Dean Dzoja
AGR*1110
University of Guelph

Micro Turbines

December 1, 2015

Section 1

Nepal is a beautiful tiny country. Ontario is about seven and half times bigger than Nepal. The capital city of Nepal is Katmandu, and the most recognized tourist attraction in Nepal is Mount Everest. Their population is roughly 31 million people, which is 4 million less than Canada. However when you compare the size of Canada to Nepal their population is respectively big. Unlike Canada, Nepal is a developing country and the majority of their population lives under the poverty line. About 70% of the labour force in Nepal is engaged in Agriculture, and most of them are subsistence farmers. This means that they only grow enough food to feed themselves and their families. The Nepalese GDP per capita is $694, while Canada's is $51,958. Which just shows how underdeveloped their economy is. Being a subsistence farmer occupies most of their time and they can't afford to pursue other ventures like a better education, which would help them succeed and grow the countries economy. Canada's labour market is only 6% involved in agriculture. The numbers have been declining year after year due to more industrial farming and the increasing manufacturing sector in Canada. Another important fact of Nepalese life is that most of their population is living without any form of electricity. Their national electricity production is about 3.4 billion KWH. That numbers seems big but when taken into account that Canada produces 644 billion KWH, it puts the Nepalese output into perspective of how underdeveloped that industry is in Nepal. Therefor most of their population lives without access to basic power and can't improve their productivity. Nepalese farmers mainly grow Maize, rice, wheat, barley and millet. Nepal is separated into three general regions The Mountain region,

where Mount Everest is located. Highlands, and Terai. The mountain region isn't very suitable for agriculture, however many farmers practice livestock farming in this region. Secondly, the highlands just under the mountain region, where most farmers implement terrace farming to prevent erosion on the steep slope. The main crops they grow here are potatoes, and corn. Lastly, the low land region or the *Terai* region. This is where most of the agriculture takes place in Nepal because it has the most fertile land and it is relatively flat. In the Terai region they mostly grow rice on paddy farms, but anything can grow here really.

Not many people really know what a microturbine is. Micro turbine technology has become more and more lucrative for farmers and other industries, due to its low cost operation and efficient energy output. This technology was introduced recently and has become an increasingly popular form of clean energy generation. The main fuels that run a microturbine vary. Many of the farmers in Canada and the US use natural gas, or agricultural waste such as methane from manure. Essentially anything that can be burned is an energy source. A specific fuel that many of the Nepalese farmers would have is agricultural waste. All that is required of the farmer is to put in their left over biodegradable waste from harvest into the micro turbine, or collect animal waste for the methane gas. This type of energy production from plant waste is called *biomass energy*. The fuel is put into the turbine and the turbine is turned on. The generator than burns the fuel and produces steam as a reaction. This turns the turbine inside. The turbine is the only moving part in the whole system and that makes the turbine easy to use and maintain. It only requires periodic maintenance but can run for thousands of hours

before it needs to be cleaned and looked after. These turbines would be extremely efficient and reliable in developing countries due to its fuel versatility. Because most farmers in these underdeveloped countries are farming without electricity, the microturbine is an easy and effective way of providing power to these agriculturalists that are far away from the gird, increasing their productivity and making them more efficient in their planting and harvest.

Lets look at the biggest microturbine company in the world. *Capstone Microturbine Corporation* is a giant manufacturing company originally from the United States but has now grown to a globalized scale. The CEO is Darren R. Jamison and the company was established in 1988. Capstone became a public company on June 29, 2000. Capstone has distributors all across the world including many parts of western Canada. They are a partner of the *U.S. Environmental Protection Agency of Combined Heat and Power,* which strives to improve the national infrastructure and reduce greenhouse gas pollutants. What makes this company a perfect distributor is because they have manufacturing plants in India, which is one of the adjacent countries to Nepal. Therefor the plant in India would construct the turbine and truck it over to Nepal. However, If Capstone did decide to ship their turbines from the States, here are the steps they would most likely take. Capstone is headquartered in California, Los Angeles. Los Angeles also has a shipping port that goes to many pacific countries. Step one would be building the turbine. Once a turbine has been built it would get loaded on a Capstone corporate truck and taken to the port of Los Angeles. Once loaded into a freight container, it can be placed on a ship on its way to India. The turbine would than make its way across the Pacific

Ocean to the port of Kolkata in India. From this port, the turbine could get on a truck from a logistics company in India such as *Global Express Service* or *Falcon Freight Link* just to name a few. The transportation company would drive the turbine up to Nepal where it would get handed off to the customer who placed the order. Whether it is a farmer or an international development agency, the turbine will get delivered. Capstone is also the leading company in producing clean micro turbine technology. They promote clean and efficient energy production and intend to improve their technology overtime to make micro turbines the most environmentally friendly source of simple, compact electricity production. Capstone has already sold 8,603 individual units around the world. Capstone has many models that they market, but realistically the C30, which is the smallest one, is probably the best. The C30 produces enough electricity for a single home, or a Nepalese farmer. Because a farmer in Nepal won't typically require a lot of electricity the smaller model is perfect because it is the cheapest and the most compact. The C30 is about the same size as a refrigerator. The compact generator can be installed next to a house or a barn and provide local electricity for appliances, tools, lights or other machines used for processing.

Capstone Micro Turbine Corporation did a case study on a pig farmer in South Africa during december in 2011. The farmer owns a commercial swine farm. The company wanted to see how the farmer was doing with their new 65 KWH micro turbine. The case study was to examine the efficient use of the micro turbine when using biogas produced by the commercial pigs as fuel. Overall, The micro turbine reduced the farmers operating costs, lowered the overall emissions and

provided enough electricity to power the 1000 pig operation. Methane gas, which is one of the by-products of pig farming and is also 21 times more hazardous to the atmosphere than carbon dioxide, is released by pigs as a by-product. With the installation of the micro turbine, the amount of methane gas emission has been dramatically reduced helping lower the environmental impact of the pig farm. Additionally, the farmer was impressed with the micro turbines quick ability to transition from relying on electricity from the grid to becoming a standalone generator. The micro turbine on the pig farm is used to heat the farm, run the ventilation system and pump water. The micro turbine was able to reduce the farmer's electricity usage by 30%. This is just one example of the real world applications for a micro turbine and it outlines the benefits to many farmers and producers. Micro turbines don't only have practical uses for farms, they can be used anywhere whether it be at a school, business, residential homes/buildings or transportation.

Section 2

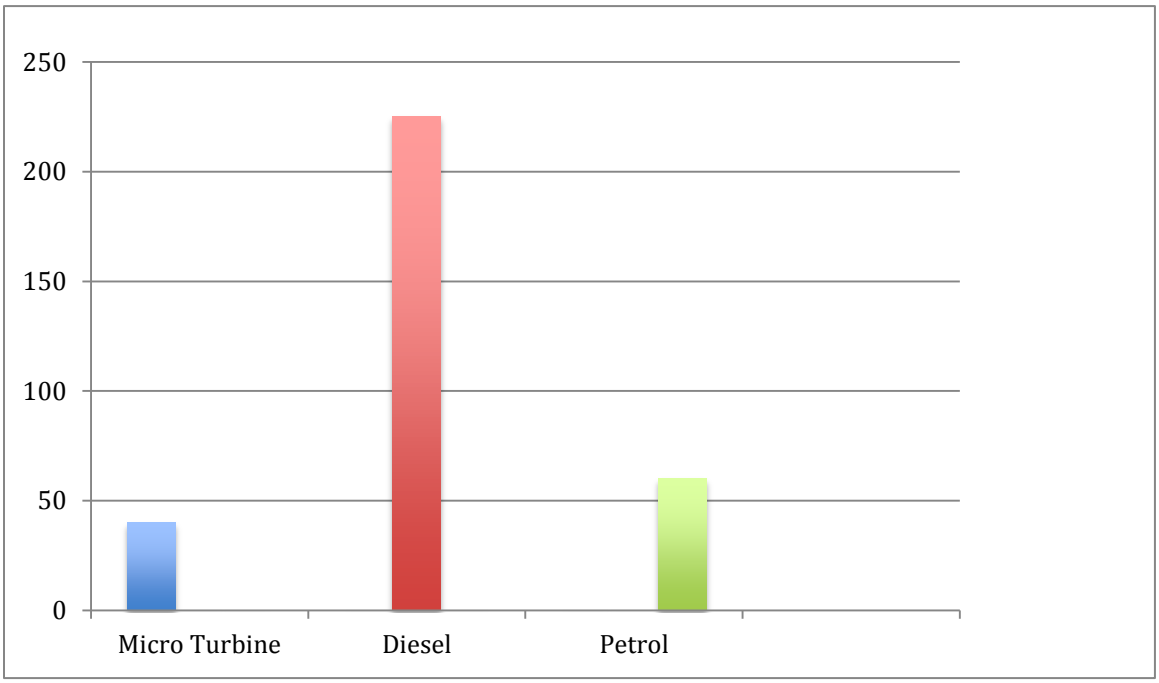
It will be fairly easy and inexpensive to get a micro turbine over to Nepal. Because Capstone owns a distributor in India, they just need to produce it there, pack it on a truck and drive it over to Nepal. Capstone Micro turbine Corporation is the main manufacturer and distributor of micro turbines across the globe. This means that there is very little competition for this market. The only other close substitutes would be other types of generators. Capstone has a patent on their "air-bearing technology" which is a technology that doesn't require coolant or lubricant.

Capstone wants to make their product the best alternative and have their prices competitive to influence farmers into switching to their system. The reason this export idea is great is because it provides a useful resource for many people in Nepal that they are currently going without. When people look at industrial countries or first world countries, they all have lots of electricity to power their manufacturing industry, homes and businesses. Micro turbines can help farmer's transition from small scale farming to commercial farming, which will allow them to compete in the global market. With access to electricity, many of the Nepalese farmers would be able to operate machinery that would make their lives easier and improve the efficiency of their farming. They could power pumps for irrigation, lights for dark spaces, recharge power tools, or power machines used for better post harvest storage. Many subsistence farmers lose 10%- 50% of their harvest due to improper storage after harvest (Professor Raizada 2015). This problem could be eliminated if the Nepalese had better storage or drying methods for their crops and grains. Many farmers have a form of granary but it is usually made out of mud or thatch and isn't the best material for keeping crops dry and isolated from the outdoor elements. With the access to electricity, farmers could power machines like dryers to dry the harvest in less time and more effectively. Additionally, 50% of energy consumption used by subsistence farmers is put towards cooking fuel. (Professor Raizada 2015) This means wood and other combustible material. Micro turbines produce heat combined with electricity. A farmer could harness this heat and use it to cook their pots, or use the electricity to power an electric stove. Currently farmers are using wood as their main fuel source and most of the heat

that is generated is dissipated because it isn't contained. But with a micro turbine, a farmer can power these appliances and make cooking more efficient and easy. Access to electricity would also allow women and children who work on a farm to spend less time working the field and more time on education, healthcare or other tasks. It is estimated that approximately 50% of women and children's time on a subsistence farm is occupied by farming, or weeding. Micro turbines could help reduce the manual labour required of farmers and help make their lives easier, and allow them to focus on more important things than weeding. Whatever electricity the farmer does not use can be sold to the national gird. This won't only help the farmer and the economy; it will also help to reduce the pollution generated from power production. The micro turbine is a clean alternative to traditional combustion generators. It burns the fuel and the steam that rises from the fuel is used to turn a turbine inside the generator producing power. This doesn't just apply to Nepal, other farmers in different countries can choose to use this type of generator to help combat climate change and reduce the amount of greenhouse gas emissions that come as a by-product of farming. The more greenhouse gas emission we can reduce the closer we are to achieving a cleaner environment. The hotter the turbine runs, the less emission is being released into the environment. How this works is that when more of the fuel undergoes a complete combustion, it produces less of other pollutants and more steam. The micro turbine produces less than 9 NO parts per million (PPM) and nearly no carbon dioxide pollution. Another environmentally friendly feature of a micro turbine is its ability to transition from AC electricity to heating. If heating is combined with electricity production the micro turbine energy

efficiency can be up to 85%. Figure 1 shows the CO2 emissions of a micro turbine compared to two other sources of combustion electricity production.

Figure 1

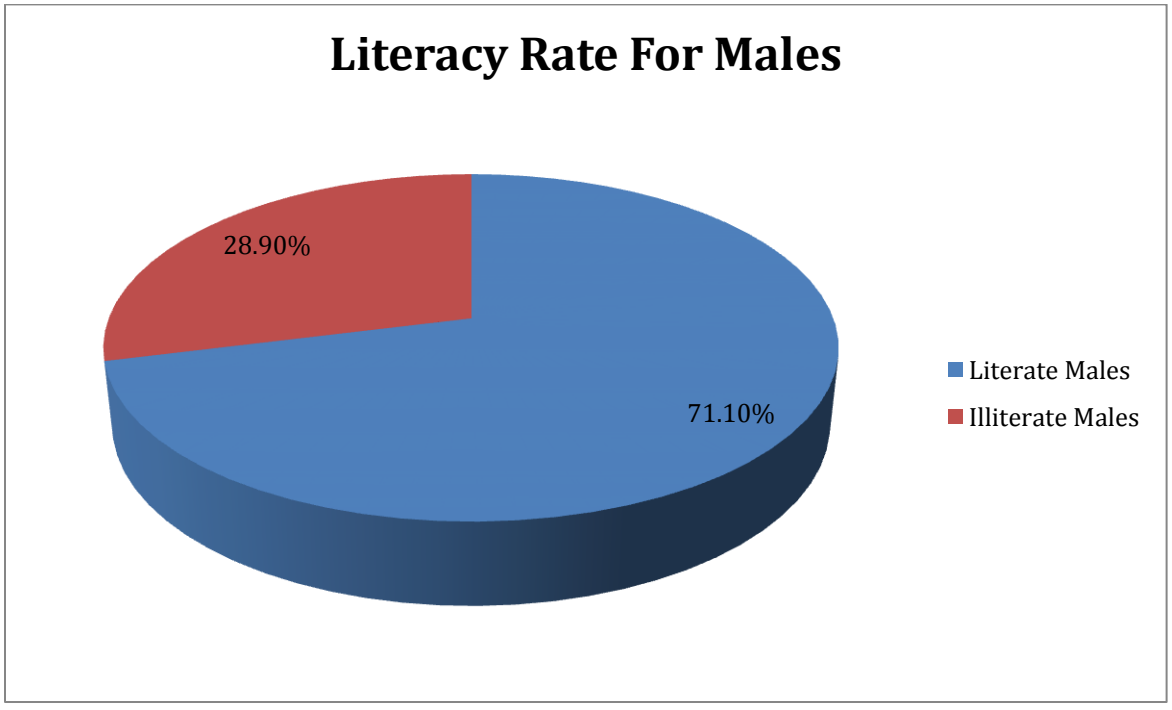


As the graph shows, the Micro Turbine emits far less CO2 into the atmosphere than a traditional diesel or gas generator. These turbines are also being used in more urban practices. Micro turbines can one day replace regular gas and diesel engines in motor vehicles. There is currently a case study done by Capstone Micro turbine Corporation in Russia where a transit bus is fuelled by the energy of a Micro Turbine. Additionally, Micro Turbines are very energy efficient. The turbines are 42% electrically efficient and 85% when combined with heat and power (Capstone Turbine Corporation). Gasoline engines are only 30-35% efficient and diesel engines are relatively 45% efficient. In the long run, the micro turbine would be emitting less CO2 into the atmosphere and would also be able to convert most of the thermal energy from combustion into useable electricity.

The micro turbine seems like the best choice for simple electricity production, but it comes with a cost. On average it will cost between $1,800-$2,800 per kilowatt. Therefor a 30kwh micro turbine would cost around $54,000. This means that any turbine that produces more than the smallest generator available will be very expensive for a subsistence farmer to afford. Micro turbines however are a long-term investment. Farmers in Canada and the United States, who use micro turbines as their primary electrical input, have seen savings ranging from $25,000 a year to $200,000 a year. This means that in time a farmer in a developing country or Nepal would be able to make their money back plus more after a couple years. Currently Nepal's government doesn't offer any subsidies for the use of clean energy production, but if they were to offer farmers subsidies, than micro turbines would be realistic for this market. Micro turbines are more suitable for established commercial farmers who already have experience in global markets and are producing large yields. However, this doesn't mean that farmers who aren't at that commercial level can't use micro turbines. The main issue is the cost and many subsistence farmers can't afford much more than an investment of a few hundred dollars. With aid from international organizations such as the Association for International Agriculture and Rural Development *(AIARD)* governments and people can receive education on the importance of agriculture in their country, learn new techniques and get introduced to new products to help them with their daily farming lives. AIARD's members consist of; Experts from universities, non-governmental organizations, foundations and private sector firms. With the wide speciality of skills, AIARD is qualified to help many farmers in poorer areas improve

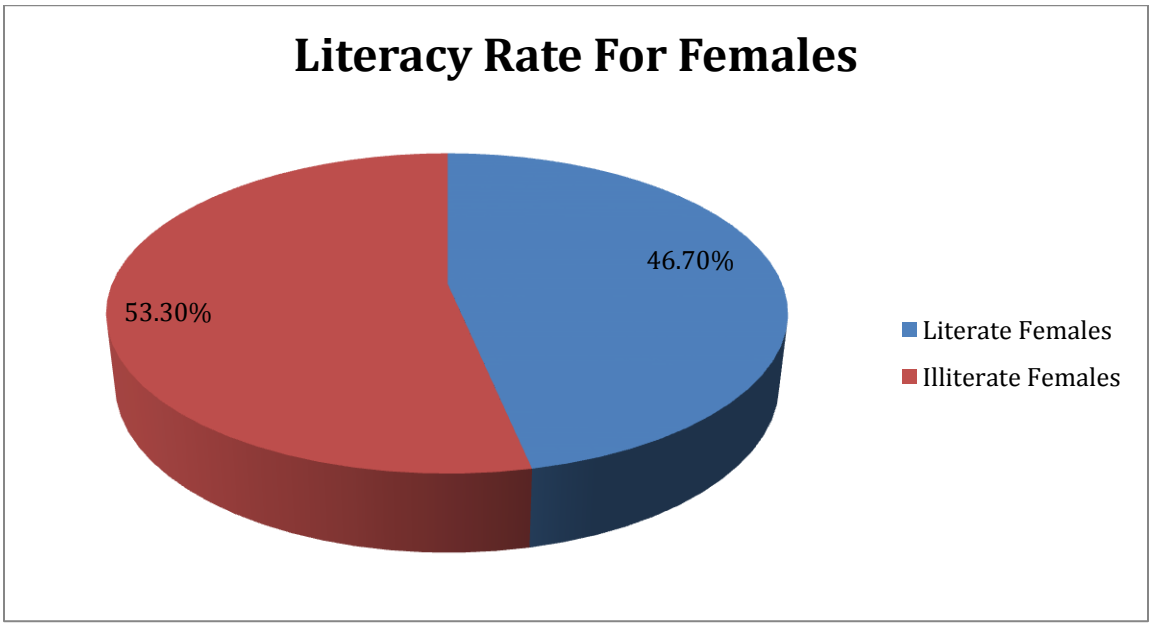
their economic situation bettering the quality of life. Interestingly enough, the government of Canada offers funding to international development projects. There is a process of applying for these grants that needs to be approved by the government after an assessment of the plausibility and how realistic the project is. The Canadian government looks at the application and if it helps improve any of the current priority of concerns in developing countries for the government of Canada they will forward the application. Currently Canada is focused on; increasing food security, securing the future of children and youth, stimulating sustainable economic growth, advancing democracy and promoting stability and security. A micro turbine would definitely be able to improve the economic situation in Nepal as well as allowing children to become educated giving them more opportunity for their future. Figure 2 shows the percentage of literate males in Nepal.

Figure 2



As the chart shows, only 71.1% of males 15 or older in Nepal can read. The graph in figure 3 shows the amount of literate females for the same age category. The amount of illiterate females is almost twice as much as the males. Literacy is important for a country to develop. If the population doesn't have sufficient education, than they won't be able to better their lives. More than half of the females in Nepal don't know how to read. This is an issue because these women won't be able to get out of an impoverished life due to their lack of knowledge.

Figure 3



Unfortunately, it is extremely hard to receive an education in a poor country where the average income for them is a littler over a couple dollars a day. With a micro turbine, the amount of money that a farmer would be able to make is worth the investment, not to mention the additional opportunities that come from increased efficiency and more time on their hands.

To conclude, Nepal is in a very bad situation where most of their population is living under the poverty line and the only way they can survive is by growing their own food. Many of these farmers are subsistence level and can't afford anything else. With the help of international development agencies, the Nepalese government, and the farmers, micro turbines in Nepal can become a realistic project. They not only save money, but would improve efficiency, productivity and crop yield. The amount of potential time saved with a micro turbine would allow many farmers the time to do other tasks, or more importantly get an education. Micro turbines could be used to heat the farmer's stove, power light bulbs, provide electricity to manufacturing units etc. These turbines are also very clean and would help Nepal combat climate change. Climate change is one of the hottest topics (no pun intended) being discussed by major world leaders right now. This just makes micro turbines more appealing to the world eye. Alone a farmer most likely can't afford a micro turbine, but with help and initiative from foreign investment, these farmers can get the technology they need to improve life in Nepal.

REFERENCES

1) Raizada, M. (2015, November 27). *Subsistence Farming in Nepal*. Lecture, Guelph.

2) Yu, A., Zaltash, A., Rizy, D., & D.Labinov, S. (n.d.). Retrieved November 30, 2015, from http://web.ornl.gov/~webworks/cppr/y2001/pres/115331.pdf

3) Tejedor, M. (n.d.). MICROTURBINES for Power Generation -Technology Scan 1.0 INTRODUCTION. Retrieved November 30, 2015, from http://www.academia.edu/12162265/MICROTURBINES_for_Power_Generation_-Technology_Scan_1.0_INTRODUCTION

4) S.John, K., & Feyisayo, K. (2013, August 23). Air Pollution by Carbon Monoxide (CO) Poisonous Gas in Lagos Area Southwestern Nigeria. Retrieved November 30, 2015, from http://file.scirp.org/Html/11-4700197_36807.html

5) Capstone Low Emissions MicroTurbine Technology. (n.d.). Retrieved November 30, 2015, from http://www.bioturbine.org/Publications/PDF/Capstone-White_Paper.pdf

6) Gremmer, B. (2014, June 1). High Efficiency Microturbine with Integral Heat Recovery. Retrieved November 30, 2015, from http://www.energy.gov/sites/prod/files/2014/09/f18/capstone.pdf

7) Mission & Objectives. (n.d.). Retrieved November 28, 2015, from http://www.aiard.org/mission--objectives.html

8) Logistics India. (n.d.). Retrieved November 29, 2015, from http://www.logisticsindia.net/Transportation_India

9) Swineline Farm. (2014). Retrieved November 27, 2015, from http://content.stockpr.com/capstoneturbine/db/Case Studies/672/pdf/CS_CAP427_Swineline_lowres.pdf

10) Funding for International Development Projects. (2015, November 27). Retrieved November 29, 2015, from http://www.international.gc.ca/development-developpement/funding-financement/fun-fin.aspx?lang=eng

11) Nepal Statistics. (2013, December 27). Retrieved November 29, 2015, from http://www.unicef.org/infobycountry/nepal_nepal_statistics.html

12) Nepal Literacy. (2015, June 30). Retrieved November 29, 2015, from http://www.indexmundi.com/nepal/literacy.html

13) Welcome Nepal. (2015). Retrieved November 30, 2015, from http://www.welcomenepal.com/

14) U.S. Export Controls. (n.d.). Retrieved November 30, 2015, from http://www.state.gov/strategictrade/resources/c43182.htm

15) Nepal. (2015). Retrieved December 1, 2015, from http://data.worldbank.org/country/nepal