DEVELOPING A NEW APPROACH FOR ANAEROBIC DIGESTION AT LARGE AND SMALL SCALE IN SUDAN

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ABSTRACT

Sudan, as with many African countries or developing countries on other continents, has most of its large rural population living away from the national grid electricity supply, either in regional cities and towns or in scattered small villages. Many of these have little or no access to locally produced electricity and possibly LPG supplies. At the same time many households in rural areas maintain some livestock, and via anaerobic digestion of the manure and other household wastes could produce enough biogas for cooking and possibly lighting needs. Most importantly, more widespread use of affordable household anaerobic digestors would significantly reduce the intense local pressure on remaining woody vegetation for firewood and also reduce the trading in charcoal from Sudan's rapidly dwindling forests and woodlands. The paper is based on a project to identify the potential for anaerobic digestion in Sudan and to help drive its greater adoption. This biogas project includes the study of cases of existing installations, and will use this information in developing a series of proposals and recommendations that will help improve stakeholder understanding, government and NGO policies, digester designs and digester management. Other outcomes will be to improve economics and access to funding streams. The program is supported by a range of stakeholders who provide technical advice, professional help and practical input. Workshops with stakeholders, project development planning, the installation of pilot projects, have resulted in several NGOs implementing biogas system installation in their programs for rural communities. Interest by government and industry has meant requests for pre-feasibility studies to be to help identify options for handling putrescibles wastes. Laboratory work using small batch digesters is developing recommendations for feedstock parameters, and related issues.

Keywords: Bioenergy, anaerobic digesters, Sudan, rural areas.

1 INTRODUCTION

The technology for small household-scale anaerobic digesters is proven and used around the world. Some countries leading in this are China, India, Nepal, Vietnam and Indonesia. While the development of household scale anaerobic digesters in Africa is not so common, many countries are working in this area – including Kenya, Cameroon, and South Africa. Biogas is also a major source of renewable energy in Europe, the USA, and elsewhere in the OECD, though usually at larger scale and involving far higher capital costs.

While the product of household-scale digesters is mainly of biogas for cooking, it can also be for lighting and even for cooling of food or medicines. Larger systems apply for the food processing industry and towns or for cities. Here it is more common for the biogas to be used for producing industrial heat and electricity, or the technology is available for it to be upgraded to pure methane and used as a vehicle fuel, and this is being trialled in India including as a fuel for motorised two-stroke three-wheeler taxis.

The potential for adoption of anaerobic digestion technology in Sudan is enormous, with the benefits of reduced deforestation, energy security, and improved handling of putrescible wastes being major drivers. The biogas program in Sudan will mean lower-cost designs are developed and that cultural and other barriers to adoption are identified and negotiated.

2 THE POTENTIAL OF BIOMASS TO ENERGY FOR SUDAN

Biomass presently provides up to 61% of Sudan's energy requirements, mostly as a source of heat energy but also as a growing production of electricity and of transport biofuels. It is clear that there is great scope to increase the production of all three forms of energy from the various types of biomass (also called 'feedstocks') that are economically and sustainably available in Sudan.

While all the attention in relation to renewable energy technologies seems to be on hydropower and electricity from solar and wind systems, the economics and flexibility of biomass-to-energy are most favourable and should not be omitted from any planning or strategy for renewable energy or any national scenario for reduction of greenhouse gas emissions. Bioenergy simultaneously provides energy plus various environmental and social benefits, including health benefits to householders, as well as reduced pressure on remaining woodlands. In practice-

- Sudan has large agricultural industries that produce very large volumes of a range of residues that can be a source of energy.
- The capital Khartoum/Omdurman, and the many larger regional cities all produce flammable and putrescible (wet organic) wastes that could be used as the source of a significant amount of electricity and industrial heat.
- The wastes and residues of food processing and intensive animal production facilities could all be converted to heat and electricity using cost-competitive and mature systems in widespread use in many other countries around the world.
- Many regional towns, cities and small settlements are not connected to the central electricity grid and also have an unsustainable demand for firewood and charcoal.
- Production of energy from biomass creates more jobs than any of the other renewable energy sources.

The present use of firewood and charcoal is unsustainable and contributing to the very high level of deforestation in Sudan. However this can be quite quickly changed by switching the source of biomass from wood and charcoal to other available and presently relatively unutilised biomass forms, and production of biogas from anaerobic digesters can play a significant role in this.

3 THE COST OF ANAEROBIC DIGESTERS

Until now in African countries the main household biogas digester design is what is commonly called 'the Chinese design'. This is a cement or masonry digester with a fixed dome constructed below ground level, with a feed-in point at or just above ground level on one side, and a discharge point on the other. The exhausted residues from the anaerobic process are progressively driven out into the discharge point by the biogas pressure that builds up in the digester's dome. This residue is then available as a fertiliser for any crop or vegetable production undertaken by the household, or for sale to other landowners.

While this Chinese design has been simple to construct, keeps a lower temperature than the air temperature and is relatively simple to manage and maintain, it involves a high commitment in the initial labour and requires both skill in masonry work or bricklaying, plus being able to afford the cost of cement and fittings. A further issue is that across Africa land tenure is often not clear or secure and to put labour into such a valuable fixed asset may not be seen as economically sensible.

However, the cost of a biogas plant of about 6 m3 can be as little as US$400-600 in those countries where digging is easy, cement is cheap, bricks or suitable stone are cheaply available and labour cost is low. This applies in some countries in South East Asia like Vietnam [1]. In countries like Sudan where labour, cement and other costs are higher the cost of a 6 m3 biogas digester will be two or three times more than this and possibly even more. But in every case it is necessary to work out a way to help householders afford to pay the up-front cost of the construction of the digester. These prices are for an in-ground brick, stone or cement construction of the proper design. Digesters like this if well made should last 20 years or more and in many cases have kept producing biogas with very little maintenance to the actual digester structure for 40-50 years.

Photo – a 12 m3 digester in construction in Khartoum, showing excavation and plastering of inside of main digester chamber (outflow chamber to rear)

It is possible to have cheaper digesters sitting above ground or made of other materials, but often these do not suit all areas (particularly not the very hot and sunny regions, or very cold regions). Some key issues for any digester include that

- Temperature changes should be very slow – so below one degree of temperature rise or fall in the content per hour. Having the digester totally below ground ensures this is the case
- There should be no leakage of air into the digester or of biogas out of the digester. Since biogas in the digester can be at quite high pressures it is important that the digester structure is strong enough.
- If the digester is below ground then filling it is easy, including with human wastes from a connected toilet. While use of toilet wastes is not common in some countries it can solve some basic hygiene and disease transfer problems. In Nepal now where up to 20,000 new digesters a year are being constructed over 80% of the new digesters installed are designed to receive toilet wastes.
- The digester is of the correct volume. If a digester is too small there will be too much manure for it and some wastage will occur. If it is too big then the initial cost is too high and its biogs production is no more than a smaller one.

4 THE ECONOMICS OF AN AEROBIC DIGESTER

The economics of producing biogas in off-grid rural regions at every scale differ from country to country, usually depending on cost of firewood, charcoal or bottled gas, or of diesel fuel for generating electricity. For Sudan one major issue driving development of use of household biogas for cooking is the high level of deforestation, and other related economic drivers relate to the cost of fossil or biomass fuels for the household or community. Presently, for households not on the grid lighting may be by kerosene and cooking by wood or even dry animal dung. All of these fuels have health impacts to the house occupants and particularly to the women involved in gathering fuels and cooking in enclosed spaces.

To work out the economics of a digester for a medium size family depends on knowing a few things – what the cost of other fuels is, what the value is of the labour in getting fuels, what the savings are in utilising the manures or other organic wastes as a feed for the digester, and what the value is of the digester residues are as fertiliser – both in avoiding cost of buying a fertiliser and of extra food produced.

The best economic outcomes from installing a biogas digester are for a family:

- that is having to buy fuel, or where collection of daily fuel takes many hours,
- where the alternative fuels are a problem to use - including being so smoky that it is a health problem,
- where the residue has a measurably good benefit for growing crops and vegetables
- where other benefits come with installation of the digester including less insects or less smells, or from availability of brighter light, or more time to do other wok that is of value.

Some of these economic points can be easily found such as:

1. Cooking. The biogas coming from 25 kg of semi-dry manures a day has energy or cooking/lighting value equal to 5 kg of wood, or 1.5 kg of charcoal or 0.6 litre of kerosene. Since a biogas cooking stove is about 5 times more efficient than a traditional 3-stone cooking fire system, the biogas from 25 kg of manure should provide a cooking time of 2.5-3.5 hours of a single burner cooker.
2. Lighting. While use of biogas for lighting is worthwhile in some instances it is a less efficient use of the gas as most of the energy of the gas simply goes to produce heat. But it may be that the lighting can allow some commercial or social activity such as lighting for a shop or school or community healthcare centre.
3. Cooling. Similarly the use for gas for a refrigerator can mean that vaccines or medicines, or perishable foods can be kept cool.
4. Food production. The residues when used as a fertiliser can increase plant growth rates or yields by up to double, depending on the plant species, the soil quality, rainfall, and how the residue is applied. Depending on the situation residue can be made into compost, mixed with irrigation water or put directly around the plant.

Altogether the economic benefits to the household or small community may often mean that the money invested in construction of the biogas digester and the fittings can save enough or earn enough that it is paid off in under 2 or 3 years.

5 REQUIREMENTS FOR A SUCCESSFUL NATIONAL BIOGAS PROGRAM

At the core of a successful program for installation of small rural biogas digesters (3-12 m3) are a number of critically important requirements –

- The access to finance for the householders through some microfinance system to provide low or zero interest loans to eligible applicants, possibly with a subsidy process at the start of the program to encourage initial take-up
- A training process for masons and the availability of fully-trained masons (including in all regional areas) to build digesters that pass all quality tests and are of approved design

- A well-designed promotion process and full support for the program by all stakeholders – including national government, Islamic organisations, national and international NGOs, and local government
- Biogas as part of reducing deforestation. Where deforestation is a problem the biogas program should be set up in parallel or in step with the program for reforestation and of public land management to reduce clearance of woodlands and illegal marketing of wood and charcoal.

Obviously the construction of larger anaerobic digesters is affected by other economic factors but may provide good returns to investment in many instances. The biogas production from larger systems may be enough to provide cleaned up gas for fuelling a spark ignition motor driving a generator. The threshold for this may be when the digester volume is over 30-50 m3 and the feedstock is of a higher biogas production potential – of such material as slaughter house wastes or of residues from food processing.

6 CONCLUSION

The need to develop alternative energy sources to wood and charcoal for households is very great in Sudan. Biogas is potentially a boon for rural families owning livestock including cows goats and sheep, and who face an increasing cost (in money or time) of getting fuels for cooking and lighting. The cost of installing a biogas digester can sometimes be paid back within only a few years, through the savings and benefits they can bring about. And a well-made digester can last for a person's lifetime, with enough biogas available every day for the cooking needs of the household. When small biogas digesters are installed in many households the total impact on use of wood and on social and economic benefits can be very great.

This biogas project will identify the existing barriers to a greatly increased adoption of anaerobic digesters, will train graduate engineers in the issues involved, and will involve and educate NGOs already working in the field in Sudan. The results will be applicable to many other countries and regions of Africa.

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