Spring 5-1-2011

Fueling Ukraine’s Future: Using Microfinance as a Tool for Reducing Energy Dependency and Changing Lives

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Fueling Ukraine's Future: Using Microfinance as a Tool for Reducing Energy Dependency and Changing Lives

A Capstone Project Submitted in Partial Fulfillment of the Requirements of the Renée Crown University Honors Program at Syracuse University

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and Renée Crown University Honors

May 2011

Honors Capstone Project in _______Economics________

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ABSTRACT

Ukraine is a country heavily dependent on other countries for its natural gas supply, leaving it vulnerable to interruptions in supply. One of its largest suppliers, Russia, has twice taken drastic means of physically closing the pipelines, thereby cutting off this supply and illustrating to Ukraine and the world the leverage that it can exercise. While at the present time the cut-offs have lasted no longer than a few weeks, future cut-offs could become more common and longer in duration. When compounded with the troubled history between the two countries, one can quickly see the precipitous situation that has the potential to escalate into armed conflict.

The methodology used in this thesis sought to identify a renewable energy technology that could help reduce this dependency on foreign energy. The technology must be feasible considering the climate, viable considering the cost, and efficient in the production of an alternative fuel source. Biogas plants (anaerobic digestion) were identified as satisfying all three of these conditions. These plants can use as an input any biodegradable material, but corn silage was quickly identified as the optimal input due to its low cost and high biogas yield. Rural farmers were then identified as the optimal target population for these digesters, due to their ownership of a large amount of land and having the existing infrastructure in place to produce corn silage. The annual natural gas demand of the rural farmers was found to be 4,200 cubic meters, which was used in the calculation of the size of the actual digester that would produce this exact amount of gas annually. The size of the digester was determined to be 9 cubic meters.

A financial analysis of the biogas plants then proved that this technology produced a large amount of natural gas equivalent, and also provided financial profits to those who constructed them. However, a problem soon arose. How could rural farmers be expected to afford the lump sum payment necessary for the construction of the digester?

A microfinance institution was then theorized that would provide the upfront capital to construct these plants, who would then lease these plants to rural farmers. These rural farmers would repay the lease over a five year term and would benefit from the opportunity cost from synthesizing their own fuel. A financial analysis of the borrower and the institution determined that both parties would benefit financially from the institution, with borrowers experiencing profits in year 1 and the institution achieving self-sufficiency in year 7.

The final section reports the impacts and final results that this institution could potentially have on the country of Ukraine. First, it evaluates the amount of carbon dioxide offsets generated by these digesters. Second, it values these carbon offsets by using the market price of Emission Reduction Units (ERUs) to identify a potential funding opportunity for the institution. Finally, it measures the total amount of natural gas that all digesters in operation would generate and its impact on Ukraine's importation of natural gas from foreign countries.

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ACKNOWLEDGEMENTS

While this paper has a single author's name on the title, I think all Honors students would agree that Capstone projects are very much a team effort that are enhanced by the opinions and suggestions of the people around you. In my case, I was blessed to have an absolutely exceptional advisor, Dr. Peter Wilcoxen, who somehow in his packed schedule found time to meet with me on a weekly basis (and sometimes two or three times a week). More than that though, he took a genuine interest in my topic. Every single time I sent a frantic e-mail or walked into his office feeling discouraged or defeated because I had hit a wall in my research, his innovation and ideas ensured that I walked out of his office feeling encouraged and motivated. His attitude that "everything will be fine" provided me much-needed assurance at a time when I doubted this project could be completed. I'm eternally grateful for his help.

In addition, a Reader's job may not be the most exciting volunteer position out there, but Professor Elizabeth Ashby was paramount in ensuring that my paper was readable and helped me to, at times, completely change the structure of my paper. While no one particularly likes editing and re-writing, Professor Ashby's comments transformed my paper from an 80-page document to a piece of work that I am truly proud of. I would also like to thank two Ukrainian students at Syracuse University, Viktoriya Zlamanyuk and Yuri Borovsky, whose contributions added much value to my Capstone project. Finally, last but not least, I'd like to thank Joseph Ralbovsky, an SU student whose enthusiasm and passion for microfinance inspired me.

ADVICE TO FUTURE HONORS STUDENTS

If you're reading this, it probably means you're being forced to, which means you're probably already following my first piece of advice which is to register for the Capstone seminar class in your junior year! If I hadn't been forced to come to terms with the fact that I had to complete this project, I probably would have procrastinated and my senior year would not have been nearly as enjoyable as it has been.

That's an important point: balance your time! Set aside large blocks of time (at least three hours in my opinion) to work on your Capstone weekday evenings and weekend afternoons, but don't let the stress of your research affect the rest of your senior year! Try to disconnect yourself from your project when you're not working on it and "plug yourself" back in when you sit back down to do more research.

Make sure to file your "change of address" form to 306 Bowne Hall because if you're anything like me and you have terrible wireless internet at your house, you'll be spending a lot of time there. In fact, Joe Ralbovsky and I kept track of how many hours we spent there, how many drinks consumed, and how many bags of popcorn consumed there in the spring semester of 2011 by tucking a sign-up sheet behind the utility box. See if you can beat my record of 46 hours over the course of the semester. If you have, please find me wherever I am (I imagine in the future all people will be tracked 24/7 by mobile GPS devices) so I can congratulate you on your academic prowess.

1. Introduction

"A dispute between Russia and Ukraine over natural gas turned nasty on Tuesday, as gas deliveries to a swath of European countries were cut off entirely amid freezing winter temperatures. The escalating fight, which began last week as a commercial disagreement over pricing, evoked a similar cutoff three years ago and reignited debate across the European Union over its deep reliance on Russian energy."

"The two state gas companies blamed each other for halting supplies. Russian analysts claimed that a looming presidential election in Ukraine lay at the root of the dispute, while energy analysts elsewhere cited pipeline politics and a breakdown in the basic transit contract between Gazprom and Naftogaz as likely causes" (Osborn, Chazan, and Miller, 2009).

Ukraine's strategic location, sharing its eastern border with Russia, has led President Viktor Yanukovych to declare the country the "bridge between the East and the West" (Yanukovych, 2010). BBC News reported that perhaps Ukraine's most important, and most volatile, asset is the fact that nearly 80% of all natural gas supplies that originate in Russia must physically pass through Ukraine in pipelines on their way to consumption in western Europe ("EU Reaches," 2009). Yet these pipelines present both opportunities and vulnerabilities. While Ukraine is able to charge a transport tariff to Russia that generates significant revenue, Russia has an almost unparalleled bargaining chip: agree to our demands or we'll cut off the gas supply to your country. To complicate matters further, past instances of high-level corruption and missed payments on the part of Ukraine has left Russia skeptical and distrustful of Ukraine's actions. In response, Russia has twice made good on its promise to completely shut off this supply to Ukraine.

As a result, it is imperative that Ukraine begin focusing its efforts on alternative sources of energy. Many inside and outside of Ukraine are exploring the concept of using various forms of renewable energy to achieve that goal. This paper will analyze the potential of using small-scale renewable energy projects that will be feasible and complement the country's geography and current structures. While there are numerous technologies currently being implemented around the world, this thesis will primarily focus on the potential for small-scale anaerobic digesters that would generate biogas, which is a natural gas substitute and could be used in the same heaters that Ukrainians now use. Similar small-scale biogas projects have already been implemented in Nepal, Moldova, and in countries throughout Africa, just to name a few.

The environmental impacts of reducing greenhouse gases may be obvious to the reader, but the financial impacts may not be as apparent. The production of biogas on-site from a digester would allow the owner to reduce significantly the cost of their fuel supply and become independent from others' unpredictable actions.

The construction costs of these digesters are too high to reasonably expect people to be able to afford with a down payment. However, in many cases it is also impossible for these same people to borrow any amount of money from traditional banks, due to little or non-existent credit and lack of collateral. This is where the role of microfinance can come into play as a potential solution.

Microfinance is the provisioning of credit to individuals that are not typically extended credit through traditional financial instruments. While there are numerous sources of funds in order to provide this credit, this thesis will seek to explore the "Kiva approach" which for the purposes of this paper will include a web-based portal that allows forward-thinking, environmentally-minded individuals that recognize the myriad opportunities these funds would provide to lend their money for a period of time.

In summary, this thesis seeks to answer the question, "What if it was possible to construct a project that would not only help to address Ukraine's energy dependency, but have reverberating geopolitical, environmental, and potentially financial impacts for decades to come? And if this was possible, how could it be funded in a country who, because of lack of resources, has updated very little of its existing energy technology?"

In order to answer this question, this paper will first provide background information regarding the history and geopolitical structure of Ukraine, new renewable technologies that could potentially help to replace natural gas, and the emerging international development tool known as microfinance. In section 5, the paper will then apply the historical research to the current situation by evaluating first the financial feasibility of anaerobic digestion, considering the geographic restraints of the region in which they will be constructed. Section 6 will analyze the opportunity for a microfinance institution to be created to help provide capital for the construction of these digesters, evaluating from both the borrower's (where the digesters are built) and the lender's (the institution's) perspective. Finally, section 7 will use the forecasts of growth from section 6 to illustrate the results and impacts this institution could have in the region and in the world.

2. The History of Ukraine: Leading up to the Crisis

2a. The Forging of Ukraine and Russia's Relationship

The complicated story between Russia and Ukraine begins nearly 1,200 years ago with the establishment of the Kievan Rus' state, a once-powerful medieval state that was invaded by the Mongol people and disintegrated in 1240 ("Kievan Rus," 2007). After this disintegration, Russia succeeded in uniting the northern Rus' provinces, including the territories of modern-day Russia and Ukraine that would serve as the foundation for a long and interconnected relationship for centuries to come.

For hundreds of years Ukraine remained a conquered territory, being occupied as a whole by Lithuania and Poland until partitioning by Poland split the country in half. While the Western portion of Ukraine was taken over by the Austro-Hungarian Empire, the Eastern portion was incorporated into the Russian Empire. It is important to note this early division in territory, as we will see later the effects that this division continues to have on Ukrainian society.

With the Bolshevik Revolution putting an end to the Russian Empire in 1917, one of Ukraine's occupants was defeated and Ukraine declared its independence on January 22nd, 1918 for the first time in its history ("Brief Ukraine History," 2011). Although independent, Poland's continued occupation of western Ukraine meant that Ukraine would not be unified.

According to the U.S. Department of State, the modern state of Ukraine emerged in 1922, when the central and eastern regions were incorporated into the Soviet Union and the Ukrainian Soviet Socialist Republic was officially created ("Background Note," 2010). Subjugated to oppressive and socialist programs, "the Soviet government under Stalin created an artificial famine (called 'Holodomor' in Ukrainian) as part of his forced collectivization policies, which killed millions of previously independent peasants and others throughout the country. Estimates of deaths from the 1932-33 Holodomor alone range from 3 million to 7 million" ("Background Note," para. 11). In 1939, following the invasion of Poland by Soviet and German troops, western Ukraine was annexed by the Soviet Union, uniting modern Ukraine for the first time in its history and increasing its territory by 50,600 square miles and increasing its population by over 7 million people (Subtelny, 1988). Now unified, Ukraine continued to lack independence.

Ukraine remained under this Soviet rule for nearly seventy years until the fall of the Berlin Wall in October 1989 set into motion a series of events that finally saw Ukraine emerge as an independent, unified country in August of 1991.

If we review the history of Ukraine, we see that only during two periods (from 1918-1922 and from 1991 - present) has Ukraine experienced independence. Yuri Borovsky, a Masters student at Syracuse University studying public diplomacy who was born in Kyiv and has lived in Ukraine all of his life, cites this singular fact as being a fundamental cause for the lack of nationalism in Ukraine and the subsequent complex relationship with Russia, a country who has shaped almost all aspects of Ukrainian life (Borovsky, personal communication, November 18, 2010).

Obviously, Ukraine and Russia's long territorial history translates to a plethora of linguistic, social, and cultural linkages that this paper will not explore for brevity's sake. These linkages continue to this day, but some Ukrainians look favorably towards these links as opportunities to play a mediating role with the East and the West. For example, Ukraine's current president, Viktor Yanukovych once said that, "We are a nation with a European identity, but we have historic cultural and economic ties to Russia as well. We can benefit from both" (Yanukovych, 2010). This paper seeks to explore one of the most valuable, and physical, links between the two countries: the precious natural gas pipelines that flow from Russia through Ukraine.

2b. Ukraine's Energy Dependency on Russia

Ukraine's current industrial production is a result of decades of subsidization and inefficiency, as Ukraine was one of the primary industrial producers of the Soviet Union. For example, in the post-war years of the Soviet Union, the industrial productivity of Ukraine doubled over the pre-war level (Magocsi, 1996). In addition, the rapid urbanization of Ukraine during the 1950s and 1960s dramatically increased its demand for energy.

Before the fall of the Soviet Union in 1991, Ukraine's arrangements with Russia provided for cheap natural gas to flow through the pipelines and subsidize the costs of this fuel. As a result, little effort was made to conserve natural gas and the industrial processes that were established before 1991 did not take into consideration the high inefficiency of the process (Evans, 1998). Following Ukraine's independency and its subsequent transition to a market economy, the country experienced a seven-year recession that saw its gross domestic product (GDP) fall by 68%, industrial output fall by 52% and capital investments fall by 74% (Pirani, 2007). This recession greatly affected the ability of businesses and consumers to modernize their equipment. As a result, much of the countries' domestic heating systems and industries are still heavily reliant on Russian gas imports (Osborn, 2009, January 5).

Since becoming independent, Ukraine has lost almost all of the natural gas subsidies it had previously enjoyed from Russia. Ukraine is a country that has seen the cost of its natural gas rise from $50 USD per 1000 cubic meters (cm) as late as 2005 to $250 USD per 1000 cm in 2009, a 500% increase in price over the course of only four years (Osborn, 2009, January 2). All amounts in this thesis that are dollar-denominated have been converted into U.S. dollars from the original currency at exchange rates current as of April 22nd, 2011.

While Ukraine's consumption of natural gas in 2010 has decreased approximately 39% since an all-time high of 84.9 billion cubic meters (bcm) consumed in 2008, much of this decrease is probably attributed to the global recession's impact on a decrease in manufacturing and the country continues to be the 14th highest consumer of natural gas in the world ("Natural Gas Consumption," 2009).

Ukraine's demand for natural gas remains high, while its domestic annual production of natural gas has remained stagnant at approximately 20 bcm ("Natural Gas Production," 2009). With such high consumption, Ukraine does not export any of its natural gas, but must import the difference between their domestic production and their consumption, which the International Energy Agency estimates at around 45 bcm annually. Natural gas constitutes nearly 65% of all energy imports for Ukraine ("2008 Energy Balance," 2008). In addition to this, the U.S. Energy Information Administration's *International Energy Annual Report (2005)* found that nearly 69% of all natural gas imports come from Russia directly. While the remaining natural gas may originate in Turkmenistan and Kazakhstan, Russia's state-owned gas monopoly Gazprom delivers this natural gas to Ukraine's border through a pipeline system ("Ukraine: Economy," 2009).

Yet Russia is not the only player in this natural gas relationship due to the geographical necessity for 80% of all Russian natural gas pipelines, on their way to consumption in western Europe, to run through Ukrainian territory. Ukraine officially owns these pipelines that are located within their territory and charges a tariff to Russia for the ability to transport through these pipelines. Russia has recognized their vulnerability and Ukraine's leverage in this situation and has, accordingly, begun the construction of two major pipelines named Nord Stream and South Stream that will be completed by 2015 and will circumvent all Ukrainian territory by being constructed underneath the Baltic and the Black Seas, respectively (Nord Stream AG, 2007).

With this precarious relationship adding fodder to an already-fragile region, it is easy to imagine this situation erupting into conflict, as it did in 2006 and 2009.

2c. The Well Runs Dry: The Gas Shut-Offs of 2006 and 2009

After a series of price and non-payment disputes arose between Ukraine and Russia in the 1990s, the situation escalated in May 2005, when it was discovered that approximately 7.8 bcm of natural gas that Gazprom had deposited in Ukrainian storage units had not been made available to the company. Gazprom quickly alleged that this natural gas had been stolen by the Ukrainian authorities, but the issue was resolved by July 2005 ("Gazprom and Naftogaz," 2005). However, price disputes and gas supply agreements could not be settled by the end of 2005 and therefore on January 1, 2006, Ukraine for the first time began to see the pressure in its pipelines begin to drop.

The supply, however, was restored three days later on January 4, 2006, in large part because of the logistics of the shut-off. Because 80% of all Russian gas exports to western Europe must flow through Ukraine, Russia had no way of cutting off the supply to Ukraine without interrupting important trade relationships with western European consumers.

While Ukraine had agreed to gradual price rises during the various resolutions and agreements that resulted, Gazprom argued that the rise in world gas prices necessitated larger increases in price. By the end of 2008 a price agreement had not been decided upon and the newspaper *RIA Novosti* reported that another natural gas disruption resulted on January 1, 2009, as Russia halted completely an export of 90 million cm per day to Ukraine ("Russia Fully Cuts," 2009). This interruption had the "domino effect" of affecting the supply of many European Union countries, yet the dispute was not settled after 20 days. On January 21, 2009, *Reuters* reported that Ukraine agreed to pay Gazprom the world price for natural gas with a 20% discount in 2009 and the full world price in 2010 ("Russia and Ukraine," 2009).

In order to examine the impact that these shut-offs can have in Ukraine, one must first explore the vulnerabilities of Ukraine when these interruptions occur and where the priorities of the government lie when it has a limited supply of natural gas.

2d. Domestic Impact of Interruptions in Supply

In order to hedge itself against such unpredictability in natural gas supply, Ukraine has built up substantial amounts of reserve gas in underground storage facilities (Woehrel, 2009). These reserves have been projected to serve the country's demand for a few months. Until this point, this reserve has been adequate as Russia has been unable to cut off the supply for more than 20 days, yet with Nord and South Stream coming online in 2015, Russia will be able to halt supplies to Ukraine without affecting supplies to western Europe. As a result, future interruptions in supply could last longer than Ukraine's available reserves.

Recent developments have impacted the necessary response of Ukraine if a disruption in supply were to occur again. As a result of the Ukrainian-Russian crisis, the European Union adopted a new Regulation in September 2010 that mandates member-states to prepare an emergency plan for household consumers in the case of a loss of natural gas supply. "The goal of the Regulation is to make sure that every member-state would be in a position to survive the loss of its main import source and continue to supply its protected clients, namely household and basic social services, for at least a period of 30 days" (Tsakiris, 2010, para. 4).

One important point of contention emerged around the breadth of the "protected clients" definition. While Europe's gas industries wanted the definition to include industrial customers and electricity producers, the definition was only marginally expanded to include small and medium-sized enterprises and essential social services, provided they are connected to a gas distribution network. Also, district heating installations that are dependent solely on natural gas for operation were included in the protected customers (Tsakiris, 2010).

As a result, those consumers that would be immediately impacted by a disruption in supply would be large industrial users and electricity suppliers. While the International Energy Agency estimates that electricity suppliers use less than 3% of natural gas as their fuel input, industrial users would be more impacted due to the fact that over 30% of their fuel input is natural gas ("2008 Energy Balance," 2008).

In 2006, Ukraine became an observer to the European Union's Energy Community Treaty, which establishes a framework for ensuring the stability of energy networks and energy security (Energy Community, 2011). In July 2010, Ukraine began to align its gas market to European standards and the formal accession process began in September 2010. The Ukrainian Parliament adopted the law on Ukrainian accession in December 2010 (Vichos, 2010). With the accession process predicted to be completed by early 2011, Ukraine will have a much stronger framework for responding to issues of energy security. As a member, it will be required to adopt the Community's acquis communitaire, which includes the aforementioned emergency plan regulation ("The Energy Community," 2010).

2e. The Geography and Agriculture of Ukraine

We have spoken at length about Ukraine's strategic position relative to other countries, but let us focus for a moment on the geographical, agricultural, and cattle-raising in order to better understand the country as a whole.

In Figure 1, we can see that the total geographic area of Ukraine is 603,700 square kilometers, with a majority of its land mass consisting of fertile plains (steppes) and plateaus. However, the Carpathian Mountains are found in the westernmost part of the country and the Dnipro River, which traverses the country from north to south, nearly divides the country in half. As a result of this large proportion of steppes and plateaus, which are two biomes conducive to agriculture, over 56% of Ukraine's land mass is considered arable land ("Ukraine," 2011).

Figure 1: Topographic Map of Ukraine

The climate in Ukraine is also conducive to agricultural production, with most of the country having a temperate continental climate. Only the southern Crimean coast has a Mediterranean climate that leads to warmer temperatures. Precipitation is disproportionately distributed, with the most being experienced in June and July in the west and north areas of the country and the east and southeast receiving considerably less rainfall during these months ("Ukraine," 2011).

While under Soviet rule, Ukraine's agricultural regions were aggressively used to produce 20 percent of the grain needs and over 60 percent of the sugar beet needs of the entire Soviet Union, despite being one of the smallest republics, constituting only 2.7% of the total land area of the Union. Soviet influence has continued to this day, as Ukraine's major exported crops continue to be winter wheat, sugar beets, and potatoes.

There are three main agro-ecological zones of Ukraine (see Figure 2), each producing crops most conducive to their soil type and temperate climate.

Polissya, located in the northern mixed forest zone and constituting 19% of Ukraine's land mass, is the least ploughed part of the territory. Conditions in this zone are suited to many cereals, pulse crops, and potatoes, and traditional development of beef-dairy cattle-raising. The Forest Steppe region, located in the central portion of the country and constituting 33% of Ukraine's land mass, has a much higher percentage of ploughed land with approximately 82% of the cultivated land within the zone prepared for agriculture. This zone's main commodity industries are its production of winter wheat and white beets, although it is also suited for maize and peas. The moister northern and north-west portions also support perennial grasses. Finally, the southern-most Steppe region is the largest region by acreage (making up 40% of the total Ukraine land mass). Large areas of this region (1.2 million hectares) are occupied by maize to be used for green fodder and silage. Its main crops include winter wheat and sunflower and the zone also supports cattle and sheep-rearing (Bogovin, 2006).

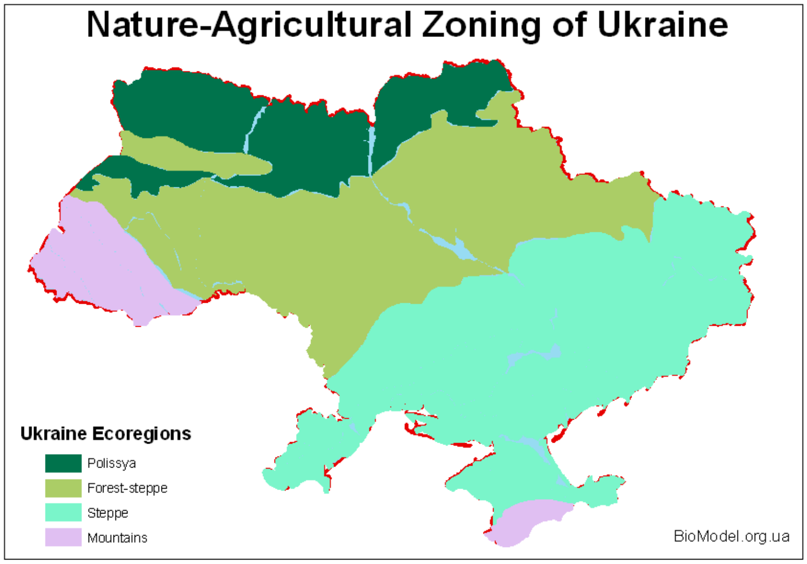

Figure 2: Agro-Ecological Zones of Ukraine

Ukraine's agricultural production has decreased significantly since the fall of the Soviet Union in 1991, due to the loss of state subsidies that farmers once enjoyed under the previous system. Land reforms in 1992 freely distributed this once state-owned land to private citizens to carry on private farming. The number of farms in the country now totals 40,000, with the average farm's area being 22.6 hectares (ha) which is a unit of measurement equal to 10,000 square meters. Individual ownership of farms has proven though to be difficult to maintain profitability. As a result, the formation of co-operatives, agrarian partnerships, and the leasing of land plots have all attempted to strengthen farm ownership and create economies of scale.

The number of livestock has decreased in Ukraine from over 24 million heads of cattle in 1990 to 7 million heads of cattle in 2005. This decrease was caused primarily because the majority of these cattle are raised on small, private farms which only hold one or two cows. These small farms do not have the capacity to store and treat any excess milk that these cows may produce in order to sell on the open market, and therefore do not have any incentive to raise more cows than needed for their own consumption. Sheep-rearing has also found popularity in Ukraine, primarily in the Steppe zone, where 60% of all sheep are found, although heads of sheep have also decreased drastically from 8.4 million in 1990 to 1.9 million in 2006 (Bogovin, 2006).

Since 1991, there has been a major shift from the state agricultural enterprises popularized during Soviet rule to more entrepreneurial single-owned farms. This private ownership is to be expected in a country like Ukraine. When the Berlin Wall came down in 1989, with the inflow of new ideas and a new system of government came a resurgence of entrepreneurial spirit that had been suppressed for decades. That spirit remains today, as is evidenced by recent Eurobarometer data that has found that 50% of Ukrainians want to start their own business, higher than the European Union average of 45% ("Entrepreneurship," 2009). Further statistics serve to reinforce this belief, signaled by an exceptional growth in the number of private farms, from 2,600 in 1991 to nearly 43,000 in 2010 and continues to grow. In addition, the number of cultivated agricultural land has grown from 1 million ha in 1991 to 4.2 million ha of land in 2010 ("Agriculture News," 2010).

Rural households also use substantially more natural gas for heating than urban households, with annual gas consumption of 2.8 thousand cubic meters (tcm) compared to 1.5 tcm in urban settings ("Household Gas Prices," 2006). For the purposes of this paper, we will assume that rural farmers consume 1.5 times the average demand for rural households, due to the fact that these farms have a number of secondary buildings that require heating for their animal stock and other farm operations. Despite this high consumption of fuel, the average rural farmer has an annual salary of only $3,000 ("Irish Farming Links," 2011).

2f. Long Lines and Shortages: A Time of Resourcefulness

Borovsky describes the Ukrainian people first and foremost as "forward-thinking" and people who "make things last" (Borovsky, personal communication, November 18, 2010). He attributes this mentality to a forced scarcity that all Ukrainians lived under during Soviet rule, where bread lines stretched for blocks and families waited months in order for their lottery number to be called for an apartment. As a result, the Ukrainian culture has been defined by this idea of resourcefulness and the country has emerged as a particularly strong proponent of environmental measures when they can be afforded. Although much of the industry sectors remain to use outdated technology for production due to the cost of this technology and not lack of interest, other sectors have begun shifting their business models to include the impact their business will have on the environment. An encouraging example is the media sector, where on March 11, 2011, Kyiv Weekly became the first eco-friendly newspaper and now uses recycled paper for all of their printed materials ("Kyiv Weekly").

2g. Summary

In conclusion, Ukraine has the most energy-intensive economy in the world (Pirani, 2007). Inefficient consumption of cheap gas and an overdependence on imported gas are an integral part of this problem and will remain so until more energy-efficient measures are implemented. Russia argues that it has provided "humanitarian aid" to Ukraine by subsidizing the cost of its natural gas for nearly 20 years, and no longer has any obligation to the now-independent country. Prime Minister Vladimir Putin defiantly declared in December 2008 that the "age of cheap gas is over" ("Putin," 2008). Amidst all of the confusion, only one thing is certain: Ukraine must diversify its energy inputs or continue to be at the whim of a foreign power. A burgeoning agricultural sector provides opportunity for renewable technologies to help achieve this diversification. However, there appears to be a mismatch between the cost of this technology and the average annual income of farmers, presenting an opportunity for innovation in the form of microfinance.

3. Microfinance

3a. Microfinance's Beginnings

The concept of microfinance is not a new idea. Traces of microfinance can be found in the Irish Loan Fund system, established in the early 1700s by author and nationalist Johnathan Swift. The Fund's purpose was to make small loans with interest for short periods, though it did not necessarily target the poor and at its peak was making loans to 20% of all Irish households annually ("The History," 2006).

Microfinance's focus on the poor was not realized until the emergence of formal credit and savings institutions in the late 1800s in Europe. These institutions were motivated by the concern to assist the rural population to break out of their dependence on moneylenders and to improve their welfare. This primary focus of microfinance institutions remains to this day.

In the broadest sense, modern microfinance refers to a movement that envisions a world in which low-income households have permanent access to a range of high quality financial services to finance their income-producing activities, build assets, stabilize consumption, and protect against risks. The traditional microfinance institution (MFI) makes small, short-term, low-interest loans to an impoverished group of people, who are responsible for repaying that loan. Unlike traditional banks, MFIs do not generally require collateral from borrowers, but instead rely upon the social pressures of solidarity lending to enforce repayment. Borrowers who do not repay are, in almost all cases, forbidden from borrowing again from an MFI.

Organizations like ACCION and the SEWA Bank (Self-Employed Women's Association) were among the first to take up this mission and did so by targeting the poorest of the poor in impoverished areas throughout Latin America and Africa ("The History," 2006)

The traditional microfinance group loan methodology was first popularized by the work of Muhammad Yunus during the founding of the Grameen Bank, a microfinance institution that was the 2006 recipient of the Nobel Peace Prize for their efforts to create economic and social development amongst the world's poor. Established in Bangladesh in 1983, the Grameen Bank makes use of a lending practice known as solidarity lending.

In many third-world countries, laws related to secured transactions (involving the use of collateral) may be absent or not enforced. In solidarity lending, loans are not given out to individuals, but instead to groups of people, using various types of social capital such as peer pressure and mutual support to offset the need for collateral. Psychologists have found that groups of five are the ideal size for these groups, as they are small enough to ensure joint responsibility and discourage free-riders, but at the same time large enough to prevent one person's misfortune from causing the group's collapse (Dowla & Burua, 2006).

In order to pay the high administrative costs involved with microfinancing (as these small loans generate an enormous amount of paperwork and often times require loan officers to travel to isolated areas to service customers) interest rates are charged on these loans, sometimes in excess of 20% (Fernando, 2006). Although these customers cannot be offered traditional bank loans due to their lack of collateral (and their alternative, loan sharks, can charge in excess of 300%), microfinance institutions have sometimes been criticized for charging substantially high interest rates that appear to contradict their mission. Microfinance institutions defend their critics with the simple, but most widely misunderstood, fact that they are not established as charitable institutions but instead as organizations offering the poor opportunities that they would not otherwise have so that they may build better lives for themselves and their families.

3b. Modern Microfinance Methodology

From microfinance's humble beginnings has emerged a complex product that now offers a wide range of services, including specific methodologies for housing, savings, insurance, and credit microfinance. For the purposes of this paper, I will focus on the methodologies behind credit microfinance that has itself expanded into various different types of loans. ACCION, one of the premier organizations in the world committed to building stronger MFIs, believes that, "credit methodology lies at the heart of microfinance and its quality is one of the most determinant factors for the efficiency, impact and profitability of an MFI" ("Credit Methodology," para. 1).

Since 1973, ACCION has worked with MFIs to adjust methodological innovations to the specific requirements of the institution. As such, a newly formed institution must first consider a number of activities involved in lending including sales, client selection, application and approval process, repayment monitoring, and delinquency management.

ACCION believes that different lending practices, such as the aforementioned solidarity lending of Grameen Bank and individual lending do not necessarily have to be contradictory but instead can be complementary, as long as they fit with the institution's overall business strategy ("Credit Methodology," 2011).

The Grameen Bank of Bangladesh also uses its own model for its MFI operations. First, it conducts surveys of geographical communities to brief the potential for operations in the village, including an evaluation of the village population and degree of poverty. After it has decided upon a suitable village that has shown need and infrastructure required for microfinancing, Grameen establishes a presence in that village. A "village center" is created, where the borrowers can meet on a weekly basis and repay their loans, while also discussing new loan applications and community issues ("Working Method," 2011). Meanwhile, groups of borrowers undergo a 5-day training course in this center where they are educated on financial products, interest rate calculation, and entrepreneurial business skills.

3c. Where Does Microfinance Work?

Microfinance's beginnings in areas such as Bangladesh and South America is not a coincidence. Microfinance functions most effectively in third-world countries that have very low standards of living, as very small amounts of money can create a real sense of financial viability for impoverished people. In addition, laws and regulations in industrialized countries tend to prevent MFIs from being as effective as they would otherwise be in an unregulated economy. As a result, Bangladesh is tied with India as being home to the most MFIs (7 each) listed in the top 50 microfinance institutions in the world (according to Forbes magazine). Conversely, none of the top 50 microfinance institutions were established in any country within the European Union or in the United States (Swibel, 2007).

This is not to say that MFIs cannot be established or function effectively in industrialized countries. Federal Reserve Chairman Ben Bernanke, an unlikely ally, spoke in November 2007 at the ACCION Texas Summit on Microfinance about the similarities in goals and core values of U.S.-based MFIs to those established in third-world countries. However, Bernanke did acknowledge the obvious differences in the operational details of U.S. programs in relation to overseas programs, also remarking that "to a greater extent than overseas, microfinance programs here have expanded their offerings to deliver education, training, and various other services to nascent entrepreneurs" (Bernanke, 2007).

3d. Case Study: USAID's Nepal Biogas Microfinance Capacity Building Program

The idea of using microfinancing to raise capital for small-scale renewable energy projects has been successfully implemented in many areas of the world, most notably in Africa, in Bangladesh through the Grameen Shakti program, and in Nepal through an interesting humanitarian partnership.

United States Agency for International Development (USAID), the United State federal agency primarily responsible for administering civilian foreign aid, has recognized the opportunity afforded by microfinance, and as a result has implemented the Nepal Biogas Microfinance Capacity Building Program ("USAID History," 2011). The UN Department of Economic and Social Affairs Division for Sustainable Development recognizes that this program "works to ensure that biogas investments are eligible for microcredit at affordable interest rates and to facilitate loans through rural based microcredit lenders" ("Microcredit for Farmers," para. 1).

USAID has advocated on behalf of microcredit lenders to the Nepalese government to raise the limit for microcredit per household from $425 to $725. In addition, USAID has provided a substantial amount of loans that have leveraged subsequent investment; the program has been successful in not only providing the capital but building the policy framework for this project to become self-sufficient after an initial period of assistance ("Nepal Microcredit," 2011).

To date, the program has achieved significant results. According to USAID, over 600 biogas plants have been constructed using microcredit, benefiting 3,000 people, and mitigating 2,700 tons of carbon dioxide. USAID's initial investment of $81,000 in MFI loans has leveraged over $200,000 in total additional investments. The microfinance institutions in Nepal distributing these loans have reported a near 100% repayment rate.

4. Feasible Small-Scale Renewable Energy Projects

There are a number of renewable energy technologies currently available and feasible that could be implemented in Ukraine in order to achieve the desired outcome of this thesis. However, this section will examine the unique advantages afforded by selecting anaerobic digestion as the preferred alternative energy source.

4a. Anaerobic Digestion: The Process

The US Department of Energy defines anaerobic digestion as the process by which microorganisms break down biodegradable materials, in the absence of oxygen, into several products that can eventually be used for the production of electricity or heat, as well as fertilizer ("How Anaerobic Digestion," 2011). The process begins with bacterial hydrolysis, at which time insoluble organic polymers, such as carbohydrates, are broken down to be used by other bacteria. Acidogenic bacteria then convert these products (sugars and amino acids) into carbon dioxide, ammonia, hydrogen, and organic acids. Acetogenic bacteria then convert these organic acids into acetic acid and additional carbon dioxide, ammonia, and hydrogen. Finally, methanogens convert these products to methane and carbon dioxide. See Figure 3 for an illustration of this process.

Digesters can be categorized as either wet or dry systems that are "fed" with inputs either continuously or loaded in batches. In a batch-fed digester, waste is fed into the inlet of the plant and the digester is sealed, allowing the microorganisms to process the waste and biogas to be produced. The amount of time that the waste must remain in the digester to allow for anaerobic digestion to completely occur, also known as its retention rate, varies based on the input type. The time required to complete the anaerobic digestion process can vary from ten days (if batch feeding with mostly solids) to eight weeks (if continuously feeding with mostly liquids) (Fowler, 2011).

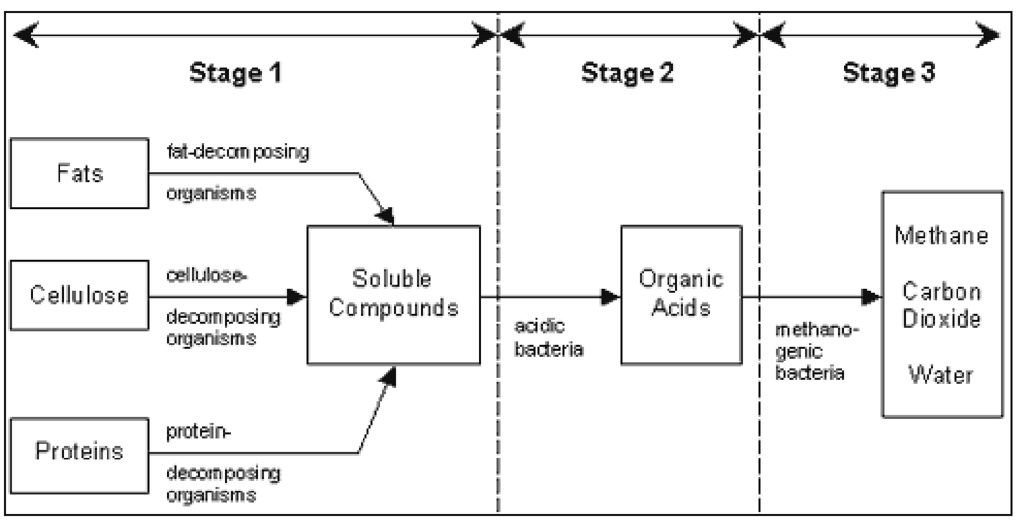

Figure 3: The Three Stages of Anaerobic Digestion

Anaerobic digestion has become a widely-used renewable energy source not only because of the availability of its inputs (food waste, animal manure, etc.) but also because of the versatility and usability of its products, including a rich biogas that can be used as a natural gas substitute and a nutrient-rich digestate that can be used as fertilizer. The methane that is produced from this process can be burned to produce both heat and electricity. In order to generate the latter, the biogas must be used as a fuel in a reciprocating engine or microturbine, a market that General Electric has explored extensively in areas of Eastern Europe ("GE Energy," 2011). Any material that cannot be digested by the microbes constitutes the digestate that can be used as a fertilizer to improve soil conditions. The technology as a whole has seen an enormous amount of growth within the last decade. While world anaerobic digestion growth data is unavailable, the Environmental Protection Agency estimates that energy production in the United States by anaerobic digestion has grown from approximately 15 million kilowatt hours/year (kWh/year) equivalent in 2000 to nearly 375 million kWh/year equivalent in 2009 ("Anaerobic Digesters Continue," 2010).

Anaerobic digestion in particular benefits from its potential for scalability, ability to be implemented almost anywhere in the world, and feasibility at almost any size of digester. Countries such as China have been successfully installing small-scale anaerobic digesters for nearly 40 years ("Anaerobic Digester," 2011). For the remainder of this paper only small-scale anaerobic digesters will be considered.

4b. The Environmental Benefits of Anaerobic Digestion

A majority of the environmental benefits of anaerobic digesters originate from the fact that this biogas serves as a replacement fuel to coal-based and natural gas resources that generate a significant amount of greenhouse gases when produced and when burned.

Biogas is unique when one takes into consideration the carbon cycle, which, simply put, is the idea that carbon is present in every living thing and when that organism dies the carbon is then released into the atmosphere in the form of carbon dioxide. Photosynthetic plants then absorb that carbon dioxide in order to grow. When these plants die, the carbon is then released back into the atmosphere and the cycle begins again.

Because biogas is synthesized from the carbon that is present in biodegradable materials, when the biogas is burned it is simply returning to the atmosphere the same carbon that was taken out in the recent past by the plants that used it to grow. When the second byproduct of anaerobic digestion, the nutrient-rich digestate, is used as a fertilizer to create more plants that will remove more carbon from the atmosphere, the system as a whole becomes carbon neutral. This process stands in stark contrast to the carbon released from fossil fuel-burning, which has been sequestered in the earth for millions of years, the combustion of which increases the overall levels of greenhouse gases in the atmosphere (“Benefits,” 2011).

In addition, anaerobic digestion processes biodegradable materials that would otherwise take up space in a landfill and reduces the amount of methane (a greenhouse gas 20 times more powerful than carbon dioxide) that would be naturally released into the atmosphere during the natural decay of that item.

Finally, in countries that collect household waste, the process of waste in an on-site digester reduces the amount of transportation that that waste would otherwise require to be brought to an incinerator, reducing the greenhouse gases associated with vehicle emissions ("Framework," 2011).

4c. Small-Scale Uses

Besides the availability of their inputs and the value of their outputs, anaerobic digestion projects are especially attractive for small-scale implementation because of the small amount of capital required to start up a plant and the low impact they have on the surrounding environment that might otherwise stir up public opposition. In fact, "anaerobic digestion facilities have been recognized by the United Nations Development Programme as one of the most useful decentralized sources of energy supply" (Ho, para. 1). Decentralization in this instance implies that energy generation is not limited to one localized area and then distributed elsewhere, but instead that energy is generated in numerous locations throughout a particular geographic area.

On a household level, the production of biogas also allows for the controlled management of animal dung and the safe production of gas for cooking, lighting, or power generation. Although these small-scale projects have experienced the most widespread usage China, where it currently holds the lead with 15 million households using such technology, these projects have been implemented on every continent in the world, except for Antarctica (Van Nes, 2006).

4d. Case Study: Moldova Biomass Heating in Rural Communities Project

The United Nations Framework Convention for Climate Change (UNFCCC), better known to most of the world by its principal update, the Kyoto Protocol, has been the primary international document that has encouraged the growth of renewable energy projects worldwide since it was established in 1992 ("Article 2," 1992). Designed in cooperation with the Kyoto mechanisms, the Community Development Carbon Fund (CDCF) was created as a public/private initiative in 2003 to provide carbon finance to the poorer nations of the world.

The Moldova Biomass Project was created in 2005 as a result of this framework, which helped to establish funds and an international forum for discussing such innovative renewable energy projects. The focus of this project in particular is the installation of individual biogas plants to help provide electricity and heat to 120 public buildings throughout the country.

The project's approach takes advantage of the beneficial decentralized energy supply of anaerobic digestion, with each project being at least 1 kilometer apart and at most 400 kilometers apart.

In order to implement the project within the country, a new Carbon Finance Unit (CFU) was created under the Ministry of Ecology and Natural Resources. The CFU is an independent legal entity that serves as a counterpart to the CDCF, and is responsible for negotiating on behalf of each individual project the Emissions Reduction Purchase Agreement (ERPA), which documents the amount of greenhouse gas emissions that are reduced as a result of the project. They also receive the carbon payments from the CDCF and transfer the money to the individual project owners ("Moldova Biomass Heating," 2005).

The benefits from this project, of course, are not limited to simply the environmental impacts that occur by providing a renewable alternative to the conventional coal-burning boilers that create massive air pollution. In addition, this project contributes to sustainable development that has reverberating economic and social effects, such as making hot water available and affordable in these public buildings and leading to an overall decrease in the cost of heat unit production. These cost savings can allow these schools and orphanages to focus their funding on their most precious resource: children's education.

4e. The Inputs and the Outputs and Efficiency

Anaerobic digesters typically can accept any biodegradable material. This can include waste paper, grass clippings, leftover food, and sewage waste just to name a few. In addition, many facilities have co-digestion capabilities that can accommodate two or more types of feedstock that can not only process animal waste generated by livestock but also grass or corn that may be used as feedstock, for example.

However, if biogas production is the aim, the "level of putrescibility is the key factor in its successful application" and the more putrescible the material the higher the yield of gas ("Anaerobic Digestion Feedstock," para. 2). A material is determined to be putrescible if it has high moisture content and a sufficient ratio of carbon to nitrogen to allow the anaerobic bacteria to convert it biologically and examples can include typical food and kitchen waste. Specially-grown energy crops such as silage can also be used as an input for dedicated biogas production.

As a result, the efficiencies and biogas yields of these inputs can vary widely and many studies have been conducted to attempt to calculate these yields. While some anaerobic digesters are able to achieve higher yield outputs than others, the following chart illustrates the average yields of various inputs.

Table 1: Biogas Potential of Various Inputs

Raw Material	Biogas Yield (m^3/ dry tonne of raw material)
Cow Manure	60
Pig Manure	65
Grain	500-560
Silage, plant tops, grass algae	400
Fruit and Sugar Beet Pulp	50-70
Chicken Dung	130
Fat	1300

As noted, these yields are measured as the number of cubic meters of biogas produced per dry ton of raw material. While each cubic meter of biogas contains the equivalent of 6 kWh of calorific energy, the conversion of biogas to electricity is a very inefficient process. Therefore, only about 2 kWh of useable electricity is generated from 1 cubic meter of biogas ("Biogas FAQ," 2011).

However, as mentioned previously, there is another potentially valuable output in the form of a digestate that consists of all the indigestible materials and dead microorganisms. The volume of this digestate as an output will be approximately 90-95% of the volume of the input that was fed into the digester. Therefore, approximately 1,984 – 2,095 kg of digestate is produced from every dry tonne of raw material ("What is Digestate," 2011) This digestate can be used as fertilizer at the farm where it was produced to increase crop yields and complete the neutral carbon cycle.

5. The Economics of It All

5a. Input Selection

As mentioned in section 4, digesters can be categorized as either wet or dry systems that are "fed" with inputs either continuously or loaded in batches. The retention rate is an important consideration, as it indicates how often the system will require labor and maintenance to replace the input.

A number of different factors should be considered when selecting the optimal input for an anaerobic digestion project. First, the cost of the input must be low enough to ensure the borrower can afford or produce it. In addition, it must generate a product that is valued higher than the opportunity costs of human consumption of the product. Second, the input must be easily obtainable for the region in which the digesters are being built and the input should not be subject to dramatic seasonal changes in production. Third, the calculated biogas yield of the input should be considered to ensure that it is an efficient input.

For this thesis, corn silage was decided upon for its high biogas yield and relatively low cost. Corn silage is defined as a fermented, high-moisture fodder that can be fed to livestock as it is high in energy and digestibility.

Corn is also one of the primary crops of production in Ukraine, the region in which we are studying. Those qualities, paired with the fact that silage is relatively inexpensive when compared with other crop alternatives, make the feedstock exceptional for anaerobic digestion. This input has an approximate retention rate of 10 days, indicating that each batch will remain in the plant for that duration of time and then will have to be removed and replaced (Steffen, 1998).

5b. Construction of the Anaerobic Digester

As mentioned in section 2, the average farmer has an annual natural gas demand of approximately 4,200 cubic meters. From this natural gas demand, we can derive the size of the anaerobic digester necessary to annually produce that amount of biogas.

First, we must divide the total amount of biogas produced per year by the number of batches per year in order to calculate the biogas produced per batch. Because corn silage has a retention time of 10 days, we can assume that there will be 36 batches per year. Therefore, when we divide 4,200 cubic meters by 36 batches, we are left with biogas production per batch of 116.67 cubic meters.

Muller and Huttner (2005) have measured corn silage to have a biogas yield of 400 cubic meters per metric ton of raw material. As a result, we can divide the biogas production per batch by the yield constant in order to calculate the amount of corn silage required per batch. When we divide batch production of 116.67 cubic meters of biogas by the biogas yield of 400 cubic meters, the amount of silage required is found to be .29 metric tons.

Now that we have calculated the mass of the input that is necessary per batch, we can use that mass to calculate the size of the anaerobic digester. Kossman (1996) states that the size of the digester should be, on average, 120-fold the quantity of silage put in daily in order to account for the production and expansion of the biogas. With a retention rate of 10 days, we can calculate the daily silage input by dividing the batch size (.29 metric tons) by the number of days required for the retention rate (10), which is found to be .029 metric tons, or 29 kilograms. When we multiply this by Kossman's constant of 120, we have found the mass of the digester to be 3480 kg.

However, anaerobic digesters are measured in terms of volume, not mass, and therefore in order to calculate the volume of the digester we must first calculate the density of the input (corn silage) that will be placed into this digester.

Dairy One Cooperative has found the density of wet corn silage to be 43 lbs/cubic foot and the density of dry corn silage to be 14.5 lbs/cubic foot ("Master Forage," 2011). Because the silage that will be placed into the digester is 35% dry matter and 65% wet matter, the calculation is (.65)(43) + (.35)(14.5) = 33.025 lbs/cubic foot. Converting the number into metric units, the density of the silage is found to be 15 kg/.028316 cubic meters. When converted into the density per cubic meter, the density is found to be 529.74kg/cubic meter.

Therefore, we can calculate the approximate volume (V) of the digester by using the density formula and dividing the mass (M) of the digester by the density (D) of the corn silage.

The density (D) formula:

$$D = \frac{M}{V}$$

can be re-written as:

$$V = \frac{M}{D}$$

substituting in variables:

$$V = \frac{3480\ kg}{(529.74 \frac{kg}{cubic\ meters})} = 6.6\ cubic\ meters$$

While the volume of the actual digester is calculated to be 6.6 cubic meters, the volume of the dome that accompanies the digester must also be added to the total volume of the biogas plant, and that is achieved by adding ¼ of the volume of the digester. As a result, the theoretical volume of the digester is 8.25 cubic meters.

However, actual volume of the digester should be 10% greater than the theoretical volume in order to account for gas expansion, and therefore we can calculate the actual volume of the digester to be rounded to 9 cubic meters for simplicity.

The Chinese fixed dome plant structure (see Figure 4) will be used as the design model for implementation. Nearly 7 million of these dome plants have been implemented throughout China for nearly 75 years and use the seasonal crop wastes from small, rural farms as the primary input. Dome plants in particular have the advantage of being cheap to build and have no moving parts or metal parts that can rust. Also, they are constructed underground which saves space, protects the digester from corrosion, and makes them less sensitive to seasonal temperature change. As a result, the fixed dome plant is well-regarded for its low maintenance costs. These dome plants also have low fixed installation costs, with costs ranging around $70 per cubic meter of digester capacity (Kossman, 1996). Therefore, the installation costs of materials would be approximately $630 for our 9 cubic meter model. These costs include the construction of the gasholder, digester/slurry storage container, gas appliances/piping, stable modification, and general engineering involved with the project (Werner, 1989). However, dome plants have some disadvantages: they often leak some gas, experience variant pressure inside the digester, and must be supervised by experienced

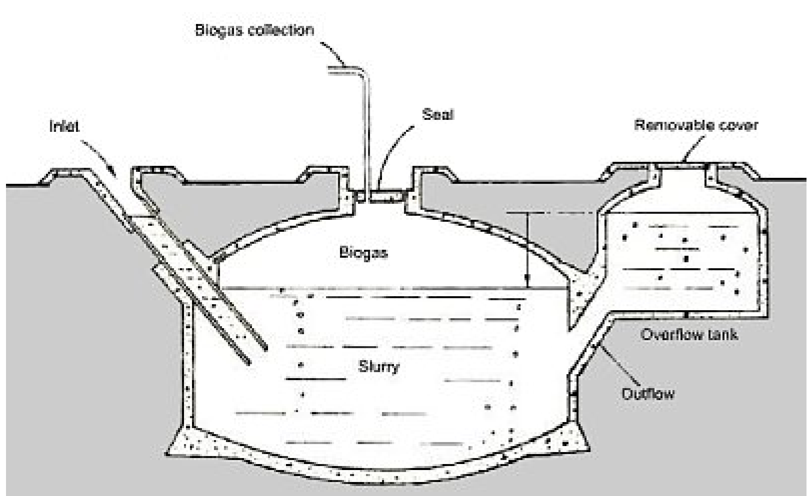

Figure 4: Chinese Fixed Dome Plant Diagram

technicians (Wargert, 2009).

In addition to the cost of materials, Wargert (2009) estimates that an average of 9 man hours per cubic meter of digester capacity must be used to construct the plant. For the purposes of this thesis, we will assume an hourly wage of $5 per hour which is substantially higher than the average hourly wage in Ukraine, but the project will be awarded as a limited contract and therefore would command a higher wage. Therefore, total labor costs of installation (81 hours multiplied by $5) will total $405. When added to the cost of materials, the total installation costs will amount to approximately $1035.

5c. Maintaining the Digester

In addition to the fixed costs of installation of the biogas plant, there are also a number of operating costs that result from the maintenance and operation of the plant. Annual maintenance costs (such as materials for repairs) have been estimated at approximately 3% of the digester system turnkey cost, equating to annual costs of approximately $31.05 (Werner, 1989).

As a result, an additional variable cost related to operation will result from the pumping, repairs, cleaning, and monitoring of the plant. Iowa State University has estimated the annual labor required for the operation of the digestion system to be approximately 44.34 man hours, amounting to annual labor costs of $221.70 (Ernst & Rodecker, 1999).

5d. Corn Silage as a Cost Factor

Low-cost corn silage can be made from every part of the corn plant, including the stalk, by placing large amounts of the silage into heaps and then rolling over the heap with a tractor or other large piece of machinery to push out the air. The heap is then covered in a plastic cover held down by tires or other heavy objects. This high-moisture feedstock is then fed into the digester once every 10 days.

At the present time, there is no standard practice for establishing a valuation method for corn silage because of its very nature of not being easily transportable and the fact that it is often regarded as "waste" because it is not fit for human consumption. Therefore, there is no market price of corn silage. The relevant cost of the input is in fact the opportunity cost of what the silage could otherwise be used for. However, Purdue University has taken a very methodical concept at attempting to value corn silage that I have utilized for my thesis (Hendrix, 2002).

The concept uses a number of equations and seeks to isolate the amount of dry grain that is present in a quantity of the semi-liquid corn silage. Once the quantity of this grain is found in pounds, it must then be converted into pounds of no. 2 corn (a label which denotes the standard corn product on the world market), which is achieved by dividing the number of pounds of grain by a factor. This quantity of no. 2 corn (in pounds) must then be converted into bushels (as the world market prices grain by the bushel). It is now possible to value the corn silage by multiplying the number of bushels of no. 2 corn by the market bushel no. 2 corn price for Ukraine.

"First, the method assumes that the dry matter of whole plant corn silage contains 50% grain. We'll assume that moisture content of the silage has been checked and found to be 65%. Therefore, dry matter content is 35%" (Hendrix, para. 5). To determine the amount of dry matter per tonne, we simply determine 35% of 2204 lbs, which equates to 771.4 lbs. Because only 50% of that dry matter is grain, we must only compute the price for half of that dry matter, which is 385.7 lbs. We then divide by a factor of .845 in order to convert our grain into no. 2 corn, which is equal to 456.5 lbs of no. 2 corn. In order to find the number of bushels, we must divide our total by 56 lbs, because there are 56 lbs of no. 2 corn in a bushel. We are then left with 8.15 bushels. According to a recent article in *Agro Perspectiva* (2011), the current market price of one bushel of Ukrainian no. 2 corn is $5.92 ("Ukrainian Grain Market," 2011). As a result, this leaves us with an estimation of $48.25 per tonne of corn silage. However, we must also consider the cost of the fertilizer, harvesting, and storing of silage. Purdue University has proposed a value of $1.00 per 100 lb. of silage dry matter per metric ton (in this case 771 lbs), resulting in an additional cost of $7.71.

Therefore, our final estimation for the cost of corn silage per metric ton is $55.96.

If we then multiply the batch size (.29 metric tons) by the aforementioned price of corn silage per metric ton ($55.96) we find that our input cost per batch will be $16.12. Because corn silage has a retention rate of 10 days, there will be approximately 36 batches each year amounting to a total annual cost for inputs of $580.19.

If we combine the annual costs for inputs ($580.19) with the annual costs for operation ($221.07) and maintenance ($31.05), we are left with total annual costs of approximately $832.94.

5e. Revenues

There are two byproducts of anaerobic digestion, one of which has real, significant value associated with it and the second of which has a usable value to the farmers themselves but little value in the open market. The first byproduct, a biogas that is 80% methane can be burned on-site for heat or cooking purposes, but in order to value the byproduct as a natural gas equivalent the amount of biogas must be multiplied by .80 in order to determine the amount of pure methane. This methane has a fluctuating value that is influenced by the price of oil and whose price has risen sharply in recent years. Secondly, the undigested anaerobic waste that is produced during the process can serve as an organic alternative for fertilizer on the producer's land, but is not easily transportable and cannot easily be sold. The opportunity costs of being able to reduce the amount of fertilizer purchased by the farmer could also be calculated as a cost savings to the user. The most important use of this fertilizer, though, would be ensuring that it is used to produce more corn at the farm it was created to complete the carbon neutrality of the system.

In addition, because of the nature of anaerobic digestion as a means of reducing greenhouse gases, these digesters will also generate renewable energy credits, which can be sold on an international market and will be discussed in further detail in section 7.

Using the batch size calculated from the previous section, we can determine the amount of biogas produced from one batch by multiplying the batch size (.29 metric tons) by the biogas yield (400 cubic meters), which equates to 115 cubic meters of biogas production per batch. The biogas that is produced is only 80% methane and 20% carbon dioxide and other undesirable compounds. The amount of biogas that is produced annually can be determined by multiplying the production per batch (115 cubic meters) by the number of batches (36), which equals 4147.2 cubic meters. However, in order to calculate the revenues using the price of natural gas (which is 100% methane) we must then multiply the 115 cubic meters by .8 in order to determine the total cubic meters of methane produced per batch. Doing so, we find that 92.2 cubic meters of methane are produced.

In order to find the annual biogas production we must multiply the methane produced per batch (92.2 cubic meters) by the number of batches (36), which equates to 3317.8 cubic meters per year.

The price of imported natural gas for Ukraine has increased significantly within the past few years, and the year 2011 is no exception. Naftogaz, the state-owned Ukrainian gas company, recently announced a 6.1% increase in price for the second quarter of 2011 to a price of $280 per thousand cubic meters ("Price of Imported," 2011). Therefore, the total annual revenue generated from biogas production can be calculated by multiplying the annual biomethane output (3.3 thousand cubic meters per year) by the price of natural gas ($280 per thousand cubic meters) which totals $928.97 per year.

5f. Profits

The traditional, simple definition of profit is explained as revenues minus total costs. As a result, in order to calculate profit we must use the aforementioned revenues generated from the methane and subtract from it the annual costs of maintenance, operation, and input. Doing so, we can calculate the annual profits for three digester sizes (see Table 2). These profit calculations do not take into consideration the cost of installation, instead illustrating annual profits for each year after year 1.

Table 2: Annual Profits to Borrowers

Size of Digester	**7 m3**	**9m3**	**11m3**
Total Annual Value of Methane Output	**$722.53**	**$928.97**	**$1,135.41**
Total Annual Costs of Operation	**$687.66**	**$832.94**	**$953.93**
Total Annual Profit	**$34.87**	**$96.03**	**$181.49**

5g. Net Present Values

While profits measure the amount of money that the project will generate each year, it does not take into account the discounted value of money over the lifespan of the project and also does not take into account the initial installation costs (IC) that the project must recover in order to be a viable project and have a positive value over the life of the project. It takes into account revenue (R), variable costs (VC), the discount rate (D), and the lifespan of the project in years (n).

The net present value (NPV) formula can be written as such:

$$NPV = -(IC) + \left(\frac{R - VC}{D}\right)\left(1 - \frac{1}{1 + D^{n}}\right)$$

While we have previously calculated installation costs, revenue, and variable costs, there are other variables that have not yet been quantified, namely lifespan of the project and the discount rate. Puxin is a popular Chinese company that produces a small scale biogas plant that states that the lifespan of a small-scale biogas plant is 30 years ("30 years lifespan," 2011). In addition, a discount rate of 5% was used for this analysis.

Substituting in the values that I have determined for a 9 cubic meter biogas plant project, we find the net present value to be:

$$NPV = -(1035) + \left(\frac{(928.97 - 580.19 - 252.75)}{.05}\right)\left(1 - \left(\frac{1}{1.05^{30}}\right)\right)$$

$$NPV = -(1035) + \left(\frac{96.03}{.05}\right)(.769)$$

$NPV = -1035 + 1477$

$\boldsymbol{Net\ Present\ Value = \$442}$

In Figure 5, we evaluate how the size of the digester influences the NPV and we see that NPV is positive when digester is larger than 8 cubic meters.

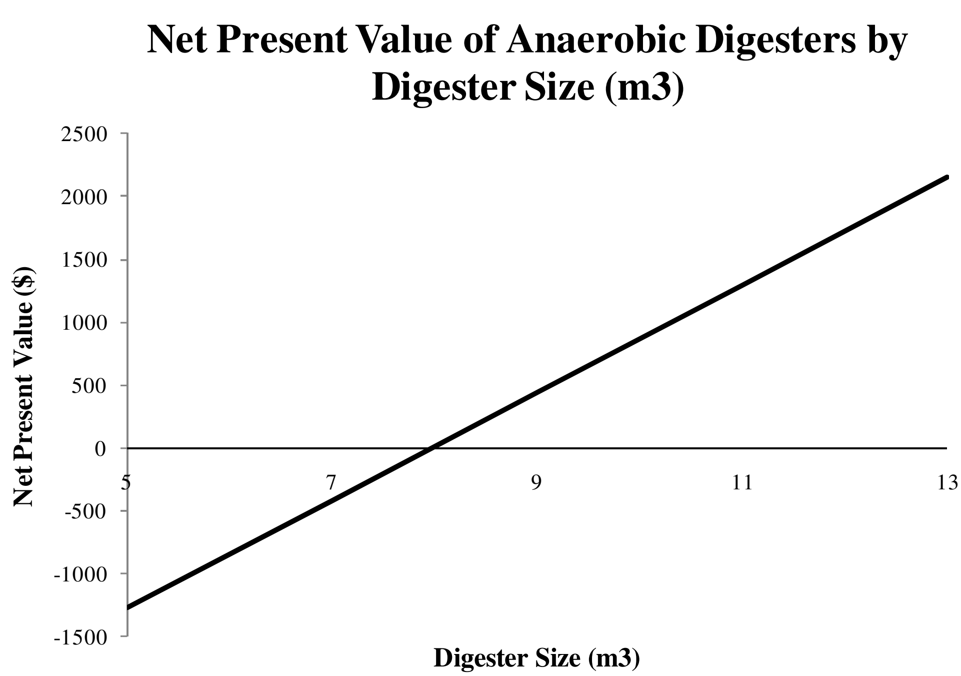

Figure 5: Net Present Value of Anaerobic Digesters

6. Implementation of MFI in Ukraine under Proposed Plan

This section seeks to apply the aforementioned concepts of microfinance and small-scale biogas plants into the creation of a functioning microfinance institution that could be implemented and succeed in the country of Ukraine. This institution will be called Zapravky May□butnye Ukraïni (ZMU), which is Ukrainian for "Fueling Ukraine's Future." The name of this institution has a two-pronged meaning, as it not only refers to the future production of the actual fuel in the form of biogas, but can also be interpreted as an institution that is investing in technology and people that will become a larger part of Ukraine's portfolio in the future.

Throughout the section, I will reintroduce unique elements of Ukraine's political and geographic climate that would necessitate the alteration of traditional techniques in both of these concepts. At the end of the section, I will describe the operation of the institution and the borrowing process. In addition, I will conduct a 20-year financial analysis for the borrowers for the institution itself.

6a. The Target Population

As described in section 2, the natural gas demand of rural households, and especially farmers, is considerably higher than their urban counterparts. In fact, assuming that farm operations require 1.5 times as much natural gas as an average rural household, with a natural gas price of $280 per thousand cubic meters, the annual farmer spends an incredible 39% of their annual income on heating costs alone!

These individual farms, with an average land size of 60 ha (148 acres), with existing infrastructure for the production of corn silage (as corn is one of the most-produced crops in the country and is used as a feedstock), and having an exceptionally high heating burden makes this group the optimal target population for an institution such as this.

The requirements for access to loans from this institution would initially be geographic and income-based. All borrowers must be located within 150 miles of a branch to ensure proximity and must have an income of at least $2,000 a year.

6b. The Framework and Regulation of a Microfinance Institution in Ukraine

Currently, there are only two functioning microfinance institutions in Ukraine: ProCredit Bank Ukraine and Nadia Ukrainy. It is difficult because there are very few "best practices" that have been designed specifically for Ukrainian institutions. However, the two institutions alone have a total of nearly 28,000 borrowers with total assets of $349 million and provide an exciting outlook and opportunity for microfinance in Ukraine ("Microfinance in Ukraine," 2011).

ProCredit Bank Ukraine, the larger of the two institutions, is a development-oriented full-service bank. While it extends millions of dollars in loans to small and medium-sized enterprises, it generally appeals to larger businesses and the average loan size is over $10,000, well above what this institution would be targeting.

Nadia Ukrainy, the smaller of the two institutions, and the structure that this microfinance institution will be modeled after, is a non-banking financial institution that is a branch of the larger HOPE International network which works in 14 different countries. Extending non-collateralized loans for microenterprises, agriculture, and housing, Nadia Ukrainy prides itself on the transparency of its interest charges, fees, and penalties ("Nadia Ukrainy," 2011). This particular commitment to client protection is necessary in a country such as Ukraine, where corruption especially in the financial sector has cast a negative light on the trustworthiness of such institutions. This institution's average size loan extended to borrowers is only $620 and has total assets of $2.6 million ("Microfinance in Ukraine," 2011).

These non-banking financial institutions (NBFI) provide banking functions without meeting the legal definition of a bank and therefore cannot take customer's deposits. However, they can provide loans and credit facilities from other sources of funding, such as venture capitalists. NBFIs in Ukraine also have low minimum capital requirements of $440,000, which is considerably lower than the world average of $7.3 million (Noel, 2006). In the case of Nadia Ukrainy, the NBFI works with a number of different partners like the Polish-based Microfinance Centre for network affiliation and with Kiva as the source of external private-citizen funding.

Prior to 2003, there were no regulatory agencies in Ukraine to oversee operations of these NBFIs and as a result many were established and began to engage in money

Figure 6: Dnipropetrovsk Oblast Highlighted on Map of Ukraine

misappropriation activities. Since this time, the State Commission for Regulation of Financial Services Markets of Ukraine has adopted a legal framework for the regulation of these institutions that has discouraged many of these inappropriate institutions from pursuing business in Ukraine, increasing the opportunity to gain market share in the country.

6c. Operation and Structure of the Microfinance Institution

One of the principles of microfinance is the proximity of the branches to the people who are being served. This close proximity not only ensures that loan agents can keep a close watch on those who are receiving these loans, but more importantly it helps to establish a positive public relations image of immersing the institution into the community. Employing local citizens also establishes a firm trust with the surrounding community. This trust is imperative to ensuring the success of the organization.

Because the target population of this microfinance institution is rural farmers, it is important to situate the founding branch in an area of Ukraine that would not only be conducive to farming, but also have a large rural population. After extensive research, the Dnipropetrovsk oblast (see Figure 6) was selected as the location for the pilot program of this institution because of its location in the southeastern steppe ecological zone, which is home to Ukraine's most arable land and has a rural population of over 600,000 people (Rowland, 2004). This centralized administrative office would serve as the institution's headquarters and would administer the institution's first loans. A timeline for expansion will be explained later in this section.

This administrative office would originally be staffed with one loan officer selected from the local population, whose responsibilities would be to appeal to rural farmers via phone and in-person presentations where the officers would describe exactly how the institution works and the benefits of anaerobic digestion. In addition, loan officers would conduct initial training sessions for borrowers until other staff was hired. The loan officers would be given a base salary and benefits with opportunities for commission-based bonuses once borrowers that they had recruited repaid their lease in full, providing motivation for loan officers to encourage repayment. An engineering professional would also be hired on staff and would be responsible for working within the established budget to contract laborers on a per-project basis to travel to the farms, construct the anaerobic digesters, and also service broken digesters.

As the institution expanded (a timeline can be found at the end of this section), additional laborers would be hired to ease in the operation of the branch. For example, a training officer would be hired to train borrowers on the basics of how their loan works, how the institution functions, and how to operate and maintain their digester. This training officer would also initially serve as the human resources representative as expansion necessitated hiring of new personnel. One branch manager would also be hired to oversee the operations of the branch and ensure that all responsibilities were being completed. One bookkeeper, whose sole responsibility would be to track and report the number and amount of loans that were disbursed, would be hired as well.

6d. Loan Structure

When the institution is first created, only one loan product will be offered: a one-time lease of an anaerobic digester completely installed by the institution, with a value of $1035. The lease would include a servicing charge of $100 that would help to cover the costs of implementing the loan. As a result, the lease's total value would be $1135. This amount, which is approximately 53% of Ukraine's gross national income per capita, can be serviced easily and optimally by traditional microfinancing.

As the institution begins to expand and increases the number of borrowers, other loan products will be introduced. Seasonal loans are often required by farmers in order to purchase seeds and equipment necessary to grow crops. The need arises because of a mismatch of when they need money (in early spring when they plant the crops) and when they have money (in the fall after they have harvested and sold crops).

While microfinance is built on the foundation that a loan term should be kept short and repayment should be often, it is also important to ensure that the borrower has the ability and capacity to repay the loan within the defined term limit. As a result, borrowers will repay their loans monthly over the course of five years to encourage consistent savings and to ensure that the amount due for repayment is small and never burdensome.

Before we can calculate annual payments (A), we must first calculate the present value of the lease (PV_L), where r equals 5%.

$$PV_L = \frac{A}{r}\left(1 - \frac{1}{(1+r)^5}\right)$$

$$1135 = \frac{A}{.05}\left(1 - \frac{1}{1.05^5}\right)$$

$$1135 = \frac{A}{.05}(.2165)$$

$$56.75 = A(.2165)$$

$$A = 262.12$$

This annual lease repayment of $262.12 (or $21.84 monthly) would be a cost to the farmer for the first five years of having the digester.

In addition, the farmer would also be responsible for the cost of purchasing or manufacturing the corn silage that will be used as an input, with an annual cost of $580.19 each year over the entire lifetime of the digester. Also, operation and maintenance would be the responsibility of the borrower, estimated in section 5 at an annual cost of $31.05. Finally, we assume for the purpose of this thesis that the rural farmer would be willing and able to complete the annual labor (44 hours) required to feed inputs into the digester and periodically clean the structure.

During this time, the effective cost of fuel decreases from $280 per thousand cubic meters (39% of average farmers' income) to $140 per thousand cubic meters (19.5% of their income) as biogas replaces their imported natural gas. When we multiply the cost savings by the natural gas usage of the farmer, we find that it would result in a first-year fuel cost savings of $588 for the farmer.

Because the term of the loan is extended over a five year period, these farmers would begin to experience positive profits of $55.61 beginning in year 1 and continuing through year 5, as the lease repayment, silage cost, and operation and maintenance costs total $873.36 and the value of the biogas is $928.97. When the lease has been repaid in full beginning at year 5, the annual profits will increase to $317.73 a year for the remainder of the digester's lifespan, as the borrower no longer has the repayment cost so their annual costs decrease to $611.24 and revenues remain constant at $928.97 (see Figure 7).

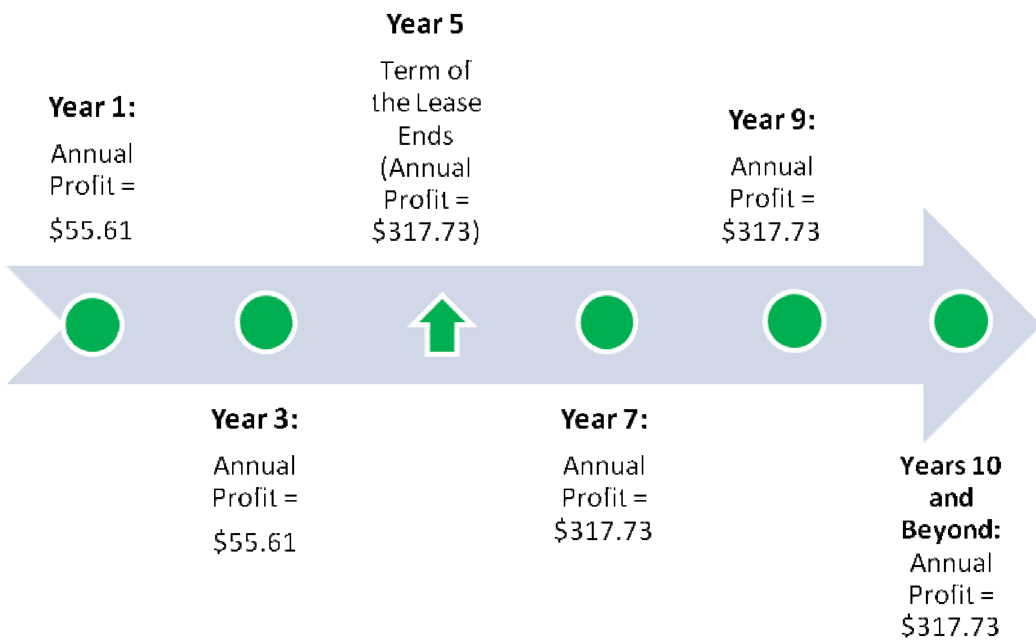

Figure 7: Timeline of Profits to Borrowers

The structure of the loans that would be given to borrowers would be based on a modified principle of solidarity lending, which was introduced in section 3. This principle believes that in order to provide non-collateralized loans, borrowers must organize themselves into groups of five in order to tap into the social capital of reliability and responsibility. While true solidarity lending will lend to the group as a whole and not to individuals, the logistics of providing digesters obviously makes this impossible. This modified solidarity lending practice states that in order for the second person to receive his or her loan, the first borrower must have attended all of the training courses necessary to receive the loan and begun the repayment process. In addition, each loan amount for each borrower must be approved by the entire group, ensuring that each group member is aware and involved in the process.

In order for the second borrower to receive his or her loan, the first borrower must have begun the repayment process and paid their first month's lease. If at any point an earlier borrower does not repay their loan, the entire group will be held responsible to help repay the loan of the delinquent borrower in order to continue the lending process.

This process continues onto the third, fourth, and fifth borrower and the lack of repayment of even one borrower can significantly hinder the loan process of all other borrowers in his or her group. This "solidarity" is able to leverage social capital to serve as the collateral generally needed for access to capital. The borrowing cycle does not end with the fifth borrower, however. In order for the first borrower to be eligible for the aforementioned seasonal loans and other additional loans that will be offered by the institution, the borrowing cycle must have been successfully completed and all five borrowers must be active in the repayment process (see Figure 8). While non-repayment is an issue that all microfinance institutions must account for, this institution is unique in the fact that the borrowers are not as mobile or likely to flee with unpaid loans because the farmers own large pieces of property with farm equipment and can easily be tracked down, preventing exploitation of the process. In addition, the cost savings and revenue from these digesters are reliable and certain. As a result, the repayment process will not be dependable on the success of an uncertain entrepreneurial venture, as is the case in many of the impoverished countries where microfinance exists.

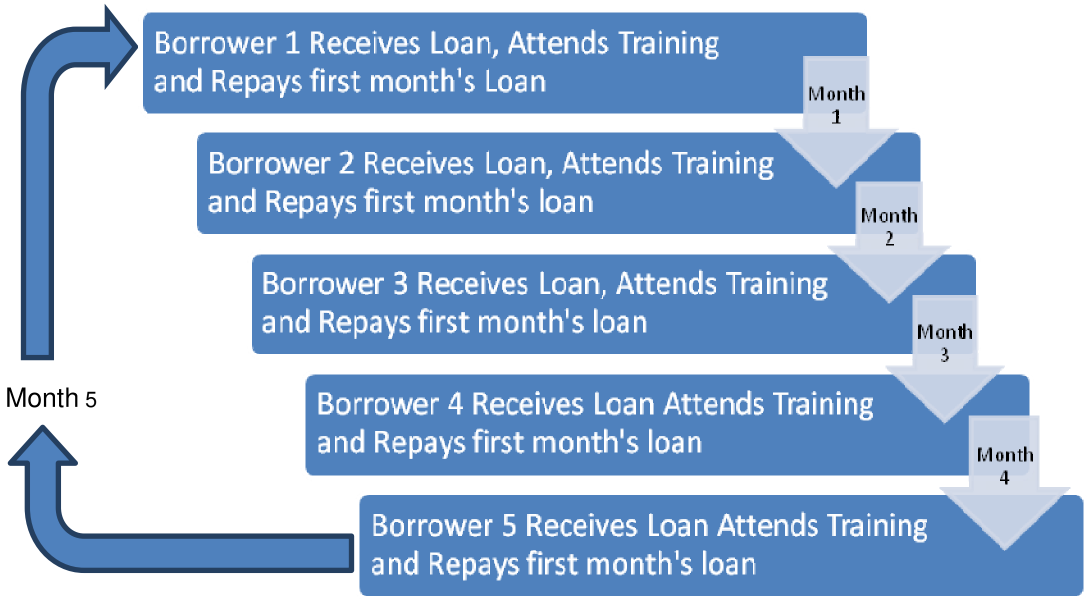

Figure 8: Institution's Borrower Cycle

6e. Portal for Funding

In the beginning of the institution, a heavy focus will be put on attracting angel investors and forward-thinking venture capitalists that would lend money to the institution (at a low or no interest rate) in order to be able to provide the first loans to be made to borrowers. This appeal is necessary because these non-banking financial institutions cannot accept deposits like a traditional bank

Once the institution has matured and established itself, a working partnership will be created with organizations that appeal to private citizens to give up the use of their capital for a period of time (generally around 6 months) so that the microfinance institution may use it for loans. The most popular of all of these organizations is a web-based funding portal called Kiva, who works with a number of field partners all across the world to showcase to philanthropic-minded citizens the stories of real, impoverished entrepreneurs in other countries that desperately need assistance. On the website, each entrepreneur has a picture and a stated goal of how much funding he or she needs to implement the project that they are proposing. The citizen can then pledge a certain amount of money through the website to help this entrepreneur achieve their goal, and the person at that time then "lends" their money to Kiva at a 0% interest rate, who then disburses these funds to a field partner to actually implement the loan. The field partner then collects the repayment of this loan over the following months and then repays Kiva. The original lender is generally repaid within 5-6 months. Therefore, the person can then "recycle" their pledge a countless number of times and can request a reimbursement of that pledge as long as they have been repaid their loan. For an illustrative example of the process, see Figure 9 below. Kiva boasts a 98.65% repayment rate and therefore there is little actual risk to the lender of losing their loan ("About Us," 2011).

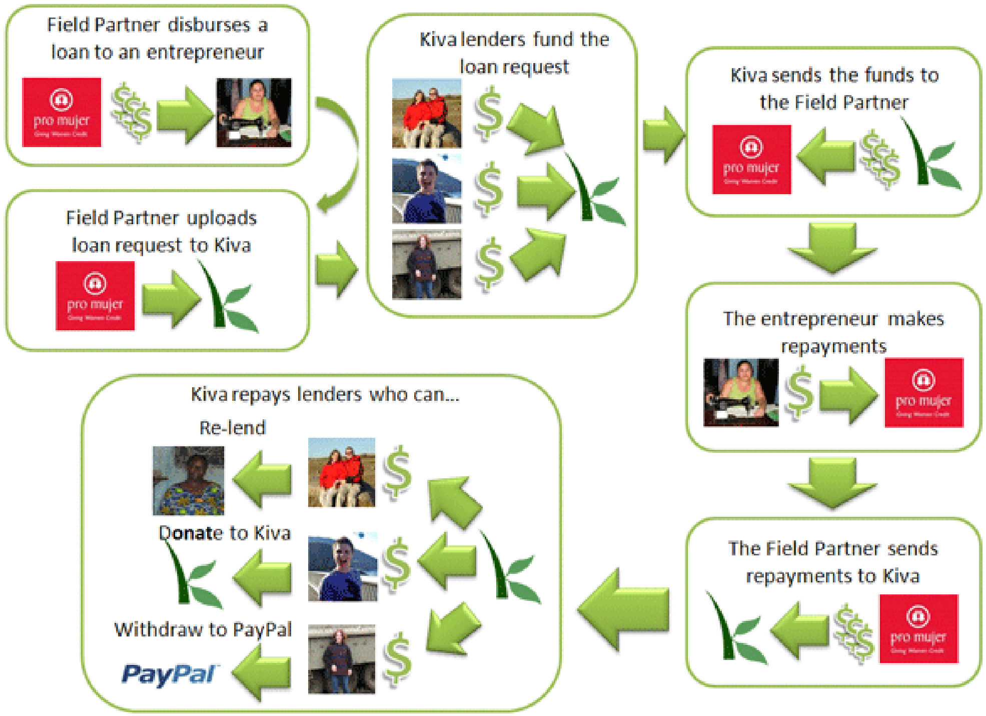

Figure 9: Kiva Loan Cycle

Kiva works in close partnership with over 130 field partners (microfinance institutions) around the world in order to implement these loans. There are strict requirements for becoming a field partner, including having an active portfolio of at least 1,000 borrowers, having a history of at least 2-3 years of lending, be registered as a legal entity in the country of origin, and having at least 1 year of financial audits. However, the benefits include a 0% interest debt capital, a short time period (1 week) required to pilot the program, low administrative costs of less than 1% as a factor of capital raised, and improved staff morale.

The process of posting borrower information onto the Kiva website would fall onto the responsibility of the loan officers, who would take photographs of the farmers, translate their background stories, and upload the images onto the website.

As seen above, this strategy of raising capital could only be implemented as the microfinance institution matured and achieved the goals required to become a Kiva field partner. Before these goals were reached, the institution would seek angel investors and philanthropic contributions in order to initially provide loans. For the purpose of this paper, we assume philanthropic investors loan capital to the institution at a 0% interest rate.

6f. Costs of the Institution

"Microfinance is a high touch, high cost business," says Adrian Gonzalez of the Microfinance Information Exchange. Operating expenses represent 62 percent of the interest rate that is charged to borrowers and includes a number of costs borne by the institution. These costs are a result of the institution's focus, as it is much more expensive to disburse (100) $1,000 loans that it is to disburse one $100,000 loan. The administrative costs of processing the high number of applications, the physical time spent traveling and visiting with borrowers, the costs of training materials to conduct training seminars, and the operation of a large number of branches necessitated by the need for being close to borrowers all contribute to this high cost of operation. Because some of these costs (rent, salaries, training seminars that can accommodate hundreds of borrowers) are fixed costs, the smaller the amount of loans and the smaller the institution, the higher the cost of doing business.

In order to eventually achieve financial self-sufficiency, the microfinance institution must pass these costs onto the borrowers in the form of fees on their loans. Critics complain that many institutions charge fees that are as high, if not higher, than the poor person's alternative: moneylenders. However, this institution would be able to keep operating costs low because the loan amount is considerably high and specialization of job duties within the institution would ensure efficiency. In addition, by at first offering only one product to borrowers, it would reduce the variable costs of being trained and servicing many different products.

Obviously the largest cost to the microfinance institution is the fact that there is a mismatch of cash flows, as they are required to pay for the cost of installing the digester in a lump sum; however they don't fully recover those costs from the farmers until 5 years later. That is why it is so important to first find investors that would be willing to lend the use of their capital during this time.

In addition, like all businesses, microfinance institutions have normal operation costs that are fixed. For instance, the wages of salaried employees would cost the institution approximately $280 per month per employee hired. The cost of renting space in an office building in the Dnipropetrovsk region will cost the institution approximately $500 per month. Utilities such as water, heat, phone service, and internet will cost the institution a further $100 per month. Original investments in office equipment like computers and fax machines will result in a cost of approximately $1000 per month for the first year. After the first year, the cost will drop to $300 per month for the remaining years, as the costs shift to less expensive training materials and other accessory expenses. Finally, the World Bank completed a study in June 2010 that found that the filing expenses of creating a business in Ukraine (opening a bank account, registration fees, and preparing a company seal) totaled a one-time fee of $136 that would be paid in the first year ("Starting a Business," 2010).

6g. Expansion Timeline

The institution aims to have consistent growth as it expands in new loans, total loans outstanding, and total operating branches to distribute these loans. In year one, the institution's first branch office will be established and will begin to disburse loans with a staff of two employees, one loan officer to establish a client base and one engineer to coordinate the construction of the digesters. In the first years, exponential growth of new loans would be expected and the number of staff would increase exponentially as well. The exponential growth of the institution would also translate into high costs that would not be able to be covered by the small amounts of revenue being generated from the repayment of the loans. As a result, the institution would rely on external financing and not be financially self-sustainable until year 6.

The institution would achieve a number of milestones during this time, distributing its 100th loan approximately 1 year after it gave out its first. In addition, the institution would qualify to become a Kiva partner approximately 3 years after its creation when it distributes its 1000th loan. At that point, it would generate significant interest and publicity from national media outlets, as well as begin receiving capital through Kiva, that would cause an increase in the number of new loans it disbursed during the third year.

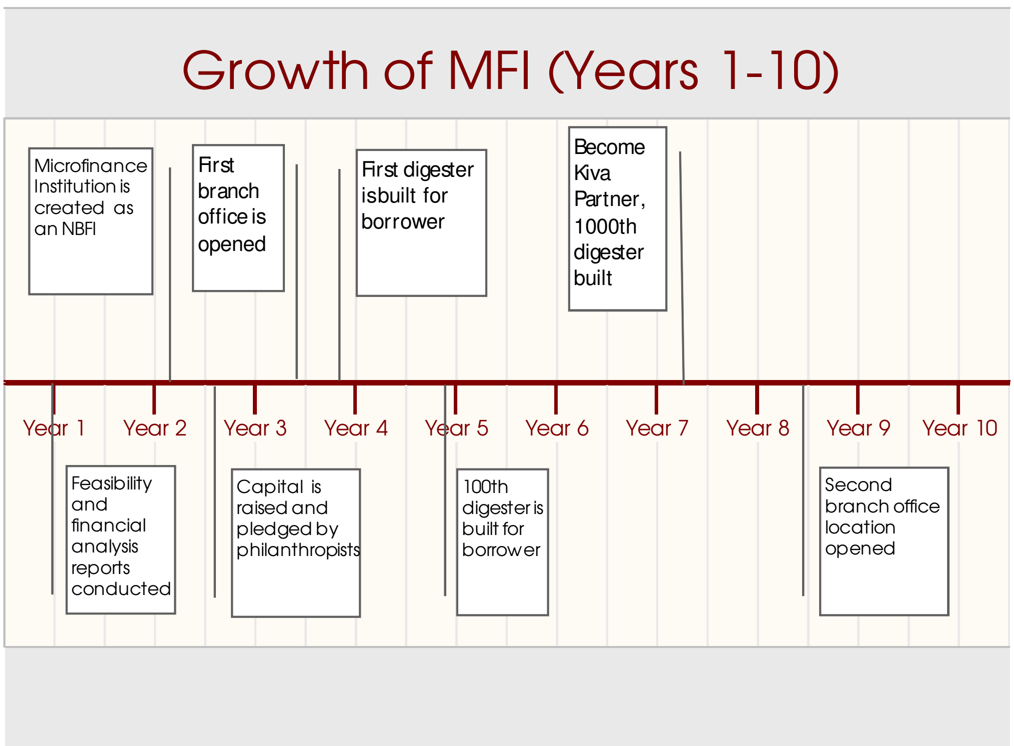

Figure 10: Timeline of Microfinance Institution Growth

In the fifth year after its creation, the institution would open a second branch elsewhere in Ukraine (see Figure 10 for the full timeline) in order to accommodate more rural farmers that would increase the institution's cost of labor, rent, utilities, and office equipment, but would undoubtedly provide a much larger target population for the institution.

In year 6, the institution would have matured into a stable organization that would see continued, steady growth. In addition, the number of outstanding loans (those which are being repaid to the institution) would also be high enough at this point to allow the institution to become financially self-sustainable and post a modest profit in that year of approximately $400,000. The microfinance institution would actually experience for the first time a decrease in the number of new loans disbursed that year, as saturation of the target population begins to occur. This decrease will continue until a new branch is constructed, which would occur once every four years under the linear growth model. At that point, the number of new loans would become cyclical, decreasing until a new branch was opened at which point the number would begin to increase again, and so on. The number of new staff hired by the institution would increase by 2 each year, except in those years where a new branch was opened, when the number of new staff would increase by 3.

As a result of this linear growth, at year 10 the number of new loans issued each year would begin to level out to approximately 1,800 per year (see Figure 11). Beginning in year 13, the total numbers of loans outstanding at any point in time would be approximately 8,900 (see Figure 12) and annual profits of the institution would remain constant at approximately $1.1 million. The first generation of the digesters built would continue until year 30, at which point those digesters that were built in the first year would begin to be phased out. At this point in year 30, nearly 51,000 digesters would have been built and in operation (see Figure 13 for an illustration of this digester growth).

Finally, see Appendix B for a full analysis of costs and revenues of this institution.

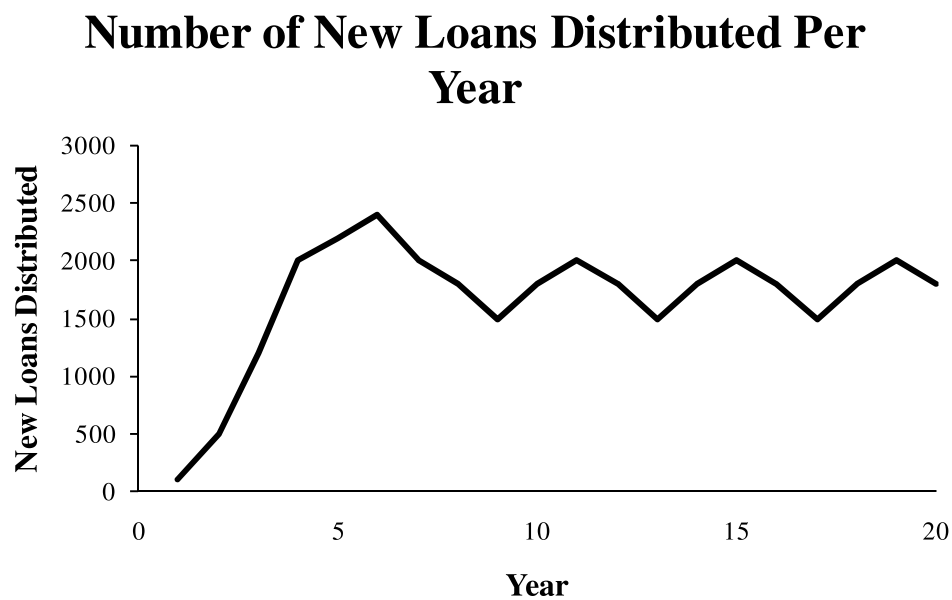

Figure 11: New Loan Growth

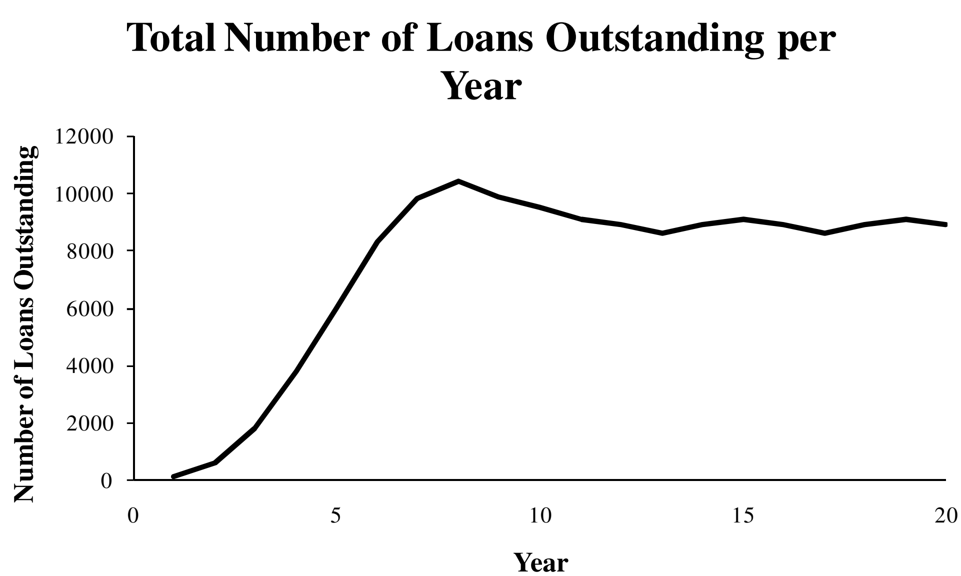

Figure 12: Projected Outstanding Loan Growth

Figure 13: Projected Digester Construction Growth

7. Results

7a. The Environmental Benefits to This Institution

As mentioned in section 3, anaerobic digesters are carbon neutral and thus their greenhouse gas reduction comes as a result of offsetting the emissions that would have been produced had the farm instead used a fossil fuel-based natural gas. In order to calculate these offset emissions, we must determine the amount of greenhouse gases that would have been released into the atmosphere from burning 3,317 cubic meters of natural gas annually (the amount of methane produced per digester from section 5).

First, we must calculate the heat content of the methane that is produced. A table located on the website The Engineering Tool Box has found the net heating value of methane to be 910 British thermal units (Btu)/ft3. In order to convert this value into cubic meters, we must multiply the number by a factor of 35.315. As a result, we find that the heat content per cubic meter is (910)(35.315) = 32,317 Btu/m3. When we multiply this number by the amount of cubic meters of methane produced annually (3,317) we find that annual heat content of each digester is approximately 106.597 million Btu.

Second, we must calculate the amount of CO2 that is emitted from the generation of this amount of heat. The Department of Energy has determine that 117.080 lbs of CO2 is produced per million Btu from methane. In order to convert this number into the metric system, we must first multiply 117.080 lb by .454 kg/lb to find that 53.2 kg of CO2 is produced per million Btu.

Finally, we must multiply the amount of Btu generated from each digester by its CO2 production constant. Doing so, we find that (106.597 million Btu)(53.2e kg/million Btu) = 5671 kg. Converting this into metric tons, we find that each anaerobic digester offsets 5.67 metric tons of CO2 annually.

Aggregating all of the digesters, we can easily calculate the total amount of CO2 that is offset annually from constructing these digesters. In year 1, total carbon offsets will amount to 567 metric tons and will continue to grow annually. For example, in year 30 when 51,000 digesters are in operation there will be a carbon offset of over 260,000 metric tons annually (see Figure 14).

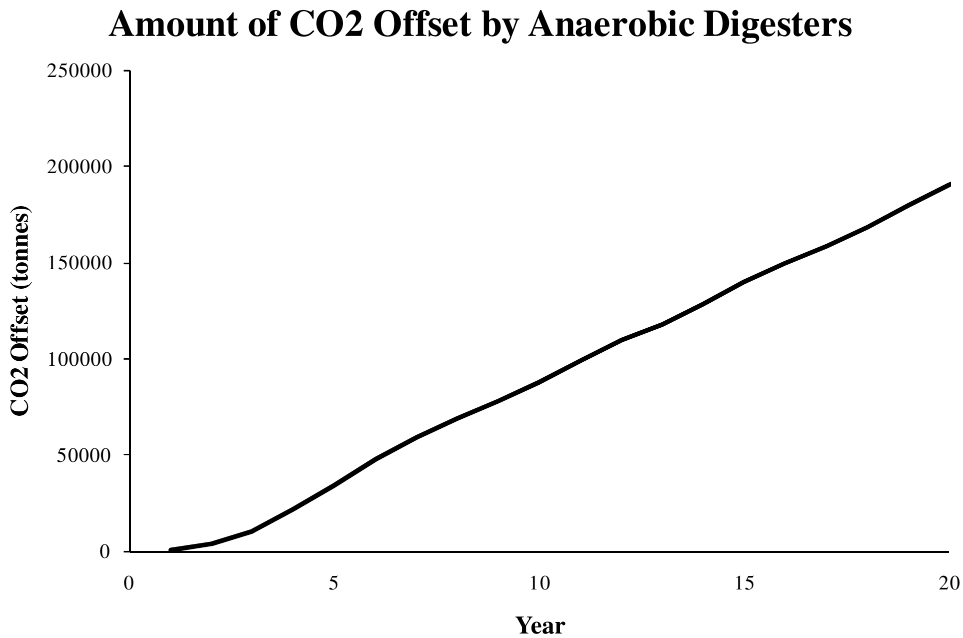

Figure 14: Projected Carbon Dioxide Offset Growth

7b. Carbon Trading: The Financial Benefits to Anaerobic Digestion

The UNFCCC has succeeded in transforming international environmental policy in the last decade in such a way that it has created an enormous number of financial incentives to implementing such renewable energy projects like anaerobic digestion. The foundation of the Kyoto Protocol has committed signatory countries to reduce their greenhouse gas emissions by a particular percentage in relation to a benchmark year that has been selected. Although this commitment encourages countries to begin the construction of renewable energy projects within their borders, the protocol also allows for countries to engage in international transactions in order to gain other emission reductions, operating on the principle that reductions in carbon emissions anywhere have the same impact on our shared atmosphere.

The most exciting of these new incentives involves the Clean Development Mechanism (CDM), which was created under Article 12 of the Kyoto Protocol, which created a carbon trading market where developed countries could purchase Certified Emission Reductions (CERs) from underdeveloped countries. These CERs are, in effect, certificates stating that projects conducted in these underdeveloped countries were proven to have reduced exactly 1 tonne of carbon dioxide equivalent ("Emission Reductions Unit," 2011).

These CERs are traded on the European Climate Exchange (ECX), which functions much like a stock market where buyers (in this case companies and private individuals) purchase enough CERs from sellers (brokers) in order to come into compliance with their respective goals or mandates for emissions reductions.

While CERs are generated from projects that originate in underdeveloped countries, there are also Emission Reduction Units (ERUs) that are generated from projects implemented in developed countries under the Joint Implementation mechanism, where developed nations can purchase emissions reductions from other developed nations. Ukraine is considered a developed nation under the Kyoto Protocol and therefore any offsets originating from projects in this country would generate ERUs. These ERUs have just recently begun to be traded on the ECX and Ukraine has emerged as the largest issuance of these certificates to date.

There is some precedent established for JI projects that in fact generate these ERUs for sale. The Palhalma Biogas Plant, a digester located at a meatpacking plant in Hungary, was recently brought online in 2008 and generates over 37,000 ERUs a year that it then sells on the ERU market ("Palhalma Biogas Plant," 2011).

The most recent data from the European Climate Exchange values June 2011 future contracts of ERUs at $18.74/metric ton of carbon emission reduction.

As a result, once the institution has matured there is real and significant opportunity for this institution to couple together the offsets achieved from its thousands of anaerobic digesters and to sell these ERUs on the ECX. In year 30, the annual value of these ERUs could reach nearly $5.5 million (see Figure 15).

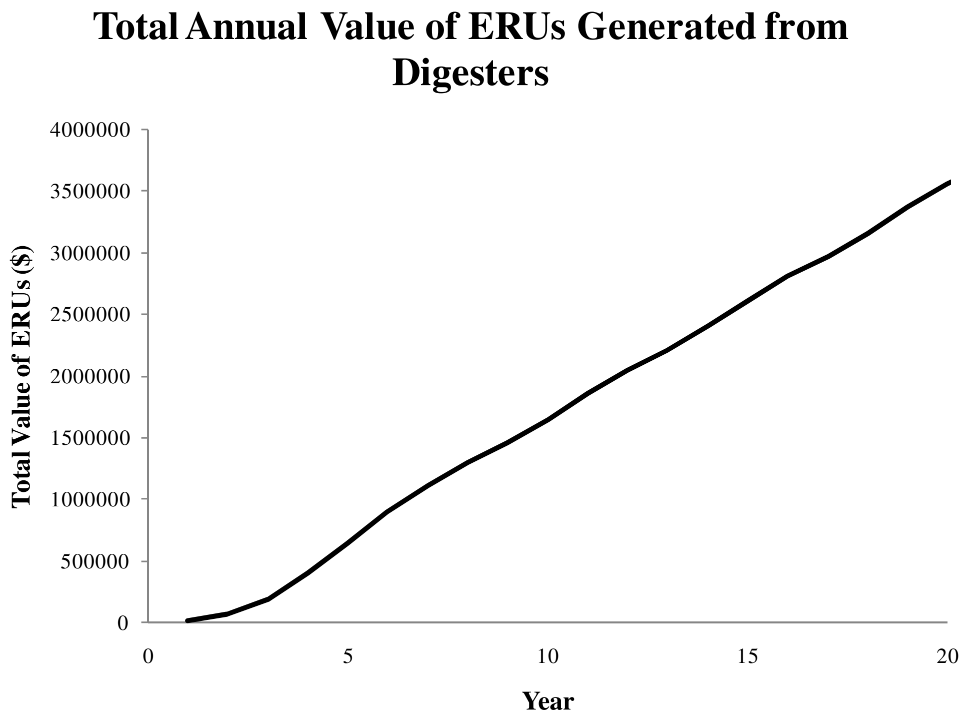

Figure 15: Projected Annual Value of ERUs

7c. The Effects on Natural Gas Imports from this Institution

Finally, it is important to calculate the impact that this institution is having on the amount of natural gas that is imported to Ukraine each year. As mentioned, approximately 75% of Ukraine's natural gas usage (60 billion cubic meters) is imported from Russia and Turkmenistan each year.

As found in section 5, each anaerobic digester produces 3,300 cubic meters of methane per year. In order to calculate the total amount of natural gas produced each year, we simply multiply 3,300 by the number of digesters. As a result, we find that while in year 1 there is a total annual natural gas production of only 330,000 cubic meters, by year 30 the total annual production has grown to 168.3 million cubic meters. While this number represents only .3% of Ukraine's annual natural gas imports, it would amount to a very significant increase in the amount of renewable energy as a portion of the country's energy production (see Figure 16).

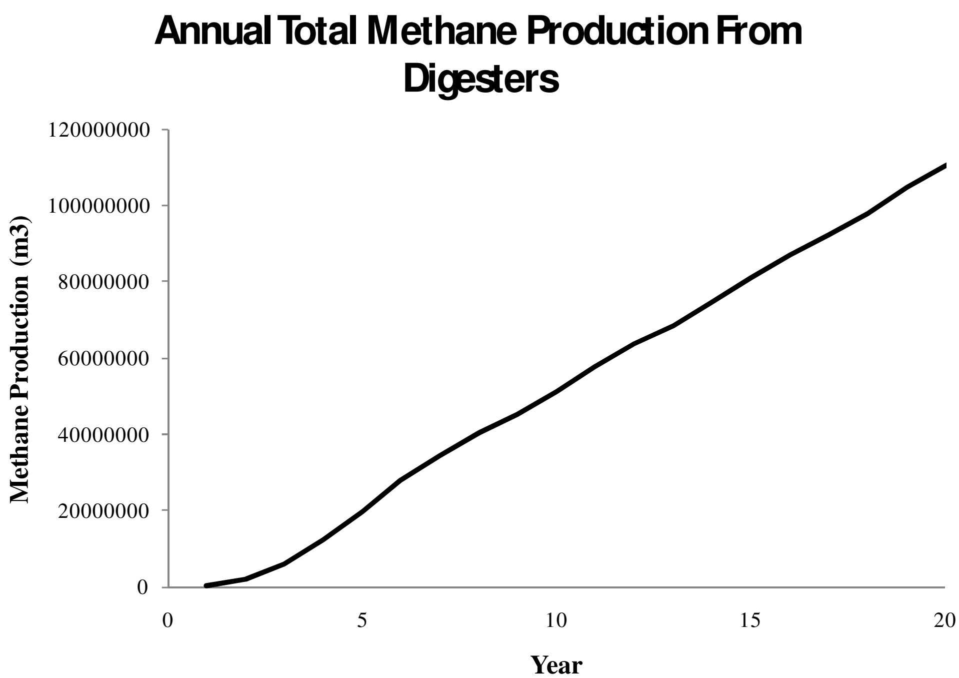

Figure 16: Projected Methane Production from Digesters

7d. Summary

In conclusion, the promise and potential for renewable energy is not simply welcomed, it is absolutely imperative in order for Ukraine to prevent a natural gas conflict that could have repercussions for decades to come. While the costs of natural gas are only increasing, the costs of renewable technologies are decreasing substantially due to producers achieving economies of scale and new research increasing efficiency. Anaerobic digestion proves particularly promising as it is a low-cost, highly efficient process that could be implemented in Ukraine. Rather than force the burden of a large lump sum payment on poor, rural farmers, it has been shown that it is financially feasible to create a microfinance institution that would lease these digesters and allow farmers to repay loans over a 5-year time period. The environmental, financial, and societal impacts that this project could have would reverberate across the world. It would fuel Ukraine's future while simultaneously changing the lives of thousands of people all across this eastern European country.

APPENDIX A

Size of Digester	9

COSTS

Initial Cost of Construction

Installation Cost (USD)/m3	70
Average Cost of Installation	630
Man Hours for Construction (9 hours/m3)	81
Total Labor Cost (@ $5/hour)	405
Total Installation Cost	1035

Operation and Maintenance Costs

Annual O&M costs (3% of digester system turnkey cost)	31.05
Labor (44.34 hours annually * $5/hr)	221.7
Annual Maintenance and Labor Costs	252.75

Input Costs

Market Price of Corn Silage (per metric ton)	$55.96
Quantity of Silage per Batch (metric tons)	0.288
Total Cost of Silage per Batch	$16.12
Length of Retention Time (days)	10
Batches per Year	36
Annual Silage Cost	$580.19
Annual Maintenance and Labor Costs (from above)	$252.75
Total Annual Costs of Operation	**$832.94**

REVENUES

Quantity of Silage per Batch (metric tons)	0.288
Biogas Yield of Silage (m3 per metric ton	400
Biogas Production per Batch (m3)	115.2
Biogas Production per Year (m3)	4147.2
Amount of Methane Produced per m3 Biogas (%)	80%
Amount of Methane Produced Per Batch	92.16
Number of Batches Per Year	36
Methane Production per Year (m3)	3317.76
Price of Natural Gas (100% Methane) per 1000 m3 in Q2 2011 (in USD)	$ 280
Total Annual Value of Methane Output	**$928.97**

TOTAL PROFIT	**$96.03**

APPENDIX B

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 15	Year 20	Year 25	Year 30
REVENUES (MONTHLY)														
New Loans	100	500	1,200	2,000	2,200	2,400	2,000	1,800	1,500	1,800	2,000	1,800	1,500	1,800
Loans Outstanding	100	600	1,800	3,800	6,000	8,300	9,800	10,400	9,900	9,500	9,100	8,900	8,600	8,900
Revenue (Monthly)	2,184	13,104	39,312	82,992	131,040	181,272	214,032	227,136	216,216	207,480	198,744	194,376	187,824	194,376
Revenue (Annual)	26,208	157,248	471,744	995,904	1,572,480	2,175,264	2,568,384	2,725,632	2,594,592	2,489,760	3,239,964	3,168,756	3,061,944	3,168,756
COSTS (MONTHLY)														
Installation of Digesters	8,625	43,125	103,500	172,500	189,750	207,000	172,500	155,250	129,375	155,250	172,500	155,250	129,375	155,250
Number of Operating Branches	1	1	1	1	2	2	2	2	3	3	4	5	7	8
Staff	2	5	8	10	15	17	19	21	24	26	37	48	60	71
Cost of Labor	560	1,400	2,240	2,800	4,200	4,760	5,320	5,880	6,720	7,280	10,360	13,440	16,800	19,880
Cost of Rent	500	500	500	500	1,000	1,000	1,000	1,000	1,500	1,500	2,000	2,500	3,500	4,000
Cost of Utilities	100	100	100	100	200	200	200	200	300	300	400	500	700	800
Cost of Office Equipment & Accessories	1,000	300	300	300	1,300	600	600	600	1,600	900	1,200	1,500	2,800	2,400
Filing Fees	11	0	0	0	0	0	0	0	0	0	0	0	0	0
Costs (Monthly)	10,796	45,425	106,640	176,200	196,450	213,560	179,620	162,930	139,495	165,230	186,460	173,190	153,175	182,330
Revenue (Annual)	26,208	157,248	471,744	995,904	1,572,480	2,175,264	2,568,384	2,725,632	2,594,592	2,489,760	3,239,964	3,168,756	3,061,944	3,168,756
Costs (Annual)	129,556	545,100	1,279,680	2,114,400	2,357,400	2,562,720	2,155,440	1,955,160	1,673,940	1,982,760	2,237,520	2,078,280	1,838,100	2,187,960
PROFITS (Annual)	(103,348)	(387,852)	(807,936)	(1,118,496)	(784,920)	(387,456)	412,944	770,472	920,652	507,000	1,002,444	1,090,476	1,223,844	980,796
Total Number of Digesters	100	600	1,800	3,800	6,000	8,400	10,400	12,200	13,700	15,500	24,600	33,500	42,100	51,000
Amount of CO2 offset (tonnes)	567	3,402	10,206	21,546	34,020	47,628	58,968	69,174	77,679	87,885	139,482	189,945	238,707	289,170
Value of ERUs	10,626	63,753	191,260	403,772	637,535	892,549	1,105,060	1,296,321	1,455,704	1,646,965	2,613,893	3,559,569	4,473,369	5,419,046
Natural Gas Produced (m3)	330,000	1,980,000	5,940,000	12,540,000	19,800,000	27,720,000	34,320,000	40,260,000	45,210,000	51,150,000	81,180,000	110,550,000	138,930,000	168,300,000

SUMMARY

With rising gas prices, countries all across the world are finding themselves in precarious and vulnerable situations. With increasing globalism also comes increasing dependence on other countries for a variety of imports, the most important of which being energy. The production and consumption of natural gas and other fossil-fuel based energy products will undoubtedly become a more and more contentious issue as global supplies decrease if demand for these fuels remains constant or increases. Few countries have had to face this situation as head-on as Ukraine. Relying on any country for 69% of its natural gas supply would be particularly problematic, but when this country is also a former hostile occupier of the country it is easy to see how this situation has the potential for conflict that could reverberate across the world.

This paper seeks to identify and evaluate alternative fuels that could be implemented in Ukraine as a part of a strategic plan to reduce Ukraine's dependency on Russia for energy. While a number of renewable energy technologies exist, anaerobic digestion was selected because of its versatility, scalability, and relatively low cost of construction and operation. In addition, these digesters can be fueled by any biodegradable material. One of the inputs with the highest biogas potential (efficiency) is corn silage, a product used by fermenting undesired parts of the corn stalk that is generally used for feeding livestock. The process for creating this silage requires very simple techniques and on many rural farms across the country this silage is already produced.

As a result, these rural farms quickly emerged as a potential target population for these digesters for a variety of reasons, including: ownership of large amounts of land upon which to build these digesters and existing production of the input. Using the rural farmer's annual demand of 4,200 cubic meters of natural gas, I was able to derive the size of the digester required to produce exactly that amount of biogas. The size of the digester needed was determined to be 9 cubic meters. By calculating the value of the biogas produced (determined to be 80% methane) and identifying the total costs of operation, maintenance, and producing the corn silage needed as an input, I conducted a financial analysis of the digester (not yet taking into account the cost of construction) and showed that this particular digester size would produce annual profits of $96.03 a year and have a positive net present value of $442. In addition, while this paper did not assign a value to the benefits afforded to a rural home from being completely independent from foreign energy, it is assumed that the dependability and self-sufficiency of the system would add value to the project.

However, as I mentioned previously, we have not yet taken into account the cost of construction both in our calculations and in our strategy for implementation. While these rural farmers have the optimal location for installation of these digesters, they do not have the financial means to afford a large lump sum payment of $1,035 required for the materials and labor necessary to construct the digester. In addition, these rural farmers (with annual incomes of approximately $3,000) do not have access to the traditional bank loans that would allow them to borrow this amount of money.

This is where the role of microfinance comes in. Microfinance has successfully been introduced in countries all across the world and is defined as the provisioning of credit to low-income people who would otherwise not have access to it. Ukraine is no exception, as it is home to two microfinance institutions (MFIs) that provide no-collateral seasonal agricultural loans and loans for entrepreneurial ventures. This paper postulates the creation of an MFI named "Zapravky May□butnye Ukraïni" (which is Ukrainian for "Fueling Ukraine's Future") that would begin offering one product in the form of a lease for the construction of the digester. This lease amount would be $1135 (the cost of the digester's construction plus a $100 processing fee) that would be repaid over the course of five years. The borrowing methodology would be a modified version of the solidarity lending principle. In absence of collateral, the institution would require borrowers to organize into groups of five and leases would only be extended to the second borrower if the first borrower had begun the repayment process and attended all required training sessions, and so on until the fifth borrower received the digester. Once all five borrowers had received a digester and begun the repayment process, the cycle would return to the first borrower who would then be eligible for seasonal agricultural loans that could assist the farmer in building their capacity.

A financial analysis was then conducted for both the borrower and the institution to evaluate the effect that these leases would have on the financial means of both parties. It was found that borrowers would benefit from producing this biogas and being able to offset completely their previous purchase of natural gas. In the first year through the fifth year, the value of the methane produced from the digester (80% of the biogas) equated to $928.97 while the cost of lease repayment, corn silage, operation, and maintenance amounted to $873.36. This left the borrower with a slim, but positive, annual profit of $55.61 in the first five years. Once the lease had been repaid in full, their annual profit would increase to $317.73 as their annual costs decrease to $611.24 and their revenues remain constant at $928.97.

In addition, ZMU would also be able to generate profit from the operations, although not immediately due to the structure of its cash flows. While their costs (in the form of paying for the materials and labor necessary for the construction of the digester) would be due as a lump sum, their revenues (in the form of borrowers' lease repayment) would not recover those costs until 5 years later. As a result, the institution would not become self-sustainable and post profits until year 7 of operations. At that point, the institution would have matured and begun to level out to issue approximately 1,800 new loans per year, have an outstanding loan portfolio of 8,900 loans being repaid, and annual profits of the institution would be approximately $1.1 million. This paper extrapolated growth until year 30, at which point the digesters issued in year 1 would be taken out of commission, when nearly 51,000 digesters would have been built and in operation.

The environmental benefits that this institution could generate would come as a result of offsetting emissions that would have otherwise been released if these rural farms had continued burning natural gas. This is due to the fact that anaerobic digestion is a carbon neutral system, as the corn that is being used as an input has already removed carbon from the atmosphere. As long as the undigested material that is removed from the digester after the biogas has been produced is used as a fertilizer to grow more corn, the system is carbon neutral and all emissions from the burning of the biogas are offset. As a result, this institution would be responsible for an amount of carbon dioxide offset equal to 567 metric tons in year 1 that will grow to over 260,000 metric tons annually in year 30.

These carbon dioxide offsets have financial benefits too. Projects that help to offset one metric ton of carbon dioxide can be eligible for the production of Emission Reduction Units (ERUs) that can be sold on an international market. The European Climate Exchange currently values these ERUs at $18.74/metric ton of carbon dioxide offset. The combined offset of digesters all across Ukraine built from this institution has the potential to generate a significant amount of additional revenue to this institution, approximately $5.5 million annually in year 30.

Finally, the amount of methane (natural gas) that is produced from these digesters is an important finding of this paper, as it directly addresses the initial problem of energy dependency. In order to determine this number, I multiplied 3,300 cubic meters of methane (the amount of pure methane generated by each digester) by the total number of digesters in operation in year 30 (51,000) and found that the natural gas production that this institution is responsible for would be 168.3 million cubic meters in year 30.

While this paper concentrated on a particular country, the importance and significance of this paper is in fact the implications that this institution could have on other countries all across the world. Ukraine is absolutely not alone in being dependent on other countries for energy. In fact, other than the major producers of fossil fuels, there is some level of energy imports present in every country's economy. The advantage and uniqueness of this project lies in the fact that its technology can operate in almost any climate and its microfinance methodology can be transferred to nearly any low-income country in the world. With rising oil and natural gas prices, more and more of these renewable technologies will become financially feasible. As our world's supply of energy decreases and demand remains constant, or increases, we must be prepared for identifying alternative sources of where we obtain our energy from. For when the wells run dry, who will be left standing out in the cold?

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