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# Evolution of biogas technology in South Sudan; current and future challenges

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## Background

Sudan is the largest country in Africa with a total area of 2.5 million km² with a population of 35 million people. The population comprises of mainly 65% Christian and Animist Africans and 35% Arabs who are predominantly Muslims.

Sudan has suffered an on-going civil war for 18 years that has resulted in; 2 million people dead, 1 million Displaced Persons (DPs) and 3 million Internally Displaced Persons (IDPs). The effect of this long conflict has been to totally impoverish the people of South Sudan and escalate the effects of natural calamities such as disease and famine. Physical infrastructures such as roads and buildings have largely collapsed. Technological development has also been a key victim in this conflict, archaic methods such as grinding grain between 2 stones and pounding by mortar and pestle are used today.

To save lives and alleviate the suffering of the war-affected civilian population in South Sudan; the international community provides humanitarian assistance through the Operation Lifeline Sudan (OLS). OLS has been instrumental in opening up access into the war-torn south by air, road and to a small extent by river so that relief supplies and services reach the needy. The work of OLS is based on the guiding principle of humanitarian neutrality that transcends political and/or military considerations. OLS works hand in hand with the Sudan Relief and Rehabilitation Agency (SRRA) as the local counterpart.

## Overview

The fuel mainly used for cooking in homes and public institutions of South Sudan is firewood. Firewood is collected from the forests and bushes by women and children -- sometimes as far as 6 km away. Large tracts of unutilized bush land resulting from displaced populations are a common feature in South Sudan. As a result, availability of firewood is not a constraint today. This however may change in future as more trees are cut down.

The main fuel used for lighting in homes and Schools is kerosene. Some rural households also use grass torches and firewood for lighting. The disadvantages of firewood and kerosene as fuels include:

- Excessive smoke pollution causing respiratory and eye problems
- High cost of imported kerosene further straining of scarce cash resources
- Dangers of fire outbreak and risk of explosions from tin kerosene lamps

## Introduction of biogas technology

Biogas technology was introduced in South Sudan during the year 2001 through a UNICEF/OLS-supported Biogas Pilot Project at the Rumbek Secondary School. In February 2001, UNICEF/OLS engaged the services of a Kenyan based company (Project Assessment Services (PAS)) to identify an appropriate biogas system for South Sudan. PAS was also required to construct and demonstrate the working of the biogas plant at Rumbek Secondary School. An agricultural consultant (Mr. David Njoroge) was assigned to carry out this task.

The choices of biogas plants available for selection included; the floating drum system (fairly common in neighboring Kenya), the fixed dome system (not common in Kenya) and the Tubular Plastic Biodigester (TPB). The TPB system has not been tested in Kenya but some work had been done and documented by Preston in neighboring Tanzania ( Bui Xuan An et al 1997). It was from the work of Dr. Preston that the UNICEF consultant knew of the existence of the TPB system. Through Email contact between the UNICEF consultant in Sudan and Mr. Nguyen Khang in Vietnam, at the University of Agriculture and Forestry, PAS imported a 7m$^3$ TPB unit from Vietnam to South Sudan. The package included a 45 minutes Videotape in Vietnamese language detailing the plant installation procedure.

Using a laptop computer and CD-ROM copies of the Video, the consultant trained 20 students and 2 Teachers of Rumbek Secondary School, first on the theory of biogas and then on installation of the TPB. This training took a period of 3 weeks. The team involved in this activity then became known as the Rumbek Secondary School Appropriate Technology Club (ATC).

Under the supervision of the UNICEF consultant and guidance from Mr. Khang via Email, the members of the ATC installed the TPB near one of the school kitchens. Subsequently, the team fed the digester with cow dung at the rate of 20 kg (1 bucket) per day. On the 25$^{th}$ day, the plant was tested by lighting the burner and the result was successful. This was the first ever practical experience with biogas technology in South Sudan. This TPB plant is today used as a biogas demonstration for the local community and visitors. It is also used to cook breakfast for 50 students. The ATC students teachers operate and maintain the TPB plant on a daily basis.

In 2002, UNICEF/OLS plans to support installation of 2 more 12.7m$^3$ digesters at Rumbek School, (ie: phase 2 of the biogas project). The aim is to reduce firewood use for cooking in the School by up to 80%. Currently, the School uses about 50 tonnes of firewood per year to cook for 400 students. The target group for training in the phase 2 of the biogas project will be the cooking staff in the School.

# Experiences with the Pilot Plant

The Biogas plant has performed satisfactorily for purposes of demonstrating that Biogas technology works. However, it has some significantly serious limitations as a cooking facility for the School.

## Gas pressure problem

After about 40 minutes of cooking, gas pressure falls drastically and the flame at the burner becomes very low. Common Sudanese meals require more than 2 hours of cooking. Often, the cook has to remove the food from the biogas burner after 40 minutes and transfer to the 3-stone firewood place. There is an urgent need to solve the gas pressure drop problem so that a sufficiently high cooking flame is maintained for 2 hours of cooking.

## Loss of bacteria and gas

It was observed that when the gas was not used, the digester expanded excessively and much of the digester material was expelled out through the outlet. The result was that active bacteria and undigested matter were lost with the effluent and low gas production followed. Adding fresh dung from animal rumen (from the local abattoir) solved this problem. Also, when much effluent was lost in this way, the level of digester slurry fell below the level of inlet pipe and gas was lost through the inlet. Adding water to compensate the lost effluent solved this problem.

## Durability

There is encouraging proof that the TPB can be a resilient and durable plant. Towards the end of 2001, Rumbek School was closed for about 3 months. During this time, the biogas plant was left unattended because all teachers and students went away. On return of the students, the plant was revived to full gas production capacity in only 3 days.

## Utilization of digester effluent

The ATC students have established a ¼ acre vegetable garden next to the biogas plant where they grow popular local vegetables such as Amaranthus and Okra. The students use the rich natural fertilizer from the Biogas plant to improve the soil on this plot. The vegetables are bought by local people and institutions, which provides some cash income for the Biogas team. UNICEF/OLS aims to support this initiative by providing high value crop seed such as Onion and Tomato to the students.

## Community Response

A Biogas Technology Community Awareness workshop named "towards intensified use of Biogas in South Sudan" was held in Rumbek between 13 and 15 of Februray, 2002. The workshop objective was to gauge the level of acceptance of Biogas technology by the Sudanese community taking Rumbek County as a microcosm. Participants were shown the TPB installation Video and conducted on a tour of the Pilot Plant at Rumbek School where the working of the plant, including the fertilizer use, was explained. The general response of the participants was as follows: Participants felt that biogas technology could:

- Considerably reduce expenditure on Kerosene and Charcoal for the war impoverished communities by using cow dung which is locally available

- Reduce the time spent by women to look for firewood in the forest and remove the common risk of snakebites while collecting firewood
- Improve soil fertility by adding organic matter from the digester for vegetable gardens and so enhance nutrition and improve household food security
- Create an opportunity for youth employment by imparting skill (biogas technology will be an employable skill once the technology is widely adopted by communities).
- Provide the communities with a clean non pollutant fuel for cooking and lighting and protect the environment by reducing tree cutting for firewood

The general mood of the 3-day stakeholder participatory workshop pointed towards an enormous potential for adoption of the biogas technology in South Sudan.

# Major challenges and opportunities

South Sudanese own large herds of cattle that are grazed in open fields and kept overnight at cattle camps. It is possible to collect several tonnes of cow dung from one cattle camp every morning. However during the dry season, cattle camps are moved far from the towns and villages in search of pasture and water. There could be a shortage of cow dung for biogas during such times. Currently, this problem is being addressed by introducing the use of oxcarts to transport dung from cattle camps to biogas plants.

Water is a scarce resource in South Sudan. Currently, biogas plants are located where OLS has provided drilled or dug water points.

The biggest challenge for the TPB is the local availability of the plastic tube and burners. These are currently imported from Vietnam and Cambodia. Efforts are being made to identify a manufacturer for the plastic tube and burners in Nairobi, Kenya.

Local availability of the tubular plastic will further reduce the cost of the TPB and so make the technology affordable to households in South Sudan. The lightweight materials of the TPB will be easily and cheaply transportable by road (from Uganda or Kenya) or by air as opposed to large gas tanks of the floating drum biogas type. Hence business people in local shops can easily stock the TPB materials. Ease of installation and low specialized skill demand is an added advantage of the TPB vis-a-vis other common biogas plant types.

# Overview of biogas in Africa

Over-dependence on firewood and booming populations has resulted in a sharp decline of woody biomass in Africa. Some African countries are already deep into an energy crisis while others are faced with an imminent crisis. The ever-increasing prices and scarcity of fossil fuels has further aggravated energy supply crises in the continent. Since 1970s, biogas has been identified as a possible solution to the energy crises in Africa, but the technology has not been sufficiently adopted by communities to replace dependence on fossil fuels and wood.

A few large-scale biogas plants were in operation in South Africa as early as 1950s. Other countries such as Kenya, Tanzania, Zimbabwe and Burundi have a fairly large number of biogas units used to provide methane gas for cooking and lighting. The fertilizer value of Biogas plants is also widely appreciated in these countries by farmers who own biogas plants.

In Kenya, European farmers introduced biogas technology in mid 1950s. By 1958, Tunnel Technology limited had constructed about 150 biogas plants in some parts of the country. The most widely disseminated biogas plant in Kenya is the Floating Drum type. The promoting agencies are:

- Special Energy Program of the Ministry of Energy and Regional Development (SEP/MOERD)
- Tunnel Technology Limited (TTL)
- Kentainers Limited
- The Fixed Dome type digester is promoted by the Christian Intermediate Technology Center (CITC)

Kenya derives about 70% of its total energy from very scarce and fast diminishing wood resources. Biogas has the potential of reducing dependence on these wood resources and pre-empt the imminent energy crises because 80% of rural Kenyans own livestock (cows, pigs, etc). More than 600,000 rural households in middle and high agricultural potential areas of Kenya keep between 2 and 6 dairy cows under zero grazing. These households are all potential owners of biogas plants. Unfortunately many biogas projects in Kenya have failed and have been abandoned less than 5 years after installation. It is estimated that that only 25% of 300 units installed between 1980 and 1990 are operational today. The high failure rate can be traced to 4 main reasons:

- Poor design and construction of digesters, wrong operation and lack of maintenance by users
- Poor dissemination strategy by the promoters

- Lack of project monitoring and follow-up by promoters
- Poor ownership responsibility by users
- Failure by government to support biogas technology through a focused energy policy

In Rwanda, biogas technology is quickly catching up through the efforts of Kigali Institute of Science Technology and Management (KIST). KIST has designed and built a $150m^3$ fixed dome digester in Cyangugu prison that is fed with human waste generated by 1,500 prisoners. This digester produces methane gas that caters for 50% of the cooking needs in the 6000 inmate prison. KIST has also solved the sewerage and hygiene problem at Lysee de Kigali School by providing a $25m^3$-Fixed Dome digester connected to 6 bio-latrines. The methane gas produced is used to cook for 400 students and for operating bunsen burners in the school science laboratories. The work being done by KIST with support from the Rwandese government is an excellent example of how government policy can move biogas technology forward and in the process, help to solve energy, budgetary and hygiene problems for poor countries in Africa.

## Constraints

The main constraints to Biogas technology dissemination in Africa can be summarized as follows:

- High initial investment cost for the common types of biogas plants (the cost of a family size floating drum plant is US$1667 - beyond the means of rural farmers)
- Lack of flexible community friendly credit schemes to help poor farmers own plants
- Bad experiences and poor image created by many failed Biogas plants
- Lack of government commitment (policy) and limited private sector input because of low profit incentive.
- Lack of recent research information on biogas technology from within and from countries where the technology has been successful such as Vietnam and Cambodia
- Lack of financial support to small firms and serious individuals to set up effective business operation in the appropriate technology energy sector.Small and seasonal disposable farmer incomes to invest in biogas technology owing to competing needs and obligations

## Conclusion

Establishment of a networking relationship with the University of Agriculture and Forestry in Vietnam, and the University of Tropical Agriculture (UTA in Cambodia, will greatly enhance promotion of biogas in South Sudan-and Africa at large by:

- Providing information on recent developments in recycling of livestock wastes through biodigesters and water plants to biogas promoters and owners.
- Promoting and perfecting the use of the low-cost Tubular Plastic Biodigester (TPB) technology in rural communities and institutions hence making biogas affordable to the poor.
- Sharing of the technology on production of the plastic tubes for the TPB so that these become locally available in remote locations such as South Sudan.
- Possibly providing scholarships for students and teachers from the disadvantaged communities in South Sudan to study Biogas related subjects in Vietnam and Cambodia.
- Possibly initiating a farmer-to-farmer exchange visit program to enhance technology transfer and friendship at the community level through sharing of experiences and cultures.

## References

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Go to top