Integrated development of biogas in West Africa

Population growth and urbanisation, going along with changes in lifestyle and consumption, lead to large quantities of solid and liquid organic waste resulting from agricultural, agro-industrial and urban activities (animal waste, crop residues, food waste, waste from food processing, sewage sludge, sewage sludge, etc.). In the absence of an adequate or deficient waste management system, these wastes can cause harm to human health and the environment. Biogas technologies are unique compared to other renewable energy forms, in that they address several challenges in sub-Saharan Africa in an integrated manner, enhancing the connections and potential synergies between sectors.

Within the framework of a (decentralised) mix of renewable energy, the production of biogas contributes to a reduction in (negative impacts of) the use of wood and fossil fuels. Better management of organic waste sources and pollution and the implementation of a clean cooking methods contribute to improved sanitation, hygiene and health. The recycling of bio-digestates contributes to improved agricultural performance and enhanced food security. And, finally, biogas production creates new businesses along the service-value chain, contributing to employment and livelihoods.

The adoption of renewable energies in developing economies is growing rapidly. In 2005, the Biogas Africa initiative was launched in Nairobi. Since then, many actors have participated in various partnership initiatives and programs to support the development of methanation. However, the dissemination of biogas in sub-Saharan Africa encounters key obstacles, such as constraints to mobilise organic residues, high initial investment (construction) costs, insufficient maturity of national biogas programs, technical, institutional and socio-cultural barriers. Innovative information and capacity building approaches are needed to support the private sector, governments and civil society to enable wider adoption and dissemination of biogas as part of a further increase in the proportion of renewable energy in Africa.

Recommendations

1. Biogas can contribute to the energy needs of West African countries, as part of a locally appropriate (renewable) energy mix, while addressing a number of other sectoral challenges. It is therefore important to stimulate integrated planning and coordination processes to overcome sectoral approaches.

2. The re-use of organic wastes as agricultural fertilisers and energy using biogas technologies, requires proper management of these resources. Governments should introduce a systematic approach to the collection and dissemination of statistics on organic wastes at various levels and sectors.

3. The development of biogas technologies cannot be achieved without institutional support at national and local level. In addition to subsidies for installation of biogas units, investment and availability of mixes of finances for equipment and recovery of by-products (fertilisers and biogas) are needed to support further development and its sustainability.

4. Development of a critical mass of specialists in biogas and related topics is key in the development in West Africa. This requires the development and dissemination of curricula including decision-making tools for the training of technicians at all levels (vocational schools, technological institutes, universities, etc.).

5. At local level access to information on the availability of organic resources and the use of by-products as well as access to various sources of financing and appropriate technologies should be facilitated through local incubator centres. The establishment of these decentralised support structures will bring together local authorities, technical services and communities.

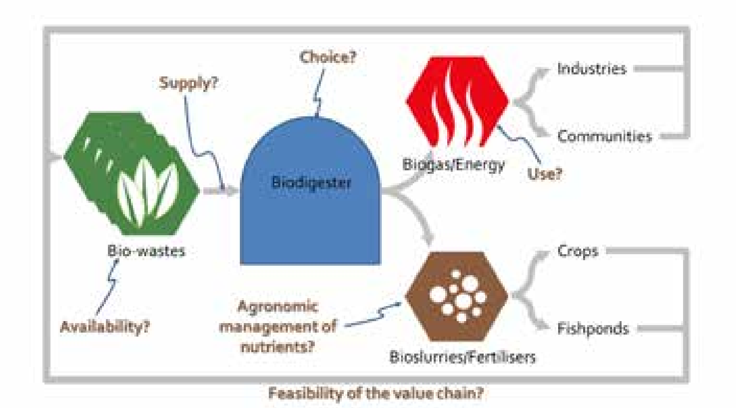
WABEF
Western Africa Biowastes for Energy and Fertilizer

Bio-wastes

Africa has an abundant potential of bioenergy in the form of plant and animal residues or bio-wastes, which are enough to produce the complementary bioenergy needed in the energy mix to satisfy the total/national demand for electricity. Around 850 million people cook and heat their homes using open fires and simple stoves burning biomass (wood, animal dung and crop waste) and coal in Sub-Saharan Africa. Opportunities exist to develop sustainable biomass and biofuels.

Bio-wastes, or "Residual Organic Products" in the broad sense, are biodegradable wastes derived from agricultural, agro-industrial and urban human activities such as manure, slurry, abattoir waste, garden or park wastes, food or kitchen wastes, sewage sludge and faecal sludge.

The potential of using bio-wastes for energy and fertiliser is based on the accumulated waste volumes of animals and crops. However, in most countries this is hardly known and quantified, hence, this does not give policy makers or entrepreneurs sufficient information on how and where to start a business or how to set out a diligent policy. WABEF proposes an operational tool for each step of the value chain on: availability of bio-wastes; supply needs for different anaerobic digestion systems; valorisation for biogas and/or agronomic management of bioslurries; viability for the whole value chain business, and ready-to-use knowledge for decision-makers and practitioners.



Biogas Value chain and questions to be answered to support decision-making and a viable business plan

wabef.cirad.fr/en

Various innovative uses of bio-wastes have been introduced and tested, such as domestic or community-managed biogas projects, using food-wastes and waste from agroindustry, or the use of bio-ethanol and biodiesel. WABEF made an analysis of the biogas sector and available technologies in a number of EU and African countries, looking at functioning, environment, embedding in existing organisational structures as well as social and economic perspectives. The key lessons and insights for West African Countries are 1) secure bio-waste supply flow; 2) incentive policy proposed by the State; 3) secure sales and recycling of bioslurries.

Lessons and challenges

The technologies are available, reliable and increasingly cost-competitive. Mobilising the necessary investments will require governments and other stakeholders to work towards an environment that is built on an enabling policy and regulatory framework. An integrated approach must also enable proper management of information, waste resources.

Potential

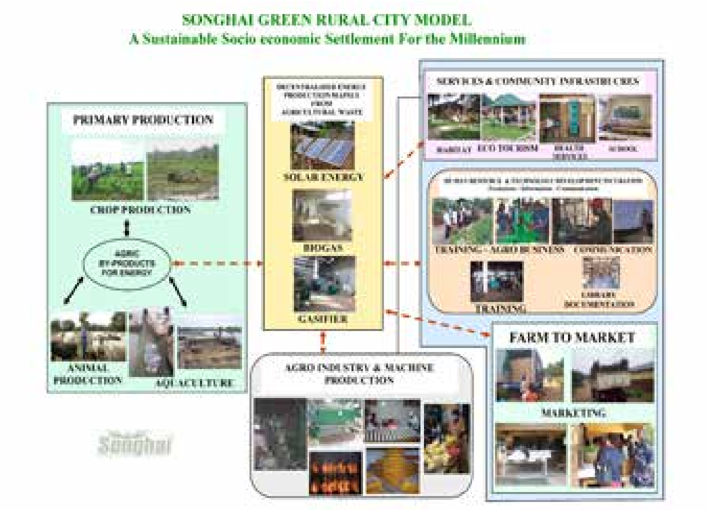
- ECOWAS/ECREEE suggests that up to 54% of Western Africa Power supply can be based on renewables in 2030 (that includes hydro-power). Most ECOWAS countries have set targets of a use of 10% to 20% renewable energy (excluding hydro-power) in 2020 and 2030 respectively.
- Bénin imports nearly 80% of its electricity, while its annual total biomass production capacity is in principle enough to satisfy the national demand for electricity (including agricultural residues and household wastes). For 2025, Bénin targets an energy mix comprising 25% of renewable energy.
- WABEF calculated that in Sénégal the potential availability of bio-wastes in 2013 (in tonnes of dry matter per year) is: 2,311 million animal waste; 2,426 billion crop residues; 0,216 million household biowastes: and 8,713 million faecal sludge.

In order to manage urban and rural development in a sustainable way, proper planning and coordination are required to assure synergies in the nexus between food, waste, water and energy adapted to local context. Proper assessment of the national and local bio-waste streams, development needs and markets result in a approaches that fit in the development momentum.

Supply unit of the Transpaille® and the biogasholders at Teriya Bugu

Songhaï Regional Centre in Bénin

Songhaï, created in 1985, is an original centre for integrated development that puts human capital and bio-energy development at the centre of the pyramid of primary, secondary and tertiary production. Bio-energy refers to crop production, animal husbandry and fish farming using solar energy, and using the biomass derived from the organic residues from plants, animals, and fish to produce biogas and syngas (the latter by gasification). Currently, the Songhaï Centre in Porto-Novo produces an average of 1,300 m^3 of gas per month, supplying two generators with a total power capacity of 75 kW for the production of electricity. This off-grid electricity production satisfies 10% of the energy needs of the Centre's three production sectors at an average price of 111 FCFA/kWh. The bioslurries (11 tons/week), are used to fertilise 5 Ha crops (horticulture and fruit production) and 2 Ha fish ponds, producing enough for the restaurant and allowing to avoid the use of 1.4 tons of chemical fertiliser per year. The synergies created at Songhaï allow organic products and residues to be sources and sinks and generating the energy necessary for integrated and inclusive socio-economic growth in rural and urban areas. Songhaï proposes this model of African rural green development, enhanced by information and communication technologies, in Bénin, Nigeria, 15 other African countries and to the world.



AEDR-Teriya Bugu in Mali

Teriya Bugu, "the village of friendship" in Bambara, is a community development centre, located 2 hours from Ségou in the direction of San, which integrates agriculture, bio-energy development, and tourism, while supporting the rural community of Korodougou. The centre is managed by *The Association d'Entraide pour le Développement Rural* (AEDR). The bio-energy mix for the centre is based on the production of 8,000 litres of Jatropha vegetable oil per year. The seeds are bought at 100 FCFA/kg from 55 producer cooperatives (25 to 30 members each). The electricity, produced by two (25 kW and 33kW) bi-fuel motors, supplies the independent grid of the centre, including the village where the employees live (500 people). Solar power is used for irrigation using water from the Bani River, as well as for heating of water supplied to the community. The Jatropha cakes is used in a Transpaille® biogas reactor with a capacity of 50 m^3 producing 12,000 m^3/year of biogas, which is used for the Centre kitchen, and 7 tons/year of digestate, to fertilise crops. The activities of Teriya Bugu support in total 7,000 people in the community of Korodougou. The bio-energy mix (electricity and biogas) is enough for the its needs, thus saving more than 35,000 litres of diesel per year, i.e. around 1,400 Euros/month.

Typologies and approaches

A number of technologies and approaches have been tested or are emerging, particularly in the nexus between food, waste, water and energy. WABEF made an inventory of biogas available technologies in 4 EU and 5 African countries, looking at performance, environment, organisational structure, and social, economic and political perspectives of technologies, and using "source and nature of bio-waste intake" (agricultural, agro-industrial, municipal) and "annual biogas produced or electric power delivered" as main indicators. For each of these categories, example businesses and lessons learned are available in the WABEF Compendium (https://wabef.cirad.fr).

The promotion of integrated development of anaerobic digestion should aim to offer key elements and information to support decision making at policy and business level on an integrated and a viable biogas value chain. WABEF has developed a number of tools to facilitate this assessment, which includes a tool to assess technology readiness level, which may indicate the maturity of the technology for a certain location.

Some valid technologies for West Africa are:

- ***Rural household small dome biodigester*** Various experiences, possibly linked to mini-grid development: A 6 m^3 biogas digester needs 50 Kg of manure/waste and 50 L of water, to produce 2m^3 of biogas daily. Women and children do not have to go out for fuelwood anymore. And if managed well the digestate may support up to 20% increase of production on 1-1.5 Ha (HIVOS/SNV, 2017).
- ***Integrated development of community, small town,*** or city neighbourhoods, including biodigesters. In Germany, Lathen the bio-energy village mixed biogas, solar and wind energy. In Ghana, Safisana is a good example of a grid connected biogas plant. Located in a large slum community, the plant offers access to sanitation for over 40,000 people, electricity generation to serve over 3,000 families daily and supply of power to the grid: treating 13 tons of toilet waste and recycles 15 tons of solid organic waste daily; and providing nutrients to about 720,000 m^2 farmland; while delivering direct and indirect health and economic benefits for 125,000 slum dwellers.
- ***Agro-Industry***. Little functioning and viable examples exist. Dekker in Netherlands uses 13,000 tonnes of mainly cow manure and another 10,000 of crop residues and urban organic waste (supermarkets) in 2 x 2,000 m^3 digesters, to produce electricity (capacity 3 x 346 kWe) and heat. Low price for electricity hampers high profit, but savings in own gas and electricity bill is considerable.
- ***Institutional biogas at schools or abattoirs.*** In Sénégal, the Dakar abattoir recycles its waste (50 tons of a mixture of paunch contents, dungs, blood and washing water per day) in a Thecogas biogas plant with a capacity of 4,000 m^3, producing 1,000 m^3 per day generating 800 kWe/day and 1,700 MW of heat annually, covering 50% of the power and all the hot water needs of the abattoir. Daily, the equivalent of 80% of the intake is evacuated as a bioslurries. Thecogas and the Biogas National Program are engaged in a labelling process for bioslurries to provide farmers with a satisfactory cost/efficiency ratio fertiliser.

Upscaling

Many countries have established national energy plans and renewable energy targets and translated these into supportive policy, institutional and investment frameworks. And a substantial number of stakeholders engaged themselves in different initiatives and partnership programs supporting development of biogas technology in Africa. However, only a few countries have managed to start implementing their frameworks, sometimes due to a lack of clear mandate and responsibility. Obstacles for upscaling and dissemination of good practices in Sub-Saharan Africa are: lack of access to inputs (waste on a regular basis and water); high capital costs and low levels of both local and international investments; high labour demand; negative public perception of the use of waste; as well as insufficient maturity of biogas programmes.

WABEF – Western Africa Bio-wastes for Energy and Fertilizer – promoted anaerobic digestion to recycle bio-wastes to produce energy and fertilisers, and as such closing the organic matter loop. WABEF mainly focused on the issue of access to data and information. For each step of the value chain, WABEF developed and tested operational tools. In Bénin, Mali, Sénégal and Cape Verde selected actors have been trained in the use of these tools, and are responsible for further uptake and dissemination.

WABEF Regional School Participants at Songhaï in July 2017. Development of a critical mass of specialists in biogas and related topics is key in the development in West Africa. This requires the development and dissemination of curricula including decision-making tools for the training of technicians at all levels (vocational schools, technological institutes, universities, etc.).

wabef.cirad.fr/en

WABEF, a toolkit to promote anaerobic digestion of bio-wastes in West Africa

What availability of Bio-Wastes? A methodology to identify, quantify and evaluate the potential availability of bio-wastes in terms of biogas production and fertiliser use of digestates is provided. Three databases have been organised (MS Excel®) to estimate the wastes from agricultural activities (crops and livestock), municipal activities (biowastes, faecal sludge and sewage sludge) and agro-industrial activities.

What supply for a collective unit of biogas? Approzut and UPUTUC simulation models are adapted for the evaluation of the supply strategies of a collective biogas unit (available and adaptable to the West African context).

Which technology to choose? The model of technical-economic analysis of biogas: Methasim© developed by IFIP is being adapted for use in West Africa through the integration of a local bio-wastes features database and a recent biogas plant features database.

What agronomic management for nutrients in bioslurries? An MS Excel® spreadsheet is developed to help local service providers, community centres, and farmers to calculate the availability of organic residue-based fertilisation, including bioslurries. This tool is operational to guide the fertilisation of vegetable crops.

How to use the biogas? A simple calculation tool for assessing the use of biogas through direct use or generation of electricity is available in an MS Excel® spreadsheet in English and French.

How to assess the feasibility and viability of the value chain? Three spreadsheet tools have been developed to address the feasibility of the value chain:

1. Business model template for Bio-wastes for Energy and Fertilizers (BEF);
2. FIETS adapted tool to BEF for monitoring and assessment of existing project;
3. Product Market Cluster tool for decision-makers

What initial and professional training? Courses on WABEF's approach and tools, included in a graduate curriculum in Sénégal and to be included in others, is proposed on the basis of the results of the project to train technicians, engineers, practitioners and decision-makers in the agriculture, agroindustry and urban sectors.

This Policy Brief was developed by the RUAF Foundation (Netherlands) in partnership with CIRAD (France), UCAD and IAGU (Sénégal), AEDR Teriya-Bugu (Mali), and Songhaï (Bénin) under the Western Africa Bio-wastes for Energy and Fertilizer (WABEF) project.

The authors are very grateful to all those involved in energy, agriculture, research, development and education in Bénin, Mali, Sénégal and Cape Verde who participated in the WABEF Regional School. Their participation made it possible to finalise this Policy Brief and we thank them very warmly for their contributions.

WABEF is an action of the Cooperation Program of the European Union and the African Caribbean Pacific Group of States for Science and Technology (EU-ACP S & T II) identified by contract n° FED / 2013 / 330-225. This publication was produced with financial support from the European Union. Its content is the sole responsibility of the authors and can in no way be considered as reflecting the views of the European Union.

This policy brief is part of the RUAF Foundation's Policy Briefs Collection.

Authors: R. van Veenhuizen and M. Dubbeling (RUAF Foundation), M. Ba (IAGU), S. Niang (UCAD), M. Kamaté (AEDR Teriya-Bugu), J. Lekoto (Songhaï) and J.M. Médoc (CIRAD)
Photo credits: WABEF team 2014-2017
Design: F. Hoekstra (RUAF Foundation)
Date of publication: August 2017
The EU-ACP S&T II Program is financed by the European Union and implemented by the ACP Group of States.