Biogas for Sustainable Development

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1. Preamble

Achieving "Sustainable Development" is a formidable challenge in the present world. It concerns technologies that can help manage growth while considering economic, social, and environmental sustenance of the society. There is an urgent need to solve the present problems faced by the society without creating any long term negative impact, which could become a critical issue to resolve for the future generations.

Energy need is an important ingredient in the modern economy, and must be evaluated in the context of the other aspects of development. In fact, modern energy services must be evolved and deployed in all aspects of the development process – e.g., energy and communications, energy and industry, energy and the environment, energy and agriculture, energy and education, and energy and public health and safety.

Biomass can be used to provide sustainable supply of the required energy through biogas, vegetable oil, biodiesel, producer gas, and by directly burning the biomass (Refer Figure 1). Notwithstanding whether the biomass is "waste" of some process or is cultivated specifically as fuel for energy generation, it is considered a "green" technology since

- The life cycle of the fuel is short (could even be less than 3 months)
- The net carbon dioxide emission from the fuel is zero – as the CO_2 emitted is generated by burning the carbon that the plant had fixed by taking CO_2 from the atmosphere and converting it to food (glucose) with the help of photosynthesis.
- The cycle can be water neutral as well
- If biogas or biodiesel is produced from biomass, the leftovers can be put back into the field as high quality manure.
- The remaining biomass could also be used with a gasifier to make producer gas. The ash could be spread in the fields as micronutrient, completing its cycle as well.

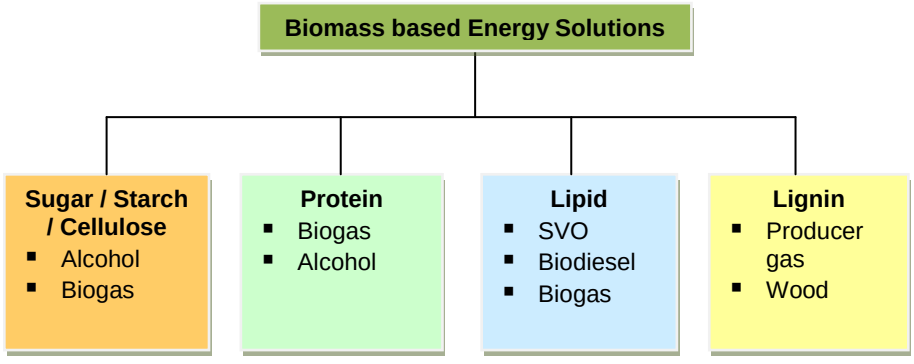

Figure 1: Options for biomass based energy

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2. Harnessing Solar energy

Sun is the only perennial source of energy we have on earth. Solar energy reaching the earth could be harnessed through devices such as solar photovoltaic cells or solar thermal absorbers. However, Nature has perfected the process of “photosynthesis”. A smart link back to the Sun could provide sustainable energy solution.

Figure 2 elaborates the concept of “sustainability”. The solution needs to lie in the intersection region of the circles representing technical feasibility, environment friendliness, economic viability and social acceptance. Our continuous endeavor should be to expand the intersection zone by undertaking innovative projects involving leading edge technologies.

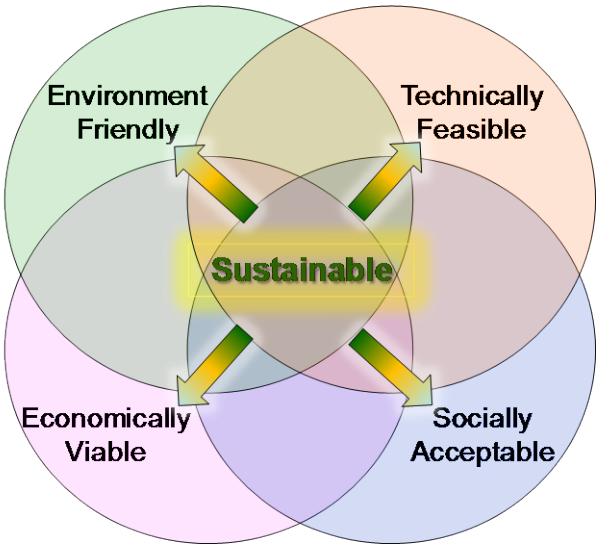

Figure 2: Criteria for Sustainability

While applying the criteria for sustainability to evaluate various options for harnessing energy from biomass, biogas route turns out to be the promising option. From Figure 1, it can be seen that sugar, starch, cellulose, protein and lipid can be readily converted to biogas. Conversion of lignin is considerably difficult. Further research will be requires to economically convert lignin to biogas.

3. Biogas for Rural Energy

Biogas is a product of anaerobic degradation of organic matter. It contains methane, carbon dioxide, hydrogen, ammonia, hydrogen sulphide and some traces of other gases along with water vapor. When the methane content in the biogas reaches close to 50%, the gas becomes easily combustible and delivers a clear blue flame when burnt with sufficient supply of air. It can safely be used as fuel for cooking or for process heating.

Typical substrates, i.e. raw materials that can be used for biogas production in rural areas:

- Agricultural waste: Maize, jawar, bajara, rice, sorghum, etc.
- Food processing waste
- Sugar factory: Molasses, spent wash, and press mud

- Industrial waste: oilcakes and de-oiled cakes, maize husk, starch effluent, etc.
- Other waste: Kitchen and hotel waste, organic waste in MSW
- Cultivated substrate: Napier grass, Elephant grass, Safflower, etc.

As seen from Figure 3, after removing unwanted impurities, biogas can used as engine fuel to generate electricity. If purity of methane can be increased to over 90% then the gas can be compressed to high pressures of over 200 bar and stored in cylinders. It can then directly replace CNG, even for vehicular application.

The effluent from the biogas plant is in the form of slurry, called as digestate. Liquid from the digestate can be separated by processes such as decantation or using simple techniques like a sand-bed filter. It could then be recycled into the biogas plant or can be used as nitrogen rich liquid fertilizer. The solids consists almost completely composted biomass. It can be used as manure. When minerals and micronutrients are mixed with the manure, it could be converted into fertilizer, which is a value added product.

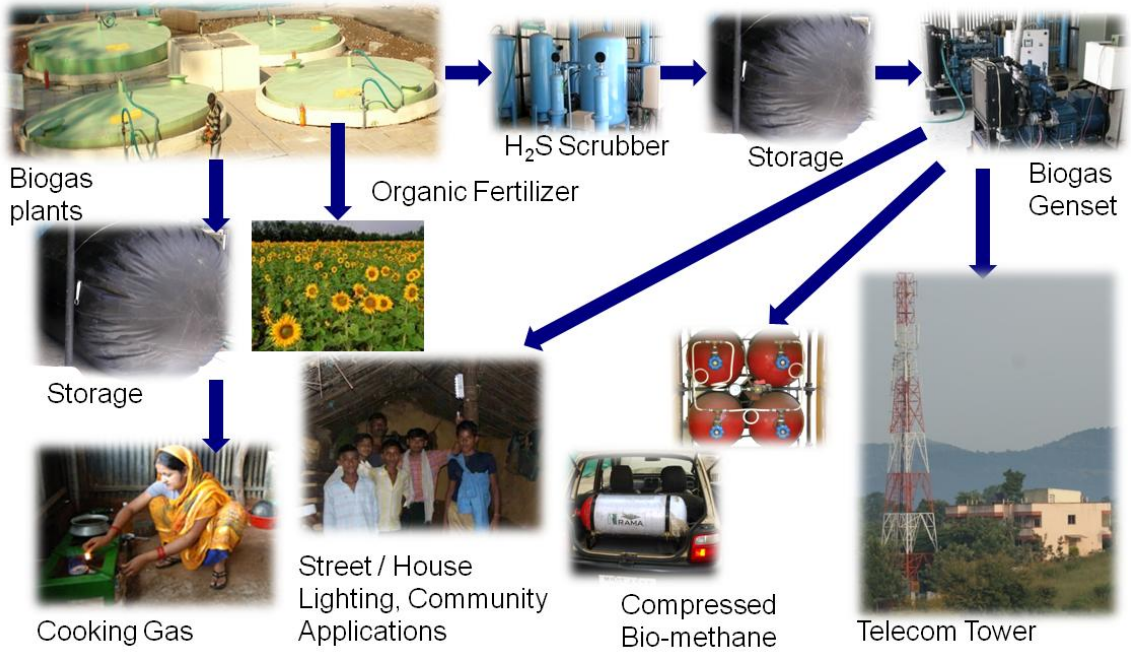

Figure 3: Biogas can provide complete solution for energy needs

4. Organic Fertilizer

Balanced nutrition is the base for a healthy plant. Amongst the different constituents such as silica, phosphate, potash, nitrogen, phosphate is one of the significant nutrients. Phosphate forms a major part of nucleic acids and is an energy source of the plant. Root growth, yield and absorption of K, Mn and N in balanced form depend on proper absorption of phosphorus.

At present this need is fulfilled in the world over by using chemical phosphates. Phosphorus can be utilized by plants only when it is in water soluble form. Other forms of phosphates are citrate soluble and insoluble. Over a period, citrate soluble forms of phosphorus get converter into water soluble forms and then it can be utilized by the plants.

Depending on the pH of the soil, water soluble part of the conventional chemical phosphatic fertilizers gets converted into insoluble form soon after it comes in contact with substances like Fe, Al, or Ca, Mg salts in the soil. The process is known as Phosphate Fixation. Fixed phosphate, which cannot be utilized, creates phosphate banks in the soil. These banks will remain unutilized for years together resulting in non-fertile land. As a result, typically, about 70-90% of the phosphorus gets fixed and only 10-30% can be utilized by the plant.

Organic Fertilizer helps overcome the phosphate fixation problem. The base of organic fertilizers is typically humus, which is compost manure. Some herbal extracts and mineral phosphate are added to it as nutrients for microbes and the plants. The Organic Fertilizer provides phosphorous to the plant over an extended period in smaller doses as necessary for healthy growth. The humus, presence of organic carbon and lower pH create favorable condition to avoid the phosphate fixation process. Eventually 90-95% of the total phosphorus can be utilized by the plant for its nutrition,

The humus makes the soil porous and rich in microbes. It is also observed that continuous use of Organic Fertilizer can make available over time the previously fixed phosphate. On application of Organic Fertilizers, considerable improvement in yield even up to 25%, have been recorded.

Recent developments in the technology have opened the possibility of using food grain and vegetable waste other than dung for biogas generation. Even the waste cake that is left after extracting oil from seeds can be used to generate biogas. Interestingly, the gas output of this starch or protein based feedstock is multi-folds than that of the cow dung. This can result in a smaller size digester as compared to the conventional one, tilting the economics favorably.

5. Pilot Project in Chhattisgarh

The German Technical Cooperation (GTZ) is in the process of setting up biofuels/biogas based decentralized power plants in 24 villages of Korba district in Chhattisgarh state under the Indo–German bilateral cooperation project “Renewable Energy Supply for Rural Areas” (RESRA), in technical collaboration with Kirloskar. Many of these villages are still unelectrified; although a few of them have grid power supply only for the home lighting, which is also inadequate. In order to improve livelihood of the villagers, this project aims to supply renewable energy based power in all these villages for irrigation and their community based microenterprises. These villages are surrounded by the forest where the Tree Borne Oilseeds (TBS) of Kussum, Jatropha, Mahua, Sal and Pongamia (Karanj) are available. These non-edible oilseeds can become primary source of raw material to produce renewable biofuels like Straight Vegetable Oils (SVO) and Biogas. The concept of the project is shown in Figure 4.

The project envisages collection of oilseeds from the forest. In order to simplify the project operations and management, and the logistics of oilseed collection and their effective usage as raw material for maximum energy production, the 24 villages are divided into six clusters. After studying the electrical load demand data of each village/cluster, the SVO and biogas gensets are accordingly designed for different villages. One village in every cluster is identified to accommodate electrical demand of each of the equipments like oil expeller and degumming unit in addition to its own electricity demand. This village can then be considered as the nodal village of that cluster. As a result, each cluster would have a facility to produce degummed SVO and oil cake for biogas generation. The remaining villages in the cluster are called as satellite villages.

To optimize the usage of degummed SVO and oilcake, one village from each cluster was identified for installation of biogas plant and biogas genset. Design optimization has led to selecting only two ratings of the SVO and biogas gensets, which would reduce variations in the installations as well as operation and maintenance instructions. SVO gensets use air-cooled

engines. For biogas gensets, water-cooled engines are used. Heat exchangers are incorporated in the engine cooling circuit to generate hot water, which is used for feed preparation for biogas digesters.

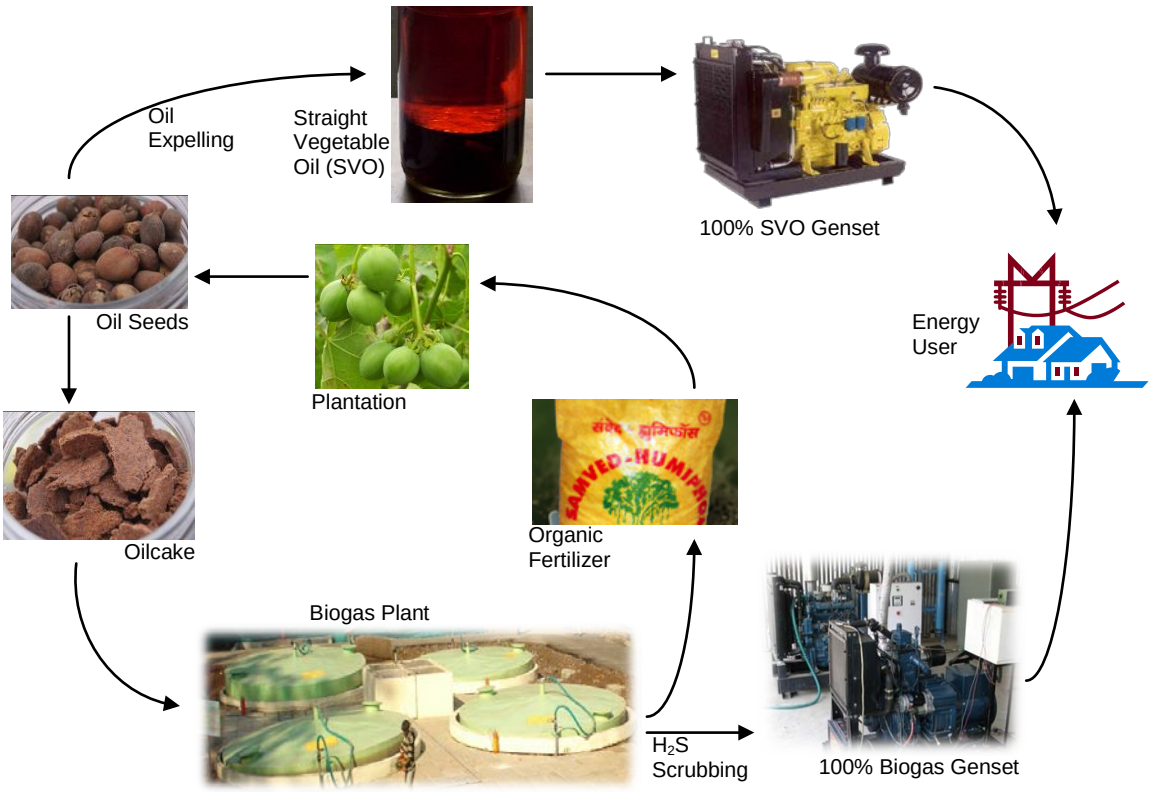

Figure 4: Concept of RESRA Project in Korba district of Chhattisgarh

A sustainable energy supply model for the purpose of generating income from renewable sources and byproducts is proposed and is demonstrated on paper as realizable. The pilot projects would serve as a display model for creating future energy policies for rural regions in India.

It may be noted that such projects for supply of rural energy will not add to CO_2 emissions. Moreover, it will provide opportunities for income generation to the village entrepreneurs. The project not just provides electricity to the villages, but actually “empowers” them to embrace (??) economic growth.

6. Sustainable and Multipliable Solution

The proposed biogas based energy solution holds good on all the four criteria of sustainability presented in Figure 2 above. The solution is “technically feasible”. Various substrates given hereinbefore have been tested at Kirloskar Integrated Technologies Limited (KITL) for their biogas potential and consistency of biogas quality and quantity.

Biomass based biogas energy is “environment friendly” as there is no net CO_2 addition, there is no harmful effluent and it does not pose any other environment related risks. In fact, it has potential to recover damaged saline infertile land. It also reduces methane emissions that would have taken place due to rotting of the substrate, which is typically, “waste” from some process.

Since the Government has heavily subsidized fertilizers and electricity, the products of the biogas plant have to compete with the subsidized price. Phosphatic chemical fertilizer is available around Rs 9.5/ kg in the market. The organic fertilizer manufactured by processing the manure from the biogas plant can be retailed at the same price. In such case, it can replace the chemical fertilizer completely and reduce the subsidy burden. It will also save foreign exchange outflow as most chemical phosphates are imported in India.

Similarly, electricity produced from biogas can be retailed at differential prices. A Corporate like Telecom Company present in the rural area can afford to purchase electricity at Rs 12 to 18 per kWh. The rural businesses could pay around Rs 7 to 8 per kWh, while the common amenities like streetlights and drinking water schemes could get it at a subsidized rate of Rs 3 per kWh.

A rural enterprise would run the biogas energy project as a business. For this business, the return on investment could come in less than 4 years. The project helps in employment generation, directly and indirectly. Hence, it is not just “economically viable”, but is attractive.

Involvement of the community is the key to the success of such schemes. The entrepreneur is local, who is identified with the help of some Self Help Group or a grassroots level NGO working in the area. The money generated by the business is recycled in the region. It creates business opportunities for local individuals through need for procurement of raw material and sale of products and services. The project also considers supply to common infrastructure of the community. All these factors would make the project “socially acceptable”.

7. Conclusion

- Biogas based energy could provide sustainable solution for rural areas
- As the economics is attractive, it becomes a multipliable and scalable model
- Supply of energy would assist rural businesses and enterprises to grow and prosper
- Production and use of organic fertilizers would improve soil and increase yields
- Considerable savings in subsidy bills and foreign exchange outflow could be achieved through such projects
- The project would help employment generation by creating local job opportunities
- Through availability of fuel and energy, the overall health and hygiene in the region will improve.
- The project promises “empowerment” of the rural community.