Metro Rooter and Plumbing, was fined $10,000 by the State Department of Ecology and charged $20,000 in clean-up fees when one employee dumped "approximately 4,000 gallons of kitchen grease and wastewater into a Tacoma-area storm drain" (CalFOG). While recorded instances of illegal dumping are hard to find, wastewater treatment professionals suspect that this behavior still occurs, although none of them chose to guess at the frequency.

When asked about haulers, one wastewater treatment manager described them as a "squirrely bunch." This flighty group is an integral part of the logistics of the FOG-to-energy landscape, but they sometimes do not play their part well and understandably so. Few haulers collect only FOG; in fact, most haulers pump septic systems for a list of regular customers and then supplement their business with FOG and as a result there are few FOG haulers. Because many hauling companies are already managing to turn a profit without FOG, they consider pumping FOG to be more hassle than it's worth, so the number of pumping companies that deal with FOG is limited. And while FOG haulers are presently eligible for a tax credit from the Oregon Department of Energy, participation is low. One state official surmised that the low participation rate is occurring not only because of a lack of awareness, as mentioned previously, but also because the FOG collection industry is still nascent and not mature enough to bank on tax rebates which are received only once a year. In other words, haulers work within a culture of self-interest, and since they rely on a short-term return on investment model, their business is sometimes at odds with using FOG for energy. For example, while disposing of FOG at energy production facilities may be more lucrative to them on an annual basis with the tax credits, the hauler may still dispose of their FOG elsewhere because in the short term it is cheaper for them. While incentives are place to encourage grease haulers to dispose of their FOG at energy production facilities, the incentives are not tailored to the needs of the grease haulers.

4.4 Institutional and Regulatory

Institutional and regulatory barriers occur, as noted by Reddy and Painuly (2004), when there are "no sufficient government regulations and/or incentives to stimulate the adoption of RETS by businesses and industries" (p. 1,436). In order to adequately address the institutional and regulatory barriers at work, this paper will first examine the Federal Public Utility Regulatory Plan Act, which sets up a foundation that allows FOG to be used as an energy feedstock. Secondly, the lack of demand as well as one state intervention that could turn the tide of lackluster demand will be addressed. Lastly, pretreatment programs at a local level will be examined.

4.4.1 The Federal Public Utility Regulatory Plan Act

Signed into law in 1978, The Federal Public Utility Regulatory Plan Act (PURPA) mandates that certain U.S. electric utilities must purchase electricity from "qualifying facilities." The stated purpose of PURPA is threefold:

1. Conservation of energy supplied by energy utilities
2. Optimal efficiency of electrical utility facilities and resources
3. Optimal rate for electric consumers (16 U.S. Code § 2611 - Purposes)

PURPA was a direct response to the 1973 energy crisis and focus on energy security by President Carter and his administration. The law was the beginning of a restructuring of the energy industry and weakened the natural monopoly held by energy companies, allowing small "qualifying facilities" to produce and sell excess energy to the grid. The lone merchant biogas plant and nine wastewater treatment plants that produce energy in Oregon fit the criteria of qualifying facilities and as such are entitled to sell their energy using net metering to electric utilities.

PURPA is essential to the future of FOG in Oregon and elsewhere because it gives WWTPs and merchant biogas plants a point of sale for any excess energy they may produce on a given day. The credits these plants accrue by selling energy back to the grid can be used to supplement their energy needs on days when their RET production is low. Gresham, Oregon's WWTP, for example, is expected to be energy neutral by 2015 with a mix of solar and biogas energy thanks to the net metering permitted by PURPA. Unlike Gresham, which is an outlier, typical WWTPs can expect to be able to cover 60-70% of their energy costs with on site creation annually. FOG can help these facilities reach those high levels, thereby diversifying the region's energy portfolio and, in the case of WWTPs, saving money for ratepayers.

Despite the advantages PURPA provides for public and private biogas plants in Oregon, these plants still face substantial challenges like the lack of a comprehensive energy plan in the U.S. and enforcement at a local level.

4.4.2 FOG and Fleet Mandates

With the exception of the few facilities in the state that accept FOG in their anaerobic digesters, there is little demand for FOG, and as such, it is frequently disposed of in the cheapest, but not most useful, ways. Until the demand for FOG is changed, there will remain a substantial hurdle to its widespread adoption. When asked what one improvement would have the greatest impact on the adoption of FOG in Oregon, one representative from JC Biomethane said, "A national energy plan–but that's unrealistic" (Interview, 11 August 2014). With the absence of a national energy plan and federal legislation dealing directly with biogas production, states must be the driving force to overcome institutional and regulatory barriers to FOG adoption. After admitting that a national energy plan was unlikely, the interviewee mentioned that the second greatest potential impact was to have a state policy that mandated that a certain percentage of all fleets in Oregon should use renewable natural gas. As explained in the introduction of this paper, renewable natural gas, or biomethane, is one of the end products of a biogas facility, like those in which FOG would be a feedstock. The interviewee from JC Biomethane commented that if and when such a policy were in force, all the FOG would quickly be "snatched up into anaerobic digesters," whereas now, FOG ends up in a variety of other locations, as was detailed previously (Interview, 11 August 2014).

The results of this proposed mandate on fleets would be similar to the growth of ethanol after the Energy Policy Act of 2005, which required that an annually increasing percentage of biofuels, typically ethanol, be mixed with gasoline. In 2004, the U.S. produced 3.4 billion gallons of ethanol, but after the passage of the Energy Policy the following year, ethanol production skyrocketed, and as of 2013 more than 13.3 billion gallons of ethanol are produced annually in the U.S. (Renewable Fuels Association). A similar law mandating renewable natural gas adoption would have a similar effect, including an increased demand for materials that are used to produce renewable natural gas, such as FOG.

If demand for FOG increased, food service establishments (FSEs), which produce the bulk of the FOG in the state, would likely change their behavior to meet it. As evidenced by the "municipal heart attacks" facing POTWs across the nation, many FSEs simply put the used fats, oils, and grease down the drain. In order for FOG to reach its full potential as an energy feedstock in Oregon, all of the possible FOG needs to be collected; however, this can only happen when strong pre-treatment programs are put in place.

4.4.3 Pretreatment Programs

Pretreatment programs are created and enforced to prevent FOG from entering sewers, but they are only effective if grease management systems are installed and used regularly by FSEs. Recent changes to the Oregon Plumbing code require the installation of a grease management system when new construction or a remodel is made (Chapter 10 of the 2011 Oregon Plumbing Specialty Code).[7] While the code change is significant and will ensure that eventually all FSEs will have the necessary equipment to divert FOG away from sewers, many FSEs will remain without grease management systems for years to come. Even when grease management systems are installed, like grease interceptors and grease traps, there is no guarantee that FSEs will use them. Governments are faced with the challenge of enforcement, which can be prohibitively expensive. For example, Portland is the largest city in Oregon with over 600,000 residents and as such has more resources

[7] Additional requirements can be found in a State of Oregon Amendment dated January 1st, 2013 titled "Grease Interceptors & Fats, Oil and Greases."

than any other city in the state, but it still could never monitor and enforce proper FOG disposal in all of the 3,000 FSEs in the city.

Because the challenge of enforcing proper disposal of FOG is so great, Portland has instead focused on incentivizing FSEs by offering technical assistance and information to help Portland FSEs to meet requirements for reducing FOG and food waste discharges through a strong pretreatment program called "Cut Through the FOG" (City of Portland). All FSEs in Portland are charged an increased sewer rate based on estimated FOG outputs according to one of twelve FSE categories that the establishment fits in, but that rate is decreased once the FSE can show proof of compliance. Grease haulers who are a part of the Preferred Pumper Program, a regional voluntary organization of municipal, county, and other government districts, provide this proof. The Preferred Pumper Program identifies grease-pumping companies that meet certain criteria established by regional municipalities and endorses them to local FSEs. Pumpers registered with the Preferred Pumper Program certify that they will follow the agreed upon standardized procedures, which increase pumping efficiency across city borders and increase the likelihood that grease traps/interceptors will be cleaned correctly, thereby reducing the amount of FOG entering the sewer system. FSEs in the region are encouraged, but not required, to use a preferred pumper, but FSE owners know that when doing business with a preferred pumper they are receiving high-quality service, which anecdotally is a rarity among pumping companies.

In order to obtain and maintain a preferred pumper status, the pumper regularly submits completed pump-out reports to the city. These pump-out reports help ensure that the pre-treatment program is working and give the city a better understanding of how much FOG exists within the city. The Preferred Pumper Program has steadily increased the number of participating municipalities in the Willamette Valley and because of its success; a similar program has been implemented in Central Oregon.

The future of FOG as an energy feedstock is dependent on a change in the institutional and regulatory system, the lack of which has created a misalignment of incentives for FOG. Despite its energy potential, FOG is currently treated as a waste and as such is disregarded. Portland in particular has made great progress in changing its regulatory system to divert FOG from the sewer systems, thus making it available for anaerobic digesters, but this work must spread and continue if FOG is to be adopted as a feedstock across the state.

5.0 Conclusions and Considerations

5.1 Summary of Research

This research identified the barriers facing the adoption of fats, oils, and grease as an energy feedstock in the State of Oregon. The study was concerned with the most important barriers that exist and negatively impact the level of adoption of FOG for energy use. Important barriers were identified using Painuly and Reddy's (2004) framework for barrier identification. Using this framework, barriers were established through analysis of the literature. Engaged stakeholders included wastewater treatment plant operators and managers, state regulators, non-profit managers, and for-profit biogas plant managers in Oregon. Stakeholders were engaged through individual unstructured interviews executed either in person or over the phone. Interview participants were asked questions that shed light on the most significant barriers to the adoption of FOG as an energy feedstock.

5.2 Findings

Research results were analyzed to identify the major barriers to the adoption of FOG as an energy feedstock in Oregon. Four major barriers were identified, which are Awareness and Information, Cultural and Behavioral, Economic and Financial, and Institutional and Regulatory.

5.3 Limitations

The goal of this research was to identify the significant barriers to the adoption of FOG as an energy feedstock in the State of Oregon. The recommendations, which follow, are meant to inform appropriate and effective policy design, but are not comprehensive. This research study was limited in several ways, and while important results can still be reported, the field has great potential for additional research.

(1) Limited Target Population: Due to time and resource constraints, this study was only able to target a select number of stakeholders. While the identified stakeholders collectively possessed significant amounts of knowledge on FOG and the market for it there were likely other stakeholders with additional insight. A more complete analysis including all wastewater treatment plants in Oregon may be able to identify

additional barriers. Additionally, the inclusion of FOG pumper and haulers in the study would have provided a more complete picture of the barriers, particularly the economic forces at work.

(2) As mentioned previously the available data on the amount of FOG is old and outdated, with the most recent study from 1998. A more recent study is needed to better gauge FOG's potential.

5.4 Recommendations

This research set out to identify barriers to the adoption of FOG as an energy feedstock in Oregon and the following recommendations address different ways those barriers might be overcome. The following policy measures would be most effective in increasing the overall adoption of FOG as an energy feedstock in the State of Oregon.

(1) Increase state funding for capital-intensive projects required to transform FOG into energy. The former Business Energy Tax Credit could serve as a model for future investment.

As has been made clear by the interviewees, financial barriers are the most significant to overcome and outside funding sources have proved crucial in the past. However, many of the former sources of funding have dried up or lapsed, and new sources should be developed to help both WWTP and merchant biogas plants utilize FOG as a biogas feedstock.

(2) Mandate that a percentage of fleet vehicles run on biomethane.

Presently, the demand for FOG and other biogas feedstocks is considerably lower than the supply. A mandate of this kind would ensure a sharp increase in demand for biogas and subsequently FOG, one of the most potent feedstocks.

(3) Increase education and oversight of food service establishments and grease haulers, ensuring proper disposal of FOG.

As noted previously, it is extremely difficult to enforce laws on proper disposal of substances like FOG. It appears that some FSE owners are unaware of the harmful effects FOG can have on the city's infrastructure and of regulations for proper disposal. Grease haulers are likewise unaware of existing regulations and available tax credits. A robust education and outreach effort would minimize this barrier. Additionally, strong pre-treatment programs are needed at a local level to divert FOG away from sewers and into digesters.

(4) Encourage collaboration between wastewater treatment professionals, facilitating the sharing of ideas.

As explained previously, the prevailing culture in the WWTP industry is slow to innovate; however, as FOG experiments continue to be successful, sharing insights and improvements among WWTPs will be vital in changing the industry culture and paving the way for future adoption.

(5) Conduct further study estimating the amount of FOG present in Oregon.

It has been quite some time since a thorough study was conducted to determine how much FOG there is in the U.S. (Wilstee, 1998), and no study has ever been conducted to determine how much FOG there is in

Oregon. As mentioned previously, one serious obstacle to widespread FOG adoption is the uncertainty of the amount of FOG in any given market.

Bibliography

Adler, Jonathan (2014, June 23). "Further thoughts on today's Supreme Court decision on greenhouse gas regulation," *Washington Post.* Retrieved: 6 November 2014 http://www.washingtonpost.com/news/volokh-conspiracy/wp/2014/06/23/further-thoughts-on-todays-supreme-court-decision-on-greenhouse-gas-regulation/

Al-Badi, A.H., A. Malik, A. Gastli (2011). Sustainable energy usage in Oman—Opportunities and barriers. *Renewable and Sustainable Energy Reviews* 15:8. Retrieved: http://www.sciencedirect.com/science/article/pii/S1364032111002528

Allen, Arthur (2014, October 14). "Prodigal Sun." *Mother Jones*. March/April 2000 Issue. Retrieved 14 October 2014: http://www.motherjones.com/politics/2000/03/prodigal-sun

Borenstein, Seth (2014, November 11). "Contaminated Water Caused By Leaky Wells, Not Fracking Process, Study Says." *Associated Press*. Retrieved 11 November 2014: http://www.huffingtonpost.com/2014/09/15/contaminated-water-fracking_n_5822652.html

Brady, Jeff (2014, November 13). "After Solyndra Loss, U.S. Energy Loan Program Turning A Profit." *National Public Radio*. 13 November 2014. Retrieved 14 November 2014: http://www.npr.org/2014/11/13/363572151/after-solyndra-loss-u-s-energy-loan-program-turning-a-profit

Bulkeley, Harriet & Kristine Kern (2006). "Local Government and the Governing of Climate Change in Germany and the UK." Urban Studies, Vol. 43, No. 12, 2237– 2259, November 2006 Archived copy accessible: https://web.archive.org/web/20130612180458/http://www.bioremediation.net/resources/brown-grease.pdf

Bullis, Kevin (2012, May 4). "Why SolarCity Is Succeeding in a Difficult Solar Industry." *MIT Technology Review*. http://www.technologyreview.com/news/427830/why-solarcity-is-succeeding-in-a-difficult-solar-industry/

Bureau of Land Management. "Summary of Onshore Oil and Gas Statistics." (n.d.) http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/statistics.html.

Bureau of Land Management. "Renewable Energy Projects Approved Since the Beginning of Calendar Year 2009." (n.d.) Retrieved 25 February 2014: http://www.blm.gov/wo/st/en/prog/energy/renewable_energy/Renewable_Energy_Projects_Approved_to_Date.html

Bureau of Land Management. "New Energy for America." (n.d.) Retrieved 28 April 2014: http://www.blm.gov/wo/st/en/prog/energy/renewable_energy.html

Carter, Jimmy (1977, April 18). "Proposed Energy Policy." Retrived 14 October 2014: http://www.pbs.org/wgbh/americanexperience/features/primary-resources/carter-energy/

Carter, Jimmy (1979, June 20). "Solar Energy Message to the Congress."

Retrieved 14 October 2014: http://www.presidency.ucsb.edu/ws/?pid=32503

Chakravorty, Shubhankar (2014, August 26). "UPDATE 2-Trina Solar plans overseas plants to bypass U.S. duties." *Reuters*. Retrieved 14 November 2014: http://www.reuters.com/article/2014/08/26/trina-solar-results-idUSL3N0QW3MX20140826

Chang, K. Lin, W. Lee, T., & Chung, K. (2011). Subsidy programs on diffusion of solar water heaters: Taiwan's experience. Energy Policy, 39, 563-567. Doi:10.1016/j.enpol.2010.10.021.

Chipman, Kim. (2010, October 5)"Solar Panels on White House Roof, Removed by Reagan, to Return Under Obama." *Bloomberg.com*. Retrived 14 October 2014: http://www.bloomberg.com/news/2010-10-05/solar-panels-on-white-house-roof-removed-by-reagan-to-return-under-obama.html

City of Portland Bureau of Environmental Services. "Cut Through the FOG Program." (n.d.). http://www.portlandoregon.gov/bes/54538

Climate Trust, The. (2011, February). "Growing Oregon's Biogas Industry: A Review of Oregon's Biogas Potential and Benefits." Retrieved 4 November 2014: http://climatetrust.org/wp-content/uploads/2014/07/Growing-Oregons-Biogas-Industry-White-Paper.pdf

Congressional Research Service. (2012, February 8). *Federal Land Ownership: Overview and Data*, p. 1.

Copperfield Research. (2013, June 17). "Solar City (SCTY) - The Emperor('S

Cousins) Have No Clothes." *SeekingAlpha.com*. Retrieved 14 November 2014: http://seekingalpha.com/instablog/890075-copperfield-research/1959622-solar-city-scty-the-emperor-s-cousins-have-no-clothes

Duffiled, James A. and Keith Collins, (2006, January). "Evolution of Renewable Energy Policy." *Choices Magazine*. washttp://www.choicesmagazine.org/2006-1/biofuels/2006-1-02.htm

Energy Information Administration. (2014, April) *Monthly Energy Review.*

Energy Information Administration. "Natural Gas Prices." (n.d.) Retrieved 16 November: http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm

Energy Policy Act of 2005. Accessible: http://www.gpo.gov/fdsys/pkg/PLAW-109publ58/html/PLAW-109publ58.htm

Enivronmental Protection Agency. "Learn about Biodiesel." (n.d.) http://epa.gov/region9/waste/biodiesel/questions.html

Environmental Protection Agency. "Water & Energy Efficiency." (n.d.)Retrieved 18 November 2014: http://water.epa.gov/infrastructure/sustain/waterefficiency.cfm

Epstein, Paul R., Jonathan J. Buonocore, Kevin Eckerle, Michael Hendryx, Benjamin M. Stout, Richard Heinberg, Richard W. Clapp, Beverly May, Nancy L. Reinhart, Melissa M. Ahern, Samir K. Doshi, & Leslie Glustrom (2011). "Full cost accounting for the life cycle of coal." *Ecological Economics Reviews,* 1219, 73–98.

Farrell, John (2013, July 17). "Is Solar Cheaper Than Grid Electricity? Yes. And No." *Clean Technica*. Retrived 25 September 2014: http://cleantechnica.com/2013/07/17/is-solar-cheaper-than-grid-electricity-yes-and-no/

Federal Energy Regulatory Commission. "What is a Qualifying Facility?" (n.d.) Retrieved 22 November 2014: http://www.ferc.gov/industries/electric/gen-info/qual-fac/what-is.asp

Fountain, J. E. (2001). Paradoxes of Public Sector Customer Service. Governance, 14(1), 55.

Gallucci, Maria (2014, November 4). "UN Climate Change Report: World Must Phase Out Most Fossil Fuels To Avoid Catastrophic Global Warming." *International Business Times*. Retrieved: 5 November 2014 http://www.ibtimes.com/un-climate-change-report-world-must-phase-out-most-fossil-fuels-avoid-catastrophic-1718132

Geothermal Energy Association. "Geothermal Basics – Employment." (n.d.) Retrieved 24 April 2014: http://www.geo-energy.org/geo_basics_employement.aspx

Glanz, James. "Deep in Bedrock, Clean Energy and Quake Fears." *New York Times*. 23 June 2009. Retrieved 11 November 2014: http://www.nytimes.com/2009/06/24/business/energy-environment/24geotherm.html?_r=1&scp=1&sq=altarock&st=cse

Gosden, Emily (2014, November 2). "UN climate change report: time running out to prevent 'dangerous, irreversible' impacts of global warming." *The*

Telegraph. Retrieved 5 November 2014: http://www.telegraph.co.uk/earth/environment/climatechange/11203771/UN-climate-change-report-time-running-out-to-prevent-dangerous-irreversible-impacts-of-global-warming.html

Gutermuth, Paul-Georg (1998). Financial measures by the state for the enhanced deployment of renewable energies. Solar Energy 64:1-3

Harmon, Katherine (2009, June 29). "How Does Geothermal Drilling Trigger Earthquakes?"*Scientific American.* Retrieved 11 November 2014: http://www.scientificamerican.com/article/geothermal-drilling-earthquakes/

Jacobsson, Staffan and Anna Johnson (2000). The diffusion of renewable energy technology: an analytical framework and key issues for research. *Energy Policy* 28:9. Retrieved from: http://www.sciencedirect.com/science/article/pii/S0301421500000410

Johnson, BE (1994). Modelling energy technology choices: which investment analysis tools are appropriate? *Energy Policy* 22.

Kempton, Willet and Linda L Layne (1994). "The consumer's energy analysis environment." *Energy Policy* 22 (10) 1994.

Kennedy/Jenks Consultants (2008, July 3). "Final Energy Independence Project." http://www.oracwa.org/pdf/energy-independence-report.pdf

McCormick, Kes, Tomas Kåberger (2007). "Key barriers for bioenergy in Europe: Economic conditions, know-how and institutional capacity, and supply chain co-ordination."*Biomas and Bioenergy* 31, p. 443-452.

Menanteau, Philippe, Dominique Finon, and Marie-Laure Lamy (2003). "Prices versus quantities: choosing policies for promoting the development of renewable energy." Energy Policy 31, 799–812.

Mufson, Steven (2014, September 15). "Study: Bad fracking techniques let methane flow into drinking water." Retrieved 12 November 2014: http://www.washingtonpost.com/blogs/wonkblog/wp/2014/09/15/study-bad-fracking-techniques-let-methane-flow-into-drinking-water/

Natural Resources Defense Council (2012, September). "American Wind Farms: Breaking Down the Benefits from Planning to Production."

Owen, Anthony D (2006). Renewable Energy: Externality Costs as Market Barriers. *Energy Policy* 34.

Pentland, William (2013, July 8). "Germany's Solar Industry Is Imploding." *Forbes*. Retrieved 26 September 2014: http://www.forbes.com/sites/williampentland/2013/07/08/germanys-solar-industry-is-imploding/

Port, Otis (2004, September 5). "Another Dawn For Solar Power." *Bloomberg Business*. Retrieved 14 October 2014: http://www.businessweek.com/stories/2004-09-05/another-dawn-for-solar-power

U.S. Enivornmental Protection Agency, "Coal." (n.d.) Retrieved 17 November 2014: http://www.epa.gov/cleanenergy/energy-and-you/affect/coal.html

United States Geological Survey. "Induced Earthquake." (n.d.) Retrieved 11

November 2014: http://earthquake.usgs.gov/research/induced/

Wüstenhagen, Rolf, Maarten Wolsinkb, and Mary Jean Bürer (2007). Social acceptance of renewable energy innovation: An introduction to the concept. Energy Policy 35, 2683–2691. Retrieved from: http://www.sciencedirect.com/science/article/pii/S0301421506004824

Renewable Fuels Association. "Historic U.S. fuel Ethanol Production." (n.d.) Retrieved 22 November 2014: http://www.ethanolrfa.org/pages/statistics#A

Shahan, Zachary (2014, September 4). "13 Charts On Solar Panel Cost & Growth Trends." CleanTecnhica.com. Retrieved 2 October 2014: http://cleantechnica.com/2014/09/04/solar-panel-cost-trends-10-charts/

Solar Foundation (2014, Janurary). The, *National Solar Jobs Census 2013*.

Syrus Energy. "Anaerobic Digestion explained." (n.d.) Retrieved 29 July 2014: http://syrusenergy.com/anaerobic-digestion-explained/

Thrill, Scott (2014, September 3). "No Matter Who 'Wins' the US-China Solar War, the Rest of Us Lose." *SolarEnergy.net*. Retrieved 14 November 2014: http://solarenergy.net/News/matter-wins-us-china-solar-war-rest-us-lose/

United Nations (2014, November 2). "Climate change threatens irreversible and dangerous impacts, but options exist to limit its effects." Retrieved: 5 November 2014 http://www.un.org/climatechange/blog/2014/11/climate-change-threatens-irreversible-dangerous-impacts-options-exist-limit-effects/

Waterfield, Bruno (2014, January 16). "Germany is a cautionary tale of how energy polices can harm the economy." *The Telegraph*. Retrieved 23 September 2014: http://www.telegraph.co.uk/finance/newsbysector/energy/10577513/Germany-is-a-cautionary-tale-of-how-energy-polices-can-harm-the-economy.html

Wile, Rob (2013, November 18). "Solar Power Could Be A Total Game-changer — But They Still Need To Figure Out One Thing." *Business Insider*. Retrieved 27 September 2014: http://www.businessinsider.com/renewable-energy-storage-problem-2013-11#ixzz3EV0vD1zD

White House, The (2014, May 9). "Inside the White House: Solar Panels." Retrieved 21 October 2014: http://www.whitehouse.gov/photos-and-video/video/2014/05/09/inside-white-house-solar-panels

Woody, Todd (2012, April 12). "Solar Power Plant Builder BrightSource Energy Pulls IPO." *Forbes*. Retrieved 14 November 2014: http://www.forbes.com/sites/toddwoody/2012/04/12/solar-power-plant-builder-brightsource-energy-pulls-ipo-on-eve-of-offering/

Yergin, Daniel (2011). *The Quest: Energy, Security, and the Remaking of the Modern World.* New York: Penguin Books.

Appendix

Interview Guide

1) Tell me a little bit about your work and position
    a. Commerical
    b. Non-profit
    c. Government
2) How long have you been involved in the industry?
    a. What is your experience with fats, oils, and grease as an energy feedstock.
3) From your perspective as a (fill in blank, e.g., wastewater treatment engineer), what are the most significant barriers to the adoption of FOG as an energy feedstock in Oregon?
    a. Cultural?
    b. Financial?
    c. Political?

4) When thinking about barriers to FOG as an energy feedstock, does Oregon have any unique barriers compared to other states and regions of the U.S.? If so, what are they?

5) What are some things legislators and government agencies could be doing differently to overcome these barriers and help facilitate the growth of FOG as an energy feedstock here in Oregon?
    - If they talk only about one-level of government, prod them about the other "missing" levels, including federal.

6) What are some things private sector companies could be doing differently to overcome these barriers and help facilitate the growth of FOG as an energy feedstock here in Oregon?
    - E.g., Can banks develop new financing instruments (something this specific might work best, or only with investor-type stakeholders)

7) What would strengthen market opportunities for FOG in your opinion?

8) What are some things non-profits could be doing differently to overcome these barriers and help facilitate the growth of FOG as an energy feedstock here in Oregon?

9) Now that you've identified actions that legislators, government agencies, private sector companies, and non-profits can take, and thinking only of the Oregon situation, which two or three actions are likely to have the

highest impact (defined as removing the most barriers and doing the most to facilitate adoption of FOG as energy source)?

- Make sure they explain why they think this.

10) Regarding these "highest impact" actions, how feasible are they? i.e., are they the kinds of things that you think can be achieved in today's political environment?

- If YES, have them explain why they think this.

- If NO, ask them if there are some other "actions" that, while lower in impact vis-à-vis their top high impact choices, might be more feasible and thus able to make some headway toward increased FOG development and use.

11) From your perspective as a (fill in blank, e.g., wastewater treatment engineer), what kind of additional information would help make you more likely to push forward into FOG development and use?

12) Some people have suggested that we need to write an entirely new policy to clear away the barriers and effectively promote the development and use of FOG as an energy feedstock. Do you agree? YES or NO.

- Even if a NO answer, then ask them what are the most important things that should be in this new policy

13) Currently, what are the biggest incentives for using FOG as an energy feedstock?

14) Is there anything else that you think I should know about FOG as an energy feedstock?