

(ii) soil conditioner impact on physical and biological properties of the soils

(iii) safety: presence of toxins and heavy metals.

The raw *Jatropha* cake and the digested *Jatropha* cake have high nitrogen mineralisation potential, and despite a high presence of phorbol esters toxins may be considered as organic fertilisers. Experiments at Teriya Bugu showed no presence of these toxins in fruits and cereals after fertilisation with *Jatropha* cake, while the yield of tomatoes improved considerably (from 22 t/ha to 31 t/ha, Traoré, Kamaté et al, 2015). In Mali, there is no standard yet for the use of *Jatropha* fertiliser, but AEDR is working on this with ANADEB.

In addition, WABEF analysed the business of the centre. This exercise provided insight into the social business of biogas, highlighting the need to look at various segments and to combine mixes of inputs and outputs. Since the rehabilitation of the bio-digesters, Teriya Bugu no longer lacks biogas to meet its cooking needs for the hotel. This results in savings on hotel costs and also an increase in the purchase price of seeds of *Jatropha* to producers (100 FCFA / kg instead of 75 FCFA of *Jatropha* seed). Teriya Bugu is now able to generate sufficient biogas and fertiliser for its needs.

The 55 cooperatives that Teriya Bugu works with are involved and informed about the process of valorisation of *Jatropha* cake and also of the waste. Teriya Bugu is planning now to further increase its production of RE, serving the village in biogas for cooking purposes and producing electricity for the community.

Teriya Bugu is one of the pioneers of renewable energy in Mali, with more than 30 years of experience. Together with other experiences, like that of SNV and AVSF, who are running programmes on developing family biogas in Mali, the community approach serves as a model for rural community development. Mini grids using mixes of renewable energy in villages that have sufficient raw material available are an inspiration.

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Centre Songhai: Integrated development of renewable energy in Benin

Centre Songhai in Porto-Novo in Benin is an innovative organisation for integrated development that puts human capital and bio-energy development at the centre of its activities. Currently, the Songhai model has been replicated in Benin and Nigeria and in 15 other African countries, with the support of various donors including UNDP, Songhai was recognised as a Regional Centre of Excellence for Africa by the United Nations in 2008.

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Songhai was created in October 1985, borrowing its name from a powerful and flourishing West African empire of the fifteenth century. The idea of the creation of Songhai Centre came from Father Godfrey Nzamujo, who together with others who shared his vision of giving Africa back its dignity. Supported by the government, the project at Ouando (a neighbourhood of Porto-Novo) was started on an acre of land specifically targeting African youth. Songhai Regional Centre in Ouando now covers more than 22 hectares of land and is mainly used as the organisation's headquarters and as an experimental site.

Songhai is a unique integrated development programme, designed to radically address unemployment and food insecurity associated with poverty. It also addresses environmental management. It is not simply a typical model



Participants of the Regional School in Songhai, Benin. Photo by René van Veenhuizen

of training or technology transfer, but also innovates technologies and builds capacities by forming a critical mass of young people to produce *MORE and BETTER with LESS*.

Songhai's innovative strategy consists of four basic components:

- a technology park where new ideas and techniques are developed
- an industrial park where techniques and ideas are transformed into enterprises
- an incubation centre for building skills and providing training
- a service centre.

Renewable energy in Benin

The production and use of energy are determining factors for the socio-economic development of Africa and Benin in particular. The New Partnership for Africa's Development (NEPAD) stipulated that in order to fight poverty and achieve the targets set in the Sustainable Development Goals, each African community should grow its energy production and consumption by at least 7%, to achieve 6% growth in the agricultural sector and 8% in economic growth. This requires integrated, broad and inclusive development, enabling communities to have access to this means of development. In terms of access to energy, access to quality agricultural soils and fertilisers is essential to meet the challenges of

Potential of renewable biomass energy

The annual biomass production capacity in Benin is estimated at 1003 MW, based on the availability of 3.3 million tons of agricultural residues. This biomass pool is in principle enough to satisfy the national demand for electricity. It includes:

- Residues from agricultural production: mainly cotton, sorghum, millet, rice and maize. Statistics show that Benin has relatively large quantities of residues at the national level which, when recovered, will provide around 4,356 GWh of electricity
- Livestock wastes that can be collected for the production of biogas; according to information received from the Department of Livestock, to use 80%. But the animals

needs to be housed. Statistics show there are 1,876,800 cattle, 341,700 pigs and 2,229,700 small ruminants

- Agrifood processing industries release large quantities of waste (shells and cake of cotton, palm or coconut seeds, and residues of pineapple and mango etc.) and constitute genuine energetic potential. Timber-processing residues in the form of sawdust, chips, etc. can be added to this
- Household waste is generated in urban areas in significant quantities and its valorisation could be envisaged for the development of capacities to produce electrical energy to be injected into the distribution network. For example, the City of Cotonou generates more than 700 tons of garbage per day. This potential could allow the installation of a power plant with a capacity of 5 MW.

adapting food systems to climate change and food security.

In Benin under a scenario of strong economic growth, total electricity demand would be 4,116 GWh in 2025 with an installed power requirement of 635 MW. With the current capacity of 160 MW managed by the Benin Electric Power Company (SBEE) and the Benin Electricity Community (CEB), Benin has to import nearly 80% of the electricity it consumes from neighbouring countries (Ghana, Nigeria and Côte d'Ivoire). In 2025, Benin targets an energy mix comprising 24.6% of renewable energy.

The Government of Benin supports the enhancement of renewable energy and the use of bio-wastes, through research and financing, including through:

- SREP: A large-scale renewable energy development program in low-income countries
- The second Compact of the Millennium Challenge Account, signed on September 9, 2015 in Washington, which aims at the reconstruction of the energy sector and includes production, distribution, institutional reform and decentralized energy components. This agreement is worth about \$ 411 million
- Financing of private developers to set up infrastructure for the production of electricity from renewable energy sources
- Financing through its own funds in conjunction with concessional loans from development banks.

WABEF and the Songhai Centre

In order to meet these challenges, Songhai is promoting an integrated system that includes the recycling and upgrading of organic residues from agricultural production (animal waste, crop residues, and processing effluents). New ideas and techniques are disseminated in the Technological Park of Songhai.

Within the framework of the WABEF project, extension and teaching materials have been developed and made available to inform and educate the general public on biogas production technology. The park receives more than 450 visitors each week on average. These are potential future agricultural entrepreneurs, specialized in the field of renewable energies. On average, there are 40 young people who specialise in biogas per semester. The framework also welcomes 5 to 10 students from universities and elsewhere for their research work on biogas production and recovery technology.

Currently, the Songhai Centre in Porto-Novo produces an average of 1,300 m³ 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 digestate (11 tons/week), is used to fertilise 5 hectares of crops (horticulture and fruit production) and 2 hectares of 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 Songhai allow organic products

Gbéko town is located about 30 kilometers from Porto-Novo, and has 20,000 inhabitants. Like all rural areas in Africa, Gbéko's economy is characterised by non-competitive, unprofitable and non-attractive subsistence agriculture for young people. This leads to a massive rural exodus of young people from the region. The rural electrification project is supported by Ministry of Mines, Energy and Water. It consists of developing decentralised renewable energy as a central lever for transformation and rural development, creating a synergy between agricultural production and energy.

Energy will come from biomass issued from forest products, animal waste and agricultural by-products and residues. Green energy (biogas, gas) and solar energy will be produced not in a centralised but rather a distributed way. The challenge will be to connect them and redistribute the energy through a smart grid. Thus, each zone and each family is both producing and consuming energy.

It will be used for various agricultural and para-agricultural activities such as year-round irrigation, processing and conservation of agri-food products, transport to create an internal market and exchange networks with other regions.

- *Bringing energy to the 20,000 inhabitants of the isolated district of Gbéko, and around the Songhai Centres*
- *Starting similar pilots in other isolated rural areas and other Songhai centers*
- *Transferring skills to local Songhai partners and creating an enabling environment.*

The advantages are increased and diversified production and related technological activities along the value chain. This aims to create opportunities and increase purchasing power, savings and investment capacity of communities. The project will be further extended to Gbéko, Parakou, Savalou, Kinwedji, and Ikemon, with Porto Novo as the centre of research, development and training.

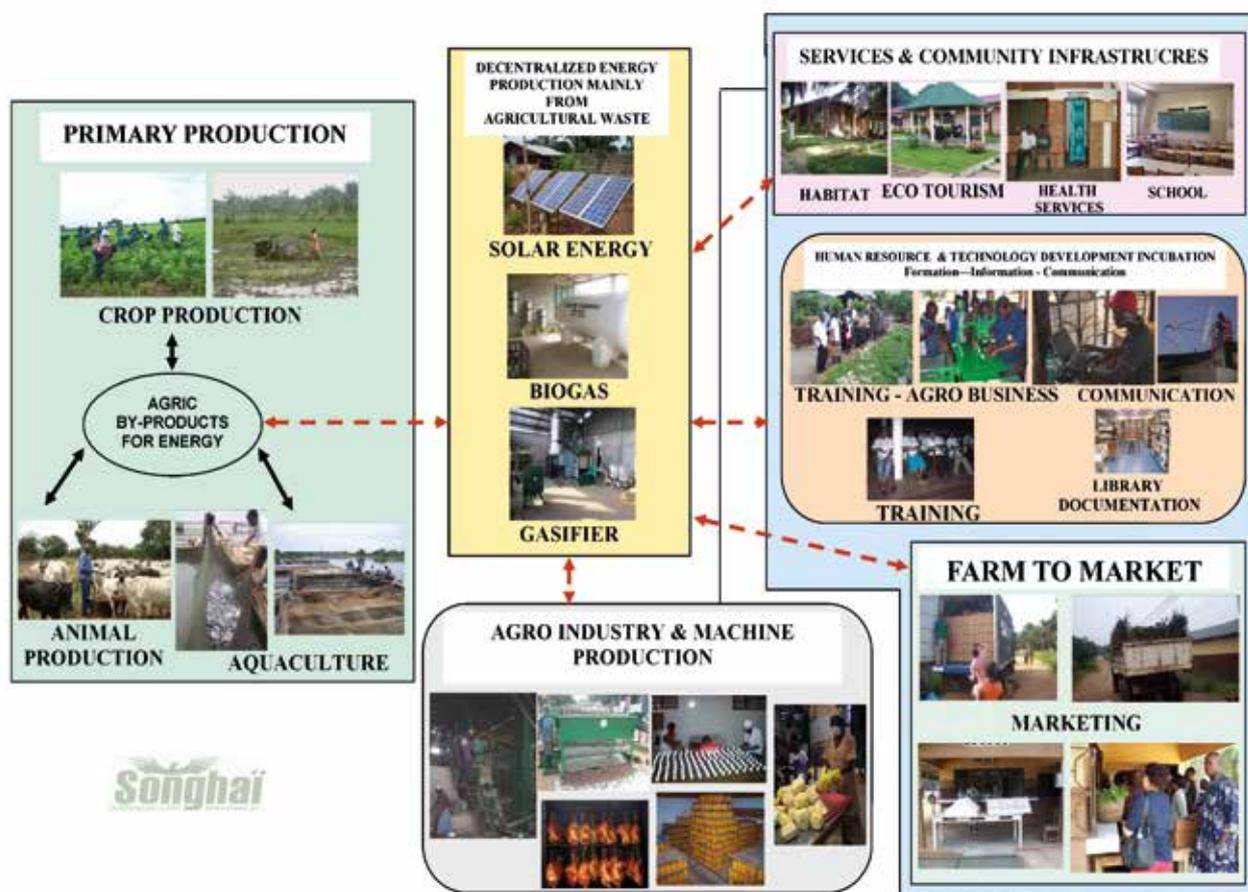
and residues to be sources and sinks and generating the energy necessary for integrated and inclusive socio-economic growth in rural and urban areas. Supported by WABEF, Songhai has analysed the costs and benefits of the biogas system and has taken the measures suggested to make it more efficient.

Related activities of Songhai

In partnership with SNV Benin, Songhai has developed and installed nearly 200 household bio-digesters, valorising agricultural residues, and supporting local power generation for SMEs. Songhai succeeded in increasing or even doubling the conventional production of biogas with the introduction of Efficient Microorganisms. SNV Benin, Songhai, the Directorate General of Energy, Ministry of Agriculture and ABERME, are involved in developing further use of biogas in Benin. A National Biogas Programme is being developed, as in Ghana.

SONGHAI GREEN RURAL CITY MODEL

A Sustainable Socio economic Settlement For the Millennium



Songhai has furthermore developed a gasifier that supplies co-generators of 60 kW for the production of electricity for fruit-juice processing plants and heat for drying vegetables, fruit or pellets for fish. This *Singaz* product is derived from valorisation of tree-pruning residues, palm kernel shells, coconut shells, corn cobs after ginning, etc. The biochar produced after the gasification is currently valued and developed as soil conditioner, fertiliser and for the purification of the waters used in fish culture. Photovoltaic solar energy is also developed and used to enable the operation of the crop irrigation network and lighting.

Integrated development, Songhai's ambitions

The Songhai Centre is recognised by United Nations agencies as a Centre of Excellence for the promotion of entrepreneurship in Africa. The Songhai model is a viable initiative for further development and acknowledged as such by the Benin Government. Songhai is facilitating the Benin Renewable Energy Platform with the Government.

The integrated project "Songhai Energy" aims to produce, and to stimulate the production of, renewable energy. The aim is not only to meet the energy needs of the various Songhai Centres in Benin, but to work in the same way with and for the surrounding communities, particularly those located in rural areas. This will also help to reduce the rural exodus and impact the increase of urban slum, with a

positive impact on their development. A good example of this decentralised energy development or micro-grids is the Songhai experimental rural electrification project in Gbêko, which is a key element in the sustainable socio-economic transformation of rural areas into green cities in Benin.

Recommendations

Based on Songhai's (including WABEF's) experience and work, the following recommendations are given:

1. Enhance information on total wastes generated and biomass energy value and the potential in Benin
2. Enhance information on available technologies
3. Increase access to finance and stimulate entrepreneurship
4. Further establishment and implementation of a National Biogas Programme.

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