An Alternative System

A comparative study of the household barriers to adopting alternative energy systems

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Abstract

Environmental health is gaining more attention and momentum as global populations rise simultaneously with the need for efficient and sustainable energy sources. In this study, I investigate the household-scale barriers to adopting alternative energy systems (AES) in Swaziland, South Africa and Portland, Oregon using the direct and indirect relationships that households have with given energy systems. Swaziland is currently experiencing massive environmental degradation due to population increases and unsustainable fuelwood gathering practices, sparking an energy crisis. Portland, while considered a "green" city, sources the majority of its energy from environmentally harmful fossil fuels. Both areas have the ability to transition to more efficient, alternative energy systems; yet, something is holding them back. Through expert interviews and survey methods, I conclude that the barriers to adopting AES are present and uniquely tied to their location, with Swaziland experiencing sociocultural impediments and Portland bearing financial constraints as the strongest barrier.

Introduction

Environmental health is gaining more attention and momentum as global populations rise simultaneously with the need for safe surroundings and personal health. The most recent World Health Organization (WHO) report (2013) has released eight UN Millennium Development goals that are seen as crucial elements for positive environmental and human well-being (http://www.un.org/millenniumgoals/). Ensuring environmental sustainability is of extreme importance, agreed by "...all of the world's countries and all the world's leading development institutions" (http://www.un.org/millenniumgoals/), and targeted to be achieved by the not-so-far year of 2015. While this broad goal may seem ambitious, it is crucial that action is taken quickly and with passion in order to provide a sustainable and healthy progression for both current and future human-nature environments.

Major issues arise, from climate change to deforestation, when attempting to provide sufficient energy to the world's population while maintaining a healthy environment. Human development has seemed to stay consistent with increasing energy use, currently from sources that are both unsustainable and finite (Dias et al. 2004). Not only will these sources (i.e. fossil fuels) eventually become exhausted, but their production and consumption are producing negative externalities that are felt worldwide (IPCC 2013). The question does not come as a surprise: How do we keep up with a growing energy demand while providing for a healthy, sustainable future?

The utilization of Alternative Energy Systems (AES) on the household level would provide increased energy efficiency both locally while holding the possibility for a more energy-efficient future worldwide (Lund and Mathiesen 2009, Painuly 2001). Further, households that are without access to clean, efficient energy systems hold the possibility of being rooted to a cycle that can limit the accessibility to improve quality of life and sustainable development (Pachauri and Jiang 2008). Individual choices, usually stemming from the dominant figure within a household, seem to be the deciding factor regarding a household's adoption of AES. However, various barriers have been identified that seem to hold households back from engaging in such goals.

In order to investigate the barriers of adopting alternative energy systems, I have explored two regions of differing situations. Swaziland, a small landlocked country situated within the borders of South Africa, is a developing nation of whom's household majority relies on biomass (fuelwood) as the main source of energy for cooking and heating. Reliance on an energy source that replaces itself very slowly in comparison with a skyrocketing population (see figures 4 and 5) has allowed the local forests of Swaziland to degrade at an unsustainable rate. The adoption of AES can help relieve the stresses being felt by the local environments, both human and natural.

Portland, Oregon, a developed city in the Pacific Northwest, is assumed to be one of the "greener" parts of the United States. With a well-developed bike culture, the leading hybrid car presence in the US, and rising local farming agenda, it is no surprise that Portland is seen as one the nation's most energy-efficient regions. However, the city still relies primarily on imported fossil fuels in the residential, commercial, and industrial sectors. Understanding what hinders Portland residents from utilizing energy at more efficient levels can provide solutions to movement towards ensuring environmental sustainability.

There is a similarity between these two very different regions: Both Swaziland and Portland are currently using unsustainable energy systems in an inefficient manner. The statement begs: Why? What is holding these places back from implementing Alternative Energy Systems, and in what ways are these barriers of adoption both different and similar? Through my research, I conclude that the barriers to adopting Alternative Energy Systems are present and uniquely tied to their location, with Swaziland experiencing sociocultural impediments and Portland bearing financial constraints as the strongest barrier.

Energizing the Environments

As a requirement for all ecological systems, energy is produced and consumed (actually, it is transformed due to the conservation of energy) in a variety of ways that can produce both positive and negative effects on Earth's many environments. Initially, humans relied on the use of our bodies, of wind and water power (through poorly harnessed), and of the energy stored within our biological surroundings, such as wood (McNeill 2000). Time and technology has progressed, as has energy system, source, production, and consumption:

TABLE 1.4 WORLD FUEL PRODUCTION, 1800–1990

	Production (millions of metric tons)		
Type of Fuel	*1800*	*1900*	*1990*
Biomass	1,000	1,400	1,800
Coal	10	1,000	5,000
Oil	0	20	3,000

Source: Elaborated from Smil 1994:185–7.

Note: These figures do not reflect the energy yield of these fuels: a ton of oil gives 5–10 times as much energy as a ton of firewood, and perhaps twice as much as a ton of coal.

Figure 1: World Fuel Production from 1800-1990 (Mcneill 2000)

TABLE 1.5 WORLD ENERGY USE, 1800–1990

	1800	*1900*	*1990*
Total (millions of metric tons of oil equivalent)	400	1,900	30,000
Indexed (1900 = 100)	21	100	1,580

Source: Elaborated from Smil 1994:187.

Figure 2: World Energy Use from 1800-1990 (Mcneill 2000)

The Industrial Revolution allowed a massive leap in energy production and consumption, providing humans the ability to convert energy stored within the earth's crust, fossil fuels, from biological to mechanical (McNeill 2000; Stacey et al. 1977). Not only did the change to mechanical output increase the power and flexibility of previous energy practices, it also steered an increase in global energy production and use as noticed in figures 1 and 2.

Global primary energy source has also changed widely starting slowly in the 1800s, with fossil fuels experiencing the majority of use:

Table 3.3 Changes in the global primary energy mix, 1800–2008 (percentage of total energy demand).

Year	*Coal*	*Crude Oil*	*Gas*	*Hydro-electricity*	*Nuclear*	*Biomass*
1800	1.7					98.3
1900	47.3	1.5	0.5	0.1		50.5
1950	45.1	19.5	7.5	1.2		26.8
1960	38.1	27.1	11.0	1.7	0.0	22.0
1970	27.9	38.2	16.1	2.2	0.4	15.2
1980	27.4	37.8	17.8	2.1	2.6	12.3
1990	27.1	32.9	20.6	2.3	5.5	11.6
2000	23.0	33.7	22.6	2.5	6.4	11.8
2008	28.9	30.9	22.8	2.5	5.7	9.2

Source: Calculated from Smil (2010: 154).

Figure 3: Changes in the global primary energy mix by source (Goldthau 2013)

From figure 3, we can see how drastic the transition from a pure biomass-reliance energy system to the current-day's predominant use of fossil fuels. This suggests that transitions to different energy sources and systems can occur quickly and with overarching dominance. Further, it has been found that resource scarcity may not be the primary driving force in seeing transitions in energy source and system, but rather it is a convergence of social, commercial, and geopolitical conditions (Podobnik 2006). While dozens of options exist world-wide, fossil fuels provide for over 80% of energy in the United States and 91% of energy worldwide (U.S. EIA 2013). The remaining 20% come from a mixture of energy sources, with renewables, such as wind and hydropower, at 9% and nuclear-powered electricity accounting for 8% (U.S. EIA 2013).

In order to sustainably advance, however, it is critical that a more efficient use of energy is implemented. Not only will climate change, induced by accelerated greenhouse gas emissions caused by the burning of fossil fuels, produce environmental variability that may have catastrophic consequences, but the current level of energy use will not be able to sustain future generations (IPCC 2013; Smil 1994;). Therefore, it is critical that AES using energy in a much more efficient and sustainable manner be put into practice.

Discussion revolving around AES seems to be largely economic; however, there is much more involved in this modern dilemma. In a global scheme, current unsustainable energy trends have had great success due to a variety of characteristics, such as economic viability, global adoption, and system reliance. It is also true that renewable energy is currently viewed as predominantly unfeasible due to its economic weakness in both local and global markets (Howarth and Andersson 1993; Podobnik 2006). Further, the psychological aspect involved in making a switch from current systems to new, unknown systems is one that proves to be uncomfortable for most (Schweizer-Reis 2008). While economic hindrances may be the primary cause for a lack of renewable energy use in some cases, environmental psychology can help us understand issues that lay beneath the surface.

Environmental attitudes and behaviors play a crucial role in determining the use and outcome of certain technologies. If any one party has the economic stability and feasibility to use renewable energies, what is holding them back? Often, the issue of energy sustainability is looked at as being an issue of technicality- technical use, risk, and cost (Schewizer-Reis 2008). However, even if every individual was able to install, maintain, and succeed in sustainable energy system practice, it is still questionable if a transition from fossil fuel use could occur quickly and easily.

Environmental attitudes refer to the way in which individuals or groups understand, identify, and perceive their concepts of "environment". For the past 200 years, American attitudes have placed personal needs above environmental concerns due to cheap fuels, industrial growth, abundant natural resources, and an environment that seems to absorb pollution (Sovacool 2009). Feeling entitled to dominate nature, the recent environmentally-conscience mindset is contrasting to many that believe in past cultural mindsets of correlating energy consumption with economic growth (Sovacool 2009). Currently, the term "environmentalist" may evoke images of a nature-loving, Prius-driving, recycling enthusiast. However, this now-dated image has of little use when looking beyond the elementary aspects of current environmental issues. It is a common mistake to clump those involved in environmental studies into basic conceptual groups, as many citizens only understand the surface of the complexities involved in many environmental issues (Lorenzoni et al. 2007; Lorenzoni and Pidgeon 2006; Moser 2010; Senbel 2014). This dilemma, on the other hand, does help us understand how the masses view environmental issues and concept. By the investigation of both individual and community understandings, identifications, and perceptions of environments and related issues, such as renewable energy, one can understand the actions and behaviors that affect these environments.

Behavior, on the other hand, refers to how individuals or groups interact with their surroundings and resources. Both overconsumption and misconsumption seem to be the guiding behaviors, seen in many societies, that lead to energy crises, as the issue of resource scarcity seems to be on the rise at a rate unlike what we have noticed in the past (Princen 2002). However, technology seems, to many individuals, to be the answer for many of our resource scarcity problems. Clear links have been found between technology and environmental conservation behaviors; as the former increases, the latter seems to decrease (Wray-Lake et. al. 2010). This link is stronger in younger individuals, possibly due to their faith in technology and the instant fixes that it may generate. Social-individual acceptance, in this case, may be driving environmentally-conscious practice (Wüstenhagen et al. 2007). Literature can affect ones behavior towards the environment as well. Portrayals, ideas, and arguments regarding the environment can mold one's attitude, in turn influencing behavior. This is relevant to renewable energy sources and systems, for they are currently in the smallest percentage of use globally. Is this due in part to environmental attitudes and behaviors, or is it a simply an energy-economics dilemma?

Barriers to Adoption

In order to successfully utilize AES, it is essential to be able to make an easy transition from one's previous energy system. If this can occur, many of today's environmental concerns, such as resource scarcity, environmental degradation, and excessive carbon dioxide emissions, could be lessened. However, a variety of challenges arise when attempting to adopt a new energy system. These challenges of implementation are defined as barriers. The barriers to adopting AES occur in a variety of forms within commercial, industrial, and residential sectors. While the commercial (12% in 2011) and industrial (51% in 2011) sectors contribute to a fair portion of energy consumption, it seems to be the individual consumers within the residential sectors (18% in 2011) that feed the system that allows for the high rates of consumption seen in the other sectors (Ahlborg and Hammar 2011; Hirst and Brown 1990; Pachauri and Jiang 2008; Sovacool 2009; U.S. EIA 2013). Suppliers of goods and services in industrial and commercial sectors will react to the demand of consumers through economic incentive. Thus, it is appropriate to look at the household level, as understanding what holds consumers back from adopting AES may be key in changing how both industrial and commercial sectors consume energy.

Major barriers to adopting new energy systems arise and are outlined by various academics. Socio-political acceptance (broadly policy and technology in the social world), community acceptance (the acceptance of siting decisions and energy projects led by local stakeholders), and market acceptance (the process of market adoption of an innovation) are the three major types of social acceptance affecting implementation, as defined by Wustenhagen et. al. (2007). Sovacool (2009) argues that the barriers to adopting renewable energy systems and lifestyles come from cultural and institutional factors, rather than engineering and scientific factors. Comfort, freedom, control, trust, social status, ritual, and habit are the psychological factors that Sovacool (2009) believes inhibits new energy system adoption in America.

The barriers to adopting AES in the residential sector differ slightly from that of the commercial or industrial sectors. Five broad categories seem to appear in literature surround the barriers to adoption alternative energy systems within the residential sector: 1) financial/economic, 2) awareness and information, 3) technical barriers, 4) institutional and regulatory barriers, and 5) behavioral barriers (Ahlborg and Hammar 2011; Dias et al. 2004 Painuly 2001; Reddy and Painuly 2004; Sovacool 2009; Wüstenhagen et al. 2007). Financial/economic barriers refer to one's capacity to purchase and maintain a particular energy system (ex: upfront costs of solar panels). Second, the difficulty of obtaining knowledge regarding AES may overwhelm an individual, thus forcing them to resort back to the use of a simpler, easily accessible energy system. Technical barriers refers to the risk(s) involved in installing and maintaining a specific energy system. For example, the general majority of the public has little knowledge on how to install and maintain a solar panel. Forth, there may be a lack of policy and/or government action surrounding alternative energy systems in terms of involvement, thus creating an institutional or regulatory barrier. Finally, individuals face psychological challenges such as resisting change and having constraints on time, money, attention, and ability to process information regarding alternative energy systems (Reddy and Painuly 2004).

To explore the connections between the barriers to adoption AES between two different regions, I will examine various indirect and direct relationships that the residential sectors of each region have. Indirect relationships tend to be those that are less tangible and easier to transition to with the use of currency. An indirect relationship to an energy system would be the act of purchasing wood or gasoline to fuel a stove or vehicle, rather than harvesting the energy source itself. In this sense, there is little physical nor mental recognition with the energy being consumed. One simply can pay a fee for energy without seeing the externalities of their actions. Direct relationships, on the other hand, are much more intimate. They force the consumer to feel a physical (and possibly emotional) connection with the energy system at hand. Both physically gathering wood for a stove or installing and maintaining a solar panel would be considered direct relationships. Through the use of indirect and direct relationships, the barriers to adopting AES in two very different regions, Swaziland and Portland, can be related.

Case Study I- Swaziland

From May through July 2013, I spent my time studying abroad in Swaziland through the Lewis & Clark overseas program. Here, I was able to conduct research on a variety of topics, personal and academic. Being situated in the Ezulwini Valley, a peri-urban region between the two major cities of Mbabane and Manzini, allowed me to see both rural and urban sides of the country. During my stay, I worked on an independent study titled "The Barriers to Adopting New Energy Systems: Fuelwood in Swaziland." For this study, I investigated the barriers that may be preventing households back from implementing more efficient energy systems. The primary new energy systems of inquiry were insulated stoves that could act as a heater and allow for a more efficient use of fuelwood, the main source of energy for most Swazis. In order to understand the context of the situation, however, I must paint a broader picture regarding the energy agenda in this region.

In many parts of sub-Sahara Africa, biomass is the primary energy option to heat a house and cook for a family. Hammond (2007), in particular, claims that 95% of sub-Saharan Africa relies on biomass fuel for just these purposes. Further, less than 30% of households in the East African Community use Liquified Petroleum Gas (LPG) or improved cookstoves (using biomass), Senegal has only about 20% of the population using LPG, while Ghana, Mali, and Niger are using less than 10% of LPG or improved cookstoves (EAC 2006/07; ECOWAS 2006; GOG 2006). Biomass can be separated into two categories: solid fuels such as wood and charcoal, and liquid fuels including ethanol, biodiesel, and straight vegetable oil, however fuelwood is the most popular source for energy (Arnold et al. 2006). Fuelwood, an unregulated natural product in most parts of Sub-Saharan Africa, is free of charge to collect which reinforces a reliance on the inefficient and outdated energy system of wood-burning open flames.

It is important to note, however, that while fuelwood may be a free source of energy monetarily, it is very costly in terms of time and the physical energy required to retrieve it. Both time and physical output are becoming more of an issue due to increased degradation, unsustainable harvesting practices, and massive land clearance for agricultural purposes (Warwick and Doig 2004). These factors combined have been increasing the distances in which households will have to travel to access biomass energy. Further, the use of biomass as a fuel source in sub-Sahara Africa is projected to increase in the next few decades, due primarily to population increase, which will prove to be a struggle for locals as the surrounding trees and fuels become increasingly scarce (Brew-Hammond 2007).

Not only will reliance on fuelwood as an energy source become increasingly difficult, but negative health effects have been on the rise as well. Today, smoke kills more than malaria. Being surrounded by smoke due to sustained wood burning in an unventilated, contained area can contribute to a range of illnesses and diseases including acute lower respiratory illness, bronchitis, lung cancer, asthma, tuberculosis, low birth weight, infant mortality, and cataracts (Doig, Warwick 2004). Therefore, an obvious solution to leading a healthier life would be to reduce the chance of encountering smoke. Switching to cleaner fuel, such as liquid petroleum gas, kerosene, or biogas is the easiest and first step; but, the vast majority of people using biomass or woodfuel do not have access to this type of cleaner energy due to economic instability.

A variety of reasons may hinder a household's switch to AES in this region. The use of modern energy systems, such as the efficient yet very cumbersome Libhubesi "Lion" Stove- one of the most popular AES in Swaziland- (see figures 4 and 5, bottom right), or solar panels, do not agree with traditional family methods. Also, due to possible economic handicaps in these regions, many families cannot afford the most efficient energy systems. Electricity, for example, is gaining relative popularity in many households; however, the high costs involved in extending electricity-transmission and distribution lines are causing households to rely on their primary energy systems- fuelwood-burning, open-flame fires (SEA 2012). Lack of communication and access to knowledge regarding AES has also allowed households to become disengaged in outreach. Zooming in, the landlocked, last standing true monarchy in sub-Saharan Africa, Swaziland, is currently experiencing an energy crisis within the residential sector. Unfortunately, there does not seem to be a stable transition in sight.

Figures 4 and 5: Efficient stoves listed in a pamphlet produced by the Swazi government

Swaziland, while undertaking various energy related issues, has a strong, yet complicated, future energy agenda in regards to system adoption. The main energy sources used in Swaziland consist of the following: petroleum products (petrol, diesel, paraffin and liquefied petroleum gas, solid fuels (such as coal), electricity, and biomass (SEA 2012). National energy security and development is limited due to the high dependence on electricity and petroleum imports namely from South Africa (SEA 2012). Of these, biomass, specifically fuelwood, is struggling for continued use at a sustainable level.

Due to the country’s high population growth (see figures 5 and 6), however, reliance on this slowly-produced energy source is an issue. The Swaziland State of Environment Report (2012) claims that, “An over-reliance on wood fuel in rural areas has seen these resources diminish to such an extent that it is now a serious problem to collect firewood in some areas” (159).

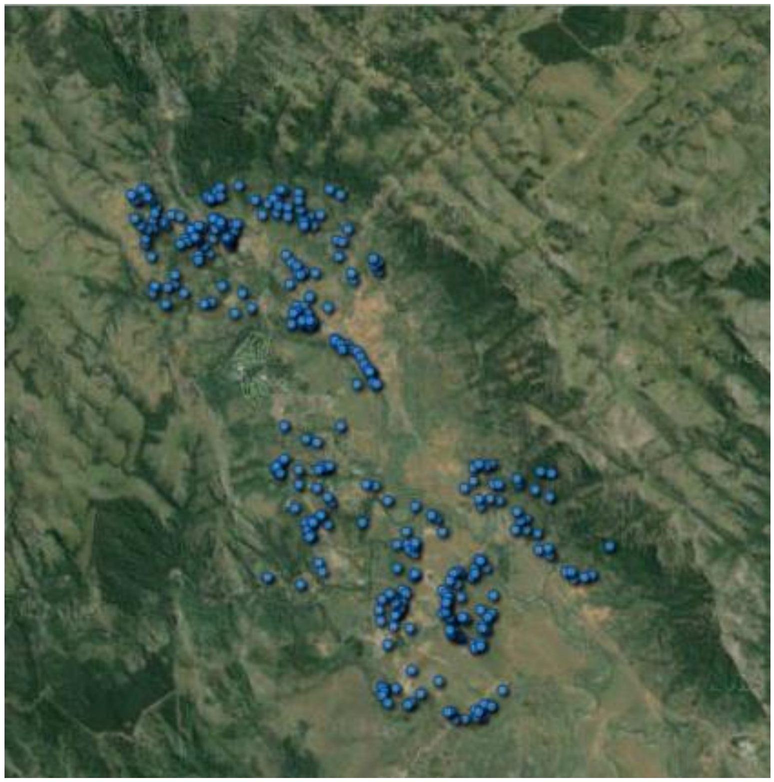

Figure 6: Ezulwini Valley settlement, 1972

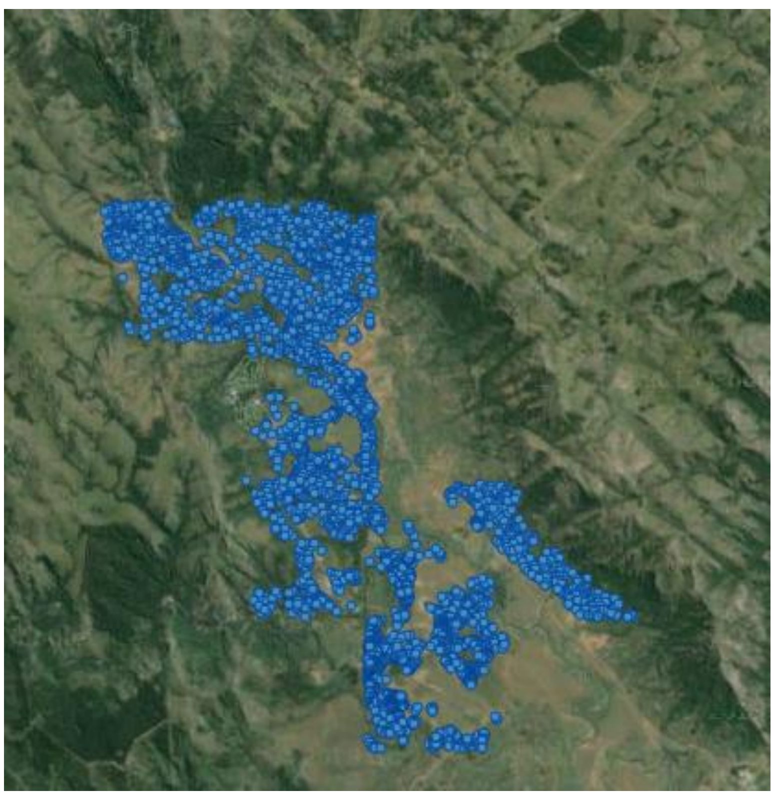

Figure 7: Ezulwini Valley settlement, current day

In attempts to combat the declining abundance of fuelwood, the Program for Biomass Energy Conservation (ProBEC) is attempting to help implement an efficient, sustainable type of wood-burning stove for households in mainly rural Swaziland. The program would decrease the pressure and degradation on forests and woody areas across all of Swaziland, increase the efficiency and safety of energy use for households, and provide economic benefits for all parties involved. It is important to note, however, that little-to-no data exists regarding both national fuelwood use and forestry status (Dladla 2014). Considering the rapid degradation, the poor on-site management, and the lack of adoption of modern energy systems, the future of Swaziland's environment and people in regards to sustainable energy use in the residential sector may be at a tipping point.

The Ezulwini Valley, a peri-urban sector between the two major cities Mbabane and Manzini, is a quickly developing area in which major energy innovations are currently being investigated due to the extreme level of forest degradation. Energy use here and in the surrounding communities is centered around the classic open-flame, high-output fuelwood energy system. Electricity is becoming popular in these areas, but again a lack of economic stability in many rural households restricts use on a large-scale. It is apparent that a variety of barriers to adopting AES exist in these areas. For example, there are strong cultural ties to the traditional way of cooking in rural Swaziland, such as being outside with an open flame over three-legged stoves, that have been passed down from generation to generation. Economically, there is little to no incentive for some to make an expensive switch of stove-types when fuelwood is abundant. Yet it is obvious that this is not the case in most parts of Swaziland, where woody vegetation used for energy has been over-harvested. Some communities in the Ezulwini Valley are forced to travel up to 4 kilometers, generally up steep slopes carrying heavy loads, in order to gain access to an energy source (see figure 8). This happens weekly, if not daily. The Ezulwini Valley, along with the four major communities of Ezulwini, Mlindazwe, Lobamba, and Mahlanya, provides a situation in which new fuelwood-based energy systems can be investigated for the benefit of Swaziland as a whole.

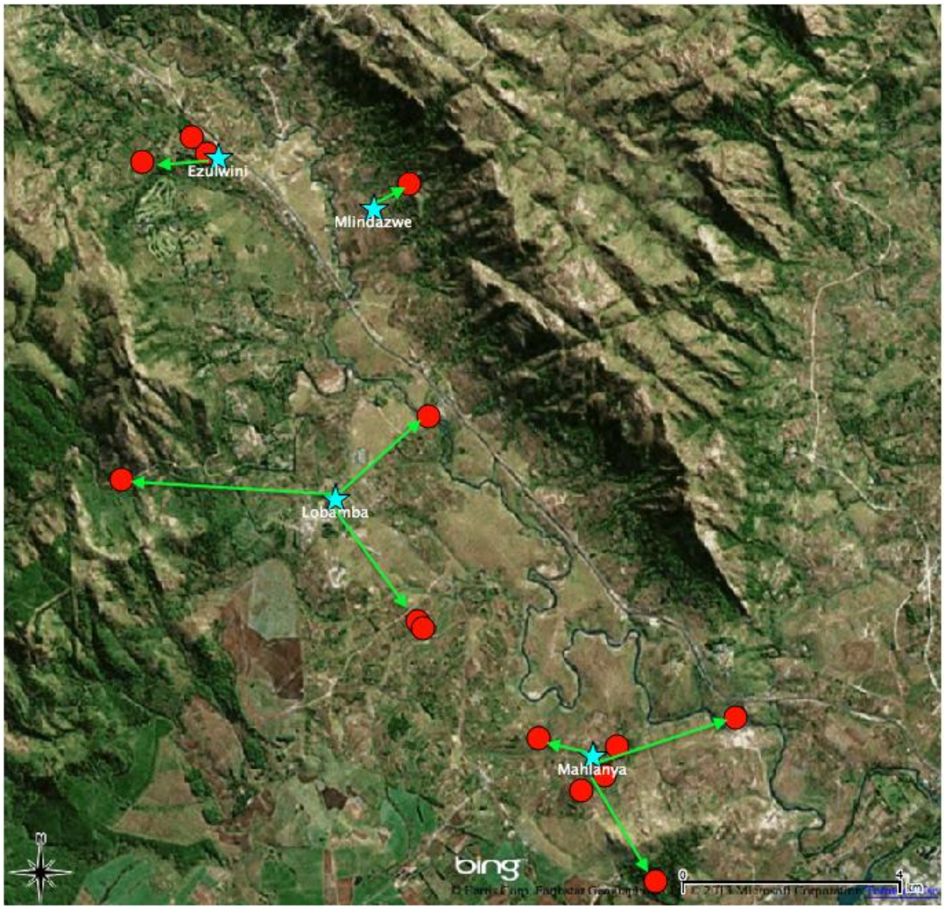

Figure 8: Distances (km) to fuelwood harvest source-points (red) from major communities (teal) in the Ezulwini Valley

Methodology

While in Swaziland, I spoke with various federal experts in the fields of energy, sustainability, forestry, and environmental health. These expert interviews were informational and informal, allowing the conversation to be free-flowing and comfortable. I prepared a series of general questions beforehand that were used to transition to deeper, concentrated subjects. The questions also allowed the subjects to give their perspectives on personal issues. Coming as an outsider and being introduced into a culture that I had very little experience with, I felt that it was inappropriate to record what was being said. I spoke with individuals on the prospect of being recorded, however the majority felt uncomfortable with the idea. Thus, I brought my computer to every meeting and took notes as thoroughly as possible given the situation.

My most significant contacts were Ms. Nombuso Olamini with the Ministry of Natural Resources and Energy, Nxumalo Dlamini and Nhlanhla Dlamini with the Forestry Department, and Issac Dladla with the Swaziland State of the Environment Authority. I met with all in the government sector of Mbabane throughout the months of June and July 2013. I also spoke with Ms. Thabile with New Dawn Engineering and Mr. Mamba, principal of KaSchiele High School; however, these last interviews were purely conversational.

Field reconnaissance data was achieved through personal action, as well as with the collaborative Environmental Health Assessment (EHA), or the "Household-Scale Environmental Health in the Ezulwini Valley, Swaziland" (Proctor et al. 2014), of the Ezulwini Valley that all students helped with on the Swaziland abroad program. Students surveyed 210 households in the four communities of Lobamba, Mlindazwe, Mahlanya, and Ezulwini, focusing on the household environmental health of four key sectors: energy, drinking water, solid waste, and human waste. Students, with the help of translators, surveyed households in small teams of 2-4 using an iPad Mini to record responses. Fulcrum, a mobile surveying application, was the primary method of survey creation and response storage. Figure 9, below, shows the assessment sections of the EHA:

Section	Content
Pre- Survey Information	Survey location, reference number Economic class surrogates Respondent age/gender
Household General	Settlement duration Number of minor/adults Most important issues
Drinking Water	Sources Treatment Quantitative/qualitative adequacy Notes/recommendations
Household Energy	General energy sources Cooking energy sources Fuel wood cooking method/location Cooking energy adequacy Notes/recommendations
Solid Waste	Disposal locations Community adequacy Notes/recommendations
Human Waste	Sanitation facility locations Community adequacy Notes/recommendations

Figure 9: Assessment sections of Ezulwini Valley Environmental Health Assessment (Proctor et al. 2014)

The data relevant to my research concerns household energy use. We assessed: general energy sources, cooking energy sources, fuelwood cooking method/location, cooking energy adequacy, notes/recommendations.

Apart from the EHA, I found local fuelwood harvest point sources with the help of locals from within the four communities. After asking where households get their fuelwood energy from, I was then led to the point sources by foot. If it was too far to walk or drive to, however, I would ask for a general estimate for direction, location, total transit and harvest time, and perceived adequacy of source levels. Those who purchased their fuelwood from street or market vendors (while personal harvesting of public fuelwood is legal, the vending of it is not) were recorded, but such markets were not considered point sources. I geolocated all major local sources of fuelwood harvest using Fulcrum.

Using ArcGIS, I was able to map every major fuelwood harvest point source in the Ezulwini Valley region. I then located community centers and produced distances to the point sources. I was thus able to see and calculate how far community members had to travel and how long it took in order to obtain their primary source of energy.

Results

Sociocultural Barriers

Sociocultural barriers are the most significant barriers in holding Swazi households back from adopting AES. Ingrained traditional ways of life may be inhibiting the adoption of new, highly efficient stoves such as the Lion "Lubisi" Stove. The classic, open-flame method of cooking is a strong part of traditional Swazi culture, upon which most rural and many urban homesteads are centered (figure 10). Because these pots and methods have worked for years and been passed down from generation to generation, there is little incentive to switch to a new, unfamiliar energy system. Swazis are also typically not a migrant people, meaning that social and community values and practices tend to stay constant throughout many generations, leading to equally consistent energy system use. By keeping a tight, local culture, there seems to be little incentive, neither from outside nor inside the community, to change their current ways of life. This disallows the penetration of government AES programs.

Figure 10: Iron pot over a fuelwood-burning flame

As stated and explained by many of my interviewees, Swazis, keeping consistent with human psychology, will tend to follow certain societal norms. If most of the households within a local community are using a certain energy system, open-flame for example, people may be marginalized if they are seen using a different energy system than others. Word of mouth is also a strong factor in household energy system adoption. Not only did most of my interviewees speak of social skepticism being a factor, but my conversations with locals have also proven that Swazis are skeptical that AES will actually live up to their promise. Many times in my conversations with locals, Swazis have asked the questions: "After spending much money on purchasing a new stove, how much money will it really save me in the end? And, will it save me money too slowly to matter? Will the new stove last as long as my old one has, or will it need to be replaced in a few years?" Also, due to the slower rate of social communication throughout the country, past energy systems seem to stick around for longer.

Finally, social-psychological barriers may play a large role on the issue at hand. Because of the strong cultural ties, trust, and tight-knit communities in Swaziland, rumors and superstitions can spread easily. I have found that superstitions surrounding the physical appearance and processes of newer energy systems tend to receive a negative reputation. For example, the extreme reflective properties of solar panels, as explained by a subject, seem to turn some Swazis off to the thought of permanently installing one onto their house. Rumors that company-created AES may be seen as falsely advertised, possibly bringing negative energy into one's household have spread. One's perception, whether it be positive or negative, of an energy system can also affect the adoption of one. Lastly, certain technologies, such as open-flamed cooking methods, can be seen as an "in" energy system, dissuading the adoption of AES. Thus, there is less of an incentive to switch to the more efficient, but less socially acceptable energy systems.

Political-Community Engagement

In Swaziland, just about everything moves a bit slower. It Political-Community Engagement is simply a way of life to not hassle about definite times, and I often found myself waiting much more than I would in the states. While this is neither positive nor negative, the relaxed culture does seem to lead to slow political and community movement when dealing with important issue. Many of the officials I spoke with agree.

The purchasing of fuelwood in Swaziland will soon become an issue if there is no government or community regulation on amounts being purchased and locations being harvested by the vendors. As of now, the strongest program to help implement an efficient, sustainable type of cooking stove for households is the Program for Biomass Energy Conservation (ProBEC). This program would decrease the pressures on local forests by offering households efficient stoves at either low prices or initially free with a very lenient monthly fee (until paid off). In turn, ProBEC would be able to decrease energy pressures on the majority of Swazi households and Ms. Olamini, Nxumalo Dlamini, and Nhlanhla Dlamini agree. However, no serious push has yet come from the government in attempts to successfully spread this movement on a large scale.

Finally, the Swaziland government does not yet seem to have a unified position on such things as sustainable, alternative, or renewable technologies. While interacting within Swaziland's government sector, I found that communication was not always successful across departments. For example, individuals within the energy departments had different views and action plans regarding ProBEC subsidies than those in the forestry departments. Because of this disagreement, a lack of momentum was also found in the push for increasing Swaziland's energy efficiency. During my time in the government sector, I heard talk of programs such as ProBEC, but never did I see or hear anything of a strong action plan.

Awareness and Information

Without political or unified community engagement, a lack of awareness and information regarding AES seems to be a realistic concern. Education programs should be implemented in order to inform and teach individuals and households how to use, fix, and maintain new technologies within their households. Energy system education, currently absent, must be locally available and households must be able to easily travel these areas to gain access to current issues and trends surrounding energy issues. If outside education and information is absent, communities will most likely keep consistent with their current, unsustainable practices.

The limited amount of data in regards to forestry and AES may prove to be hindering the adoption of such systems as well. Current forestry data in Swaziland is, at best, only estimates (Dladla 2013). There has been a push to increase awareness and coverage of the true status of Swaziland's natural environment. There is also limited records regarding amount and type of stoves sold, to whom, and to where. Many of my interviewees believe that if vendors of AES started tracking demographic and regional data to whom they provided to, a better picture could be painted in terms of use and distribution within the country. Finally, retailers are reluctant to stress this data for it may sway customers from buying their products.

Economic/financial barriers seem to be one of the least significant barriers of adoption. When questioned if individuals would purchase AES (the Lion stove, in many cases), most said they would for not only was it apparent that degradation was happening, but it was clearly understood that a more efficient energy system would help these households in the long run. Because a single household provides shelter and comfort to many generations, the adoption of AES could sustainably cater to the future needs of many.

Case Study II- Portland, Oregon

Portland is considered to be one of the more environmentally-conscious major cities in the United States. The city has had a history of seeking innovative solutions to energy use and production problems, especially in the cases of efficiency and renewable energy, dating back to the 1970s (Rutland 2008). Various policies, such as the 1979 Energy Policy, 1990 Energy Policy, 1993 CO2 Reduction strategy, 2001 Local Action Plan on Global Warming, and the 2007 Peak Oil Task Force Final Report, have been adopted in attempts to make the city more energy efficient and less polluting (Portland Plan 2009). The city itself had, in 2007, the highest percentage of bicycle commuters in the nation (Portland Plan 2009). Portland, however, has energy problems of its own.

While Portland is tending towards a greener future, the city is still heavily reliant on fossil fuels as an energy source. Figure 11 depicts the percentage of energy use by fuel source in 2007:

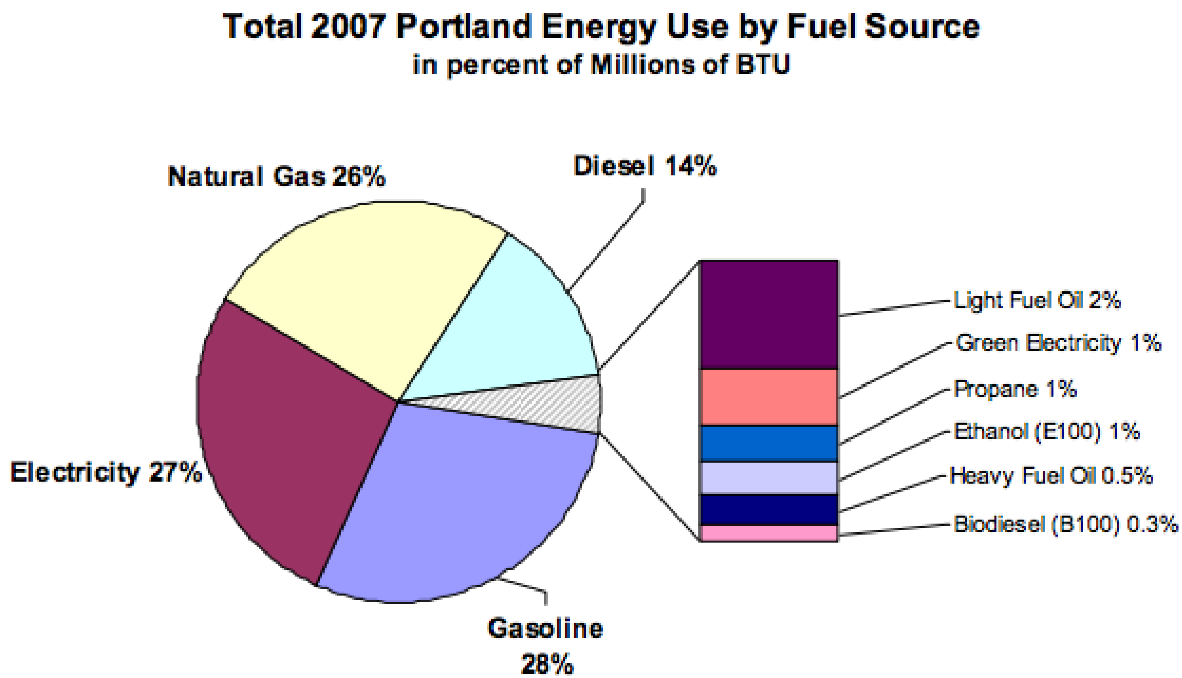

Figure 11: Total 2007 Portland energy use by fuel source (Portland Plan 2009)

While depicted as a fuel source in the above graph, electricity is actually a converted energy from other sources. The fuel sources of electricity in Multnomah County, the major Oregon county that Portland is located in, are depicted below:

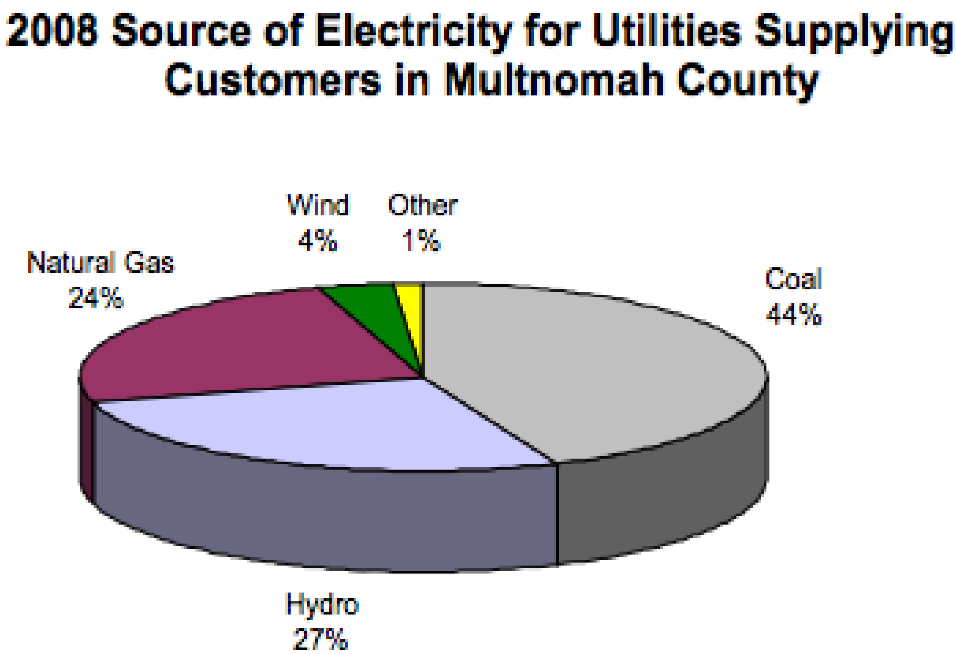

Figure 12: Sources of fuel going into electricity production (Portland Plan 2009)

One can easily see that the majority of Portland's energy comes from fossil fuels. Almost all of Portland's fossil fuel energy is imported from outside the state, hindering the city's economic growth by forcing reliance on external markets. If energy could be created completely within the city and its limits, direct energy sales would benefit Portland economically. Unfortunately, this is an unrealistic goal. The city, however, is currently working on solutions to be able to become more stable in the energy sector. Because there is currently no ultimate solution to replacing fossil fuels as an energy source yet, it is necessary to focus on creating a system that is flexible and more resilient when dealing with a reliance on these current, environmentally-harmful energy sources.

Residential energy use in Portland has seen sharp increases in the past decade, without any significant transition to AES. From 1999-2009, the cost of heating, cooling, and powering Portland's buildings had nearly doubled (to $750 million per year in 2009), largely due to increased energy costs that are projected to rise further (Portland Plan 2009). About one fifth of Portland's community carbon emissions results from the fossil fuels used to produce electricity, natural gas, and fuel oil consumption within buildings (Portland Plan 2009). The amount of carbon emitted could be reduced with the adoption of AES, such as solar panels, but no significant results have been achieved. The adoption of AES within households may provide Portland with a more energy-efficient and independent future.

With transportation alone contributing to roughly 40% of all greenhouse gases, it is no surprise that a transition to less polluting and more efficient transportation systems is necessary for a sustainable future. Efficient and/or hybrid cars can be considered AES, as they decrease negative impacts on the environment while increasing energy efficiency. The purchase and use of hybrid (and electric) cars in the Portland area has been staggering in comparison to most other major cities in the United States. In 2011, Portland had the highest number of hybrid electric car purchases in the nation at 8.8 hybrids per 1000 households, with Helena, MT and San Francisco, CA, tied for second at 6.7 hybrids per 1000 households (Statistic Brain 2012). The U.S. Metropolitan area average was a meager 1.8 hybrids per 1000 households in the same year (Statistic Brain 2012). Thanks to the city's substantial use of hybrid cars, many of Portland's proposed Climate Action Plan goals can be achieved by 2030:

> 1) "Create vibrant neighborhoods where 90 percent of Portland residents can easily walk or bicycle to meet all basic daily non-work needs and have safe pedestrian or bicycle access to transit", 2) "Reduce per capita daily vehicle miles travelled (VMT) by 30 percent from 2008 levels", 3) "Improve the efficiency of freight movement within and through the Portland metropolitan area", 4) "Increase the average fuel efficiency of passenger vehicles to 40 miles per gallon and improve performance of the road system", and 5) "Reduce the lifecycle greenhouse gas emissions of transportation fuels by 20 percent"

While policy may be moving in the right direction, other barriers surrounding Alternative Vehicle Technologies (AVT) exist.

By switching to more efficient modes of transportation, pollution would be shifted from the city center to external power-plans, improving human health within the city. Electric Vehicles (EV), while indirectly producing air pollution at off-site power plants, are considered zero-emission vehicles because of their pollution-free motors. They can be charged via outlet at home or where provided. Most Electrical Vehicles (EV) makes have a 35 MPH limitation and cannot drive for more than a few hours. Unlike EVs, Hybrid Gas-Electric Vehicles have the power, endurance, and convenient fueling of purely combustion engines. They need not be plugged in and can use alternative sources of fuel such as biodiesel or ethanol. While Portland has a good reputation for acting efficient and renewable in the energy sector, various challenges arise when attempting to transition to truly sustainable energy systems.

Methodology

Research in Portland was conducted from January 2014 through April 2014. To keep consistent with my research in Swaziland, I used similar methods to gather data. These methods can be broken up into the two main categories of expert interviews and surveying.

In Portland, I found it much harder than in Swaziland to get in contact with experts in the field. I came into contact with individuals from sustainable architecture, household, and building companies such as Cascadia Green Building Council, as well as the major electric utility provision company Portland General Electric. The interviews I did have, however, were always through the phone and conducted in a similar manner to those in Swaziland. I prepared broad questions beforehand that would naturally lead the discussion in the direction that I desired. While the interviews were not recorded, I was able to document the majority of the information conveyed. Personal information has been kept confidential due to request.

The majority of my conclusions come from survey data. I developed a survey modeled on that of Reddy and Painuly (2004) and did not target surveys geographically. My surveys were conducted using the Fulcrum application in various areas throughout Portland, such as the downtown area, Hawthorn Boulevard and 39th street, Mount Tabor, and Sellwood. I asked individuals about their perceptions of barriers to adopting AES on a numbered scale system. Individuals were questioned on three different AES: the PGE "green switch" option, solar panels, and alternative or efficient cars. PGE's "green switch" option allows consumers (households) to choose to pay a small increased amount on their monthly electric bill ($0.008/KwH, about $6-$8 a month more) in order to have the majority of their electricity come from renewable sources such as hydropower. I have considered this AES as an indirect relationship, for individuals only have to pay an increased amount, while never having put forth any intimate physical or mental effort. Solar panels, on the other hand, provide a much more intimate relationship by having individuals see the direct effect of their installed energy system. The installation, appearance, and contribution of solar panels to a household makes for a direct relationship. Efficient cars can be considered to have both direct and indirect relationships to consumers. While individuals rarely deal with most technical and mechanical issues involved in car maintenance (lessening an intimate connection), the physical aspect of this AES is noticed every day it is driven.

Using a 1-5 scale (1 being least significant barrier, 5 being most significant barrier) I proposed the following broad barriers: 1) Economic/financial barriers, 2) Awareness/informational barriers, 3) Technical risks, 4) Government/community engagement barriers, and 5) Sociocultural barriers. While surveying, I defined each barrier in a fashion that could be easily understood by the public.

Results

Results from data collection in Portland indicate that "Economic/financial constraints" is the single-most significant barrier to adopting AES, with "Government/community engagement" coming in second place. About 50 individual surveys were gathered. Results from both survey data and interview data were consistent in their conclusions. Below is a table depicting the mean averages of each response group and the total averages for each barrier, as well as a graph visually depicting this information:

	PGE's "Green Switch" Option	**Solar Panels**	**Efficient Cars**	**Total Averages (in significance)**
Economic/Financial Constraints	3.21	3.85	4.25	3.77
Lack of Awareness	2.38	2.40	1.94	2.24
Technical Risks	2.13	3.48	3.42	3.01
Sociocultural	2.02	2.75	2.83	2.54
Government/Community Engagement	3.25	3.58	3.38	3.4

Figure 13: Respondent perceived level of significance of barriers to adopting AES (mean)

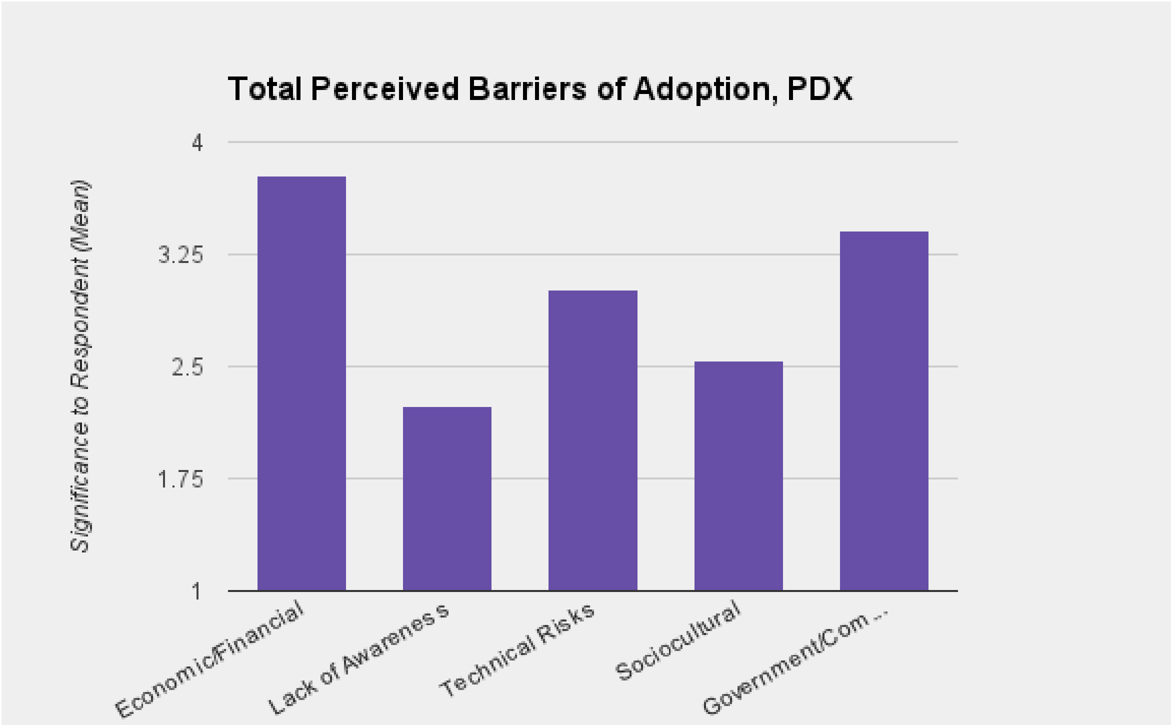

Figure 14: Respondent perceived level of significance of barriers to adopting AES (mean)

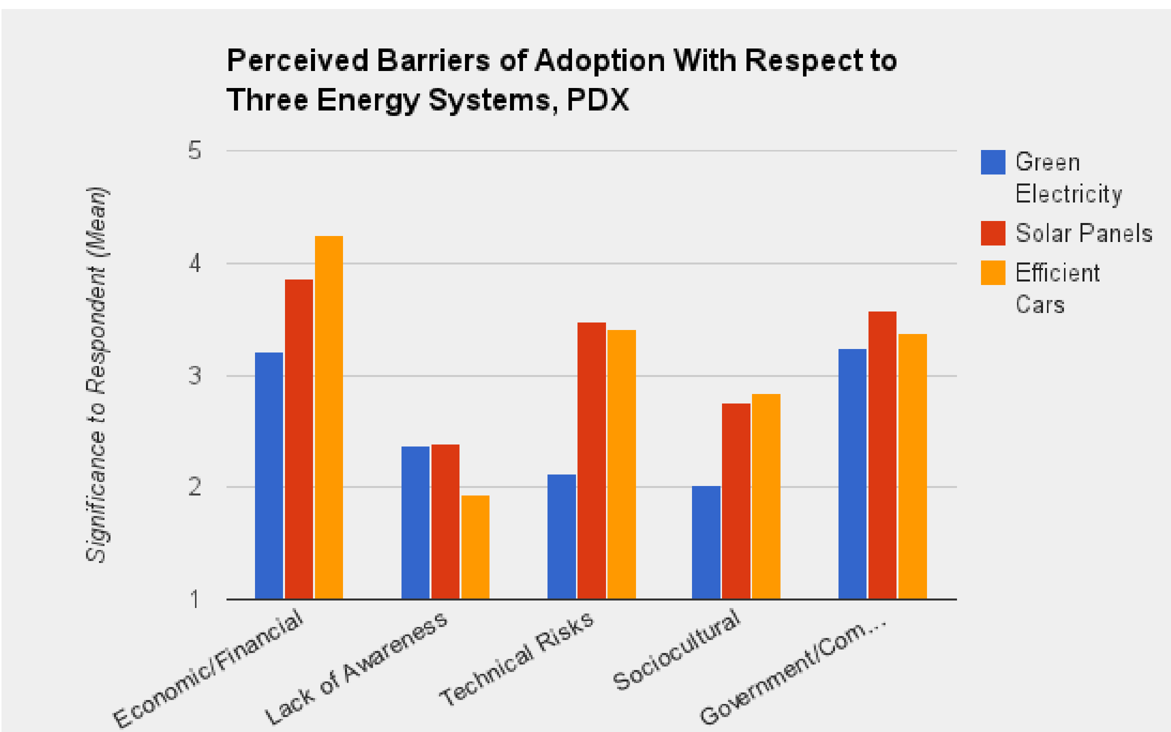

Figure 15: Respondent perceived level of significance of barriers to adopting AES (mean)

Expert interviews proved to be a supplement to the survey data gathered, fortifying the results. All individuals interviewed made definite claims that economic/financial constraints are the predominant barrier of adopting AES.

Discussion and Broader Implications

Due to the slight diversity in data gathered within Swaziland and Portland, results were presented in differing ways. That is, data gathered in Swaziland was much more vocal, text-based, and strongly dependent on expert interviews, while in Portland it was the opposite with survey data providing more quantitative results. However, many conclusions can be discussed from the data gathered. In the coming section, I will flesh out the various discrepancies and differences within each region, as well as provide possible prescriptions for an easier transition to adopting AES.

The data reveal that both Swaziland and Portland face challenges in adopting AES. However, the most significant barriers differ by region. In Portland, it is clear that the "Economic/financial Constraints" is the leading barrier to most households. This is due to a possibility of reasons of which I outline next.

It is rare in Portland to see one's energy-use impacts directly, especially in comparison to Swaziland. Most of the energy systems that are present in the city run strictly on fossil fuels as the major energy source, making it difficult for households to see the relationship that their energy use has with both local and global environments, as an externality of fossil fuel consumption is invisible to the naked eye. Therefore, it is common for households in developed, urbanized nations and cities, such as Portland, to use similar methods in attempts to alleviate such externalities. Most household solutions to increased energy efficiency foster invisible results (a decrease in carbon dioxide emissions, for example). However, it is common to see financial input as a solution to decreasing negative energy-use externalities. Households are told that the more they pay for efficient energy systems, such as a higher electricity bill for "green electricity" or a more expensive, but more efficient car, the less that their energy-use is negatively affecting the environment. It seems that in the eyes of energy consumers in PDX, economic agendas are the only way to decrease their carbon footprint, while increasing their energy efficiency.

In Swaziland, on the other hand, a negative externality of energy use is recognized every day. The more energy that households consume, the more their local environment is visibly being degraded. A solution would be to adopt a more efficient way of using fuelwood, however the new AES simply do not fit in with Swazis current way of life. Firstly, an unfamiliar, cumbersome stove would rarely fit in a typical, compact Swazi house. Second, there are currently no education or outreach programs to inform Swazis about the possibilities of AES. Finally, while Swazis to recognize a problem, their current system is working for them, so why change now?

All of these complications are not an issue for households in Portland. People know that AES exist and are available and most AES will not alter one's way of life nor would it cause a sense of uncomfortable unfamiliarity. Switching to green electricity, for example, physically alters nothing within a Portland household. It only affects one's wallet.

In Swaziland, economic or financial barriers are far lower on the list, according to both officials and the public. Sociocultural barriers are leading the challenging in adopting AES. Significant factors contributing to this may be: 1) cost of living is much lower in Swaziland, 2) cost of AES implementation is much lower as well, and 3) Swaziland's cultural practices are far different than those within Portland. Below is a list of concerning factors that discusses possible prescriptions and issues that must be looked into further.

Swaziland

Based on the interviews I have had in Swaziland, it seems that a "one-takes-all" approach is the primary method when dealing with AES adoption. ProBEC, for example, is in place to promote the purchase and utilization of energy efficient stoves. However, this program does not put the differing aspects of each household into perspective. Some households cannot fit the new, larger stove into their home due to a lack of space. Others seem to have issues implementing a new system into their lifestyles, proving that a sociocultural barrier is in place. Another case may be that households prefer to manually harvest fuelwood, rather than paying for new stoves or purchasing fuelwood from privately owned source points. ProBEC seems to lump the desires, needs, and complications of rural and urban Swazi households into one vague grouping, of which have the characteristics of: strong traditional ties that serve as a barrier, economic handicaps, and little consideration/concern for the environmental pressures on their fuelwood sources in regards to future sustainability. Thus, I feel that a system of directed action groups must be implemented in order to fully reach out to all Swazi households and communities.

To assist in the implementation of AES, interest groups may be helpful. ProBEC, for example, is being pushed only by the Ministry of Energy. I feel that community engagement would be a far better vehicle in adopting AES. Government groups alone cannot force new energy systems onto a society that has deep cultural ties without the help of community organizers or possibly grassroots organizations. If there were grassroots organizations working with the Swazi government, however, an easier and quicker transition may be viable for the household sector.

The market for AES may be contributing to a few barriers as well. While there is a sufficient supply of AES, the demand side is what seems to be lacking; but, why is this? If it is common knowledge that AES will reduce consumption, cost, and pollution, why have sales not been able to increase, or even stay steady? Do households actually need the stoves, or is the system being pressured into their lifestyle?

If technologies are good enough, households will buy them. Throughout Swaziland, households seem to have a general knowledge that with the help of more efficient stoves, the daily stresses of gathering fuelwood would be eased. Word of efficient technologies such as stoves will spread if they are helpful and affordable (especially in short-term purchase). It seems as if the Swazi government, while being relaxed, is attempting to push these technologies into the market. There may be room for helpful subsidies on stoves, technologies, or new energy systems, but without looking into case-by-case needs it will go nowhere unless a true market desire from the buyers is present. Not only do the efficient stoves being promoted seem to be clashing with many Swazi households' lifestyles, but the way that they are being promoted, by telling households simply that they need them in order to subsist in the coming years, is currently not working. A certain level of market competition is necessary for an AES to be a social and economic option for households.

Finally, data seems to be a pressing issue in Swaziland. The lack of data in the forestry department may be holding government and other organizations, such as the Swaziland Environment Agency, from providing positive solutions. The data that is present, specifically forestry data, are only estimates (Dladla 2013). The problem with this lies in the fact that those promoting AES, whether they be government or community organizations, are clueless in where local forests have been degraded the most and where are they being degraded the fastest. In some areas, obtaining fuelwood is much less of a problem than in others, strengthening the previous argument for directed action groups.

Portland

In most developed nations, the economic policy and subsidies on fossil fuel pricing causes this type of energy to be the cheapest for all parties involved. Fossil fuel use combines ease with manipulated low prices to create energy systems that are the most attractive to the public and most societies' current energy-consumption practices. Therefore, it is no surprise that the same types of economic policy and government subsidies can be applied to energy necessary for AES. For example, if there was a government incentive or subsidy in place for solar panels that would allow consumers get returns on initial costs of investments, the idea would become much more attractive. If packaged the right way, consumers would be able to not only make a cheap transition to an AES, but also increase incentives to help local and global environments due to a decrease in carbon dioxide emissions and an increase in positive energy independence and efficiency. By reducing the price of AES, subsidies and a change in policy would smooth household transitions to AES.

Both government and community involvement in the fight to become and more energy efficient city may be hindering Portland. While there are a few campaigns to decrease energy use while increasing energy efficiency, none seem to be directly addressing the broad public. Demonstration programs, headed by possibly government but preferably local communities/companies promoting AES, seem to be necessary in order to jump start the adoption of AES. In effect, the demonstrations could show the ease of switching to AES, while also projecting initial costs that, at first, seem to be intimidating for many households. In the future, the benefits from switching to AES would outweigh the initial costs, as demonstrations would validate. Demonstrations currently exist, however they seem to be packaged in a way that focused primarily on the environmental aspects of AES utilization, rather than the economic benefits. With more community/government involvement, AES could be delivered to audiences in a more appropriate way.

The topic of energy efficiency will gain more momentum as the resources that many regions depend on slowly, and in some cases quickly, disappear. The Tragedy of the Commons (Hardin 1968) has hit hard and true as the world is now seeing massive environmental degradation, from forests, to fishers, to energy sources. Throughout history, however, humans have succeeded, and sometimes failed, in finding new way to combat decreasing sources of energy. From the transition to fossil fuels to the popular uprising of renewable energy sources, it is clear that humans constantly and frequently are changing the types of energy systems that they use.

It is clear, as explained by various academics, scientists, and scholars alike, that the level of available energy is becoming threatening. However, the vast majority of renewable energy sources, from solar, to hydro, to biomass, can have the power to fuel the world if properly put into action. In places where sun is abundant, solar panels can see success if introduced, implemented, and maintained in a manner that keeps consist with the society that they are being utilized in. Where water flows ferociously, energy can see endless production if proper storage can be achieved. Although many of the slowest and hottest burning trees are usually quite lethargic in growth, highly efficient methods of burning and insulation may allow growth rates to keep up with use rates. In order for methods of sustainable and efficient energy use to come into play, alternative energy systems must be investigated further.

However, there is no doubt that challenges arise when making the transition to a more energy-efficient, sustainable society. Many energy systems, especially unfamiliar ones, clash with certain societies. Where one society sees economic challenges, the other struggles to overcome a deeply-ingrained way of life. Every case is different today, as has been every crisis in the past.

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