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India, Factor 3: Biofuels

Improving Food Security through Efficient Energy Production in India

Iowa has taken the initiative to use cleaner energy that reduces the “carbon footprint” and contributes to the prevention of global warming. It is incontrovertibly the leader in biofuel production, carrying nearly one-third of the nation’s ethanol capacity. After all, biofuels are a large part of Iowa’s economic development, which can be seen by the countless ethanol refineries sprinkled all across the state. Although states in developed countries, such as the United States, are making efforts to combat the energy crisis, villages in developing countries, such as India, are struggling to keep up with energy demands and to develop energy sources.

Although India is among one of the top developing nations, its poverty is widespread. It has a population of more than 1.2 billion people spread amongst 3.3 million square kilometers, resulting in a population density of 382 persons per square kilometer (The World Bank). India’s poor population is a total of 300 million people, and 30 percent of the rural population is impoverished (India Census). The migration from rural to urban areas has helped decrease the poverty since 1973, but the issue of poverty is still prominent. As the population continues to grow, the demand for electricity per person surpasses the production of electricity. Since there is a division between the supply and demand, electrical companies are forced to cut power. Till December 2011, over 300 million Indian citizens had no access to electricity (India’s Huge Need). In order to handle peak hours, companies supply electricity to big cities they deem more important, leaving the smaller villages and towns without an energy source. The population has adapted to power cuts by attempting to use candles, open windows as a substitute for air conditioning, and using gas stoves instead of electric stoves. But in a developing nation like India, why is there a lack of electricity? A large part of it is pegged to waste of electricity in India. According to the Times of India, around 27,000 megawatts of electricity go to waste every day in India, resulting in a loss 27% of generated power (27% of Power Goes Waste). A large amount of energy is wasted in commercial buildings. Additionally, corporations are able to sway government officials to provide more energy to one location.

The global energy crisis is defined as “the concern that the world’s limited natural resources that are used to power industrial society are diminishing as the demand rises” (What is the Energy Crisis?). Energy sources are not running out, but are not being properly utilized to benefit the economies of poverty-stricken countries like India. Most consumers blame the energy crisis on an individual practice or industry, but fail to realize that there are several causes of the crisis. Especially in India, the energy crisis stems from a culmination of overconsumption, overpopulation, poor infrastructure, energy mismanagement, delay in commissioning power plants, and finally, unexplored renewable energy options (What is the Energy Crisis?).

The agrarian state of various regions in India presents a challenge to people attempting to solve energy scarcity. Many people are uninformed about alternative energy and how it is related to electricity generation. A common misconception is that fuel is completely separate from electricity; however, alternative and renewable sources can be transformed into electricity. Electricity is made in power stations using a turbine which requires large amounts of energy to turn. Usually, coal is burned to produce heat energy, resulting in electrons to move within a coiled wire. No matter the energy source, the principle is identical. Therefore, whether fossil fuels, hydroelectric energy, or alternative fuels are used, electricity is generated using the same process (How Electricity is Made). Unfortunately, most Indian people are unaware of the mechanism and are unwilling to embrace innovative, cleaner alternatives that could ultimately solve the energy crisis.

When I visited India and heard the stories of people without energy, it made me think deeper about the situation of similar families all over India. Politicians were doing little to implement programs to distribute energy all over the country, even to small villages. As a result, residents in villages had given up on waiting for a top-down approach from local government. How could they rely on officials who made no attempts to change in the past? Instead, I began researching bottom-up approaches that revealed interesting facts about the energy crisis, renewable energy sources, local initiatives, and the standard of living for rural families.

1. Typical Family

The typical family size in India is about five people: one to three children along with their parents. In terms of size, the rural family is usually larger than the urban family due to distant relations besides the immediate family. Several families rely on subsistence farming for income in addition to activities like sowing and harvesting. Agriculture is the most common occupation and creates a single unit with members cooperating on the same economy. Most of the small farmers rely on themselves or others within the community as a source for food. Especially in Andhra Pradesh, the typical diet consists of rice, curd, and legumes (What is the Energy Crisis?).

It is also important to note how life for Indian children is affected. More than 50% of children under the age of 4 suffer from malnutrition, the majority of which live in rural areas (Children: Reducing Mortality). Today, India is considered one of the top countries for education, but in rural areas, the education is considered below standards. Less than 10% of children in rural schools graduate high school. Less than 20% of the rural population is literate and know how to do simple arithmetic (Children: Reducing Mortality). Most people consider housing a higher priority than education for their children. Schools usually do not have functioning restrooms or desks and are usually structured like a single, dilapidated room. The education also discourages creative learning and tends to focus purely on memorization. Strict learning methods are established instead of allowing free thinking. A rural child's future is likely geared in the direction of working on a village farm. The other opportunities are located outside of the area in a bigger city.

2. Typical Subsistence Farm Family

The majority of farmers in India own small acreages of land in order to sustain their families along with breeding and caring for farm animals. The typical size of farm land is around 3.39 acres and the usual crops grown are rice, sugarcane, tobacco, cotton, and mango. About 60% of the population in just Andhra Pradesh engage in agricultural activities with 80% acting as small farmers (Yost). Small farms are able to provide crops like wheat, corn, grains, sorghum, and pearl millet along with milk and dairy products from the cows. Access to the Godavari, Krishna, Penna, and Tungabhadra rivers provide irrigation to the farm lands, especially in the lowlands, allowing for the growth of sugarcane and rice, crops that require a great deal of water (Yost). The elevated regions are unable to gain as much access to the rivers and rely on cotton and lentils to move the local agricultural economy forward. As far as agricultural practices, Andhra Pradesh was one of the few states along with Karnataka, Tamil Nadu, and Punjab that played a role in the Green Revolution, which introduced a large variety of seeds and chemical fertilizers in order to increase production (Nathanson). Although originally successful, it ended in rapid decline of industrial growth. At this time, farmers cannot pay wages as it results in losing money to laborers. Small farmers, especially now during the food crisis, cannot afford this since they need to provide for their families. However, the aftermath of the Green Revolution did result in a switch to organic fertilizers and a reduced use of pesticides (Nathanson).

3. Major Barriers Facing the Typical Farm Family

A major barrier for rural farmers is receiving adequate nutrition. Gaining access to food markets that contain nutrition-rich foods requires a decent sum of money, which a poor farmer would lack. As a result, farm families are unable to obtain necessary nutrients as the food sources are costly; chicken and fish, high protein sources, can only be consumed sporadically. Since beef is not an option, other sources, like lentils and chickpeas, are looked to for protein (Yost). Even these options, however, are increased in price for external vendors to increase their profit. In addition to vendors who manipulate prices, local seed suppliers do the same when selling seeds to small farmers. By replacing high quality seeds with low quality seeds, the suppliers are able to make a higher profit for lower quality goods.

The lack of energy in India has developed into a serious problem for agricultural productivity. Considering the amount of energy required for most farm operations, a dearth of energy has had a detrimental effect on the crop yield of rural farmers. Growing and harvesting crops, raising livestock, fertilizers, pesticides, feedstock, and irrigation all require either direct or indirect energy expenditures. Irrigation is vital for productive agriculture, accounting for 40% of production worldwide and 50% of a farm's total energy use (Introduction to Energy Efficient Irrigation). Supplying water in general is energy-intensive; pumping water from wells and groundwater sources requires electricity or diesel and propane. Even rural families need kerosene, an energy source, to light lamps in their household daily. On the chance that a family uses lightbulbs, electricity, a source of energy, is needed.

Energy is needed when the farmer needs to be transported from place to place. For small tractors, petroleum is needed as an energy source to run the machine. Even without tractors, oxen for plows need to be fed, and creating feedstock requires energy. Indirectly, fertilizers and pesticides necessitate energy in order to be processed. All these factors that require energy are essential for a farmer to have high crop yields and earn a sufficient income, which allows him to sustain his family by buying food. Even for the family to eat every day and receive the proper nutrients to live, energy is needed to power even a gas stove to cook food. Nearly every aspect of a rural farming family's life, whether owning a small or big farm, requires a significant amount of energy.

The new Prime Minister of India since May 2014, Narendra Modi, has taken initiative to make electricity universally accessible and lead efforts to produce cleaner energy. As the world's third largest producer of carbon emissions, the central government is creating policies to reduce carbon emissions. In particular, Minister Piyush Goyal and the Bharatiya Janata Party have encouraged economic growth and promoted investments of over \$100 billion in creating more energy to distribute to everyone in India. He believes that increasing domestic production of energy will be "a big step towards long-term energy security of India" (India's Energy Crisis). Foreign companies like Softbank in Japan have committed to investing \$20 billion dollars into India's solar energy projects. There have, however, been increasing concerns of corrupt politicians stalling such initiatives. Pieces of legislation like the Electricity Act of 2003 have been vetoed in parliament due to the indifference of certain Indian politicians.

The current infrastructure of the power sectors is not capable of creating a sufficient and reliable power supply. In rural communities, there are also more power shortages than in cities. With only 6 hours of power availability per day, energy is a necessary yet limited resource. As mentioned previously, 300 million citizens currently live without electricity and looking to the future, as the population is expected to grow by another 400 million (India's Energy Crisis), the demand increases while the electricity supply fails to increase at the same pace. If India continues to follow the same path, another inevitable problem is carbon emissions. In 1980, China's emissions per capita were once 1.49 tons which eventually grew to six tons in 2010. India's energy industry is heading in the same direction, estimating another eight billion tons of carbon each year (India's Energy Crisis). Future trends for the energy crisis are getting worse as the demand for energy in just Andhra Pradesh

is predicted to increase by 282% before 2025, placing a strain on current energy production. If efficient energy production methods are not developed, the energy supply will not even scratch the surface of the increased demand.

4. Solutions

Although there is not just one solution to solve the Indian energy crisis and in turn, improve agricultural productivity and food security, several steps can be taken to solve the problem.

- Moving towards renewable energy
- Better distribution system
- Cutting down energy waste
- Public awareness campaigns
- Scaling up successful small projects

Mission Rural India Solar Electrification (RISE) was one such initiative that inspired me to pursue my solution. When a community group called “Someone Somewhere” encountered a tribal village named Khatisitra in Gujarat, India, the village people had never seen electricity before and used kerosene as their only energy source (The Logical Indian). Each household made less than 1,000 rupees per month (the minimum wage is 5,560 rupees) and were forced to use kerosene, even though it was costly and dangerous to use in a forest. Instead of waiting for politicians to take action, the team conducted fundraisers to raise money and collect donations to produce solar energy for the village. By assembling solar lighting kits for 100 families, the entire village finally saw electricity in their homes (The Logical Indian). By fulfilling their motto of showing the “power of common man,” the Mission RISE was accomplished in giving villagers a reliable energy source. Community groups in India like “Someone Somewhere” provide innovative solutions for difficult problems faced by millions of poor villagers. By adopting similar ideas to using solar energy, energy production can be modernized and energy can be distributed all over India. How can energy production be modernized?

I pondered a solution to all these problems and finally came across it: biofuel. By releasing fewer carbon emissions and pollutants, clean “green” bioenergy can also assist in the issue of poor air quality. In addition, as there are unlimited biomass sources to produce biofuel, accessibility to all regions of India is a benefit. Producing cellulosic ethanol requires a single material: cellulose. As the most abundant organic polymer in the world, cellulose fibers are found in all plants and woods all over the world. Therefore, their renewability makes them optimal in comparison to nonrenewable fossil fuels.

Soon, I began scientific experimentation to explore various biomass sources. I started with a biomass source called Napier grass, commonly found in India. Almost considered a “weed” in several countries, tough, thick Napier grass can grow up to 10 feet tall while using its water source efficiently. After obtaining the grass, three steps are required for biofuel production: pretreatment, hydrolysis, and fermentation. Through my own experimentation, I found that through the addition of inexpensive microbes, a significant amount of cellulosic ethanol can be produced from virtually any kind of grass. This is globally beneficial; renewable biofuel can be produced domestically in an inexpensive way from virtually anything that contains cellulose. In addition, one of the microbes needed for biofuel production, cellulase, is naturally produced by cows, an extremely common animal in India.

Not only can biofuel be used to produce electricity, but it can also be used as a substitute or an additive to gasoline or petroleum, ultimately releasing fewer carbon emissions. Unlike nonrenewable sources like coal, petroleum, and gasoline which need to be mined and are inevitably going to run out, biofuel can be produced by local companies. In addition, struggling rural farmers who struggle to

create income can channel their energy into growing energy crops like Napier grass and sorghum. By doing so, the production of ethanol will be unlimited and the rural farmers can benefit financially from the growing demand for biomass. After all, since Prime Minister Narendra Modi is fully supporting the world-class renewable energy industry and the fight against climate change, government support is likely to occur. In fact, Modi “promised to increase India’s renewable energy capacity to 175 gigawatts...” (India’s Energy Crisis). The government should implement carefully crafted policies to compensate rural farmers who work for the clean energy cause.

Public awareness also needs to be emphasized in order to solve the energy crisis. Current energy innovations are understood by few; the educated and uneducated masses must all be informed of the current energy situation. Few people actually understand the mechanism by which electricity works and how renewable energy can improve the overall economy and environment. Therefore, awareness campaigns should be run by innovative leaders to inform the public. Mission RISE is a prime example of how the people were informed of the benefits of solar energy and chose to invest their time into continuing the project.

Moving forward in the issue of food security, attempts must be made to cut down the waste in energy consumption. Informing the public of the dire need to save energy and urging local leaders to advocate for energy preservation is the simplest solution. Furthermore, communicating to electrical companies that the distribution of energy must be improved upon is the next step. By pursuing these solutions, there is a real chance for the energy crisis to be solved. Certain ideas concerning the implementation of alternative energy may require years of development and funding. On the other hand, many changes are simple enough, like informing the public of energy conservation and production. By increasing energy productivity, rural families will be able to use this to their benefit when providing food for their families, reducing food insecurity. In addition, it will increase efficiency of agricultural practices which will increase crop yield. By expanding upon these ideas in the next few years, energy can be produced to match population growth and equally distributed to all areas, ultimately helping impoverished farmers improve their agricultural productivity, overall income, and eventually, help ensure food security.

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