Waste-to-Energy Business Models: Insights from a compendium of business models

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Recovering energy, nutrients and water from domestic and agro-waste streams is gaining momentum as a new agenda for promoting sustainable development in developing countries as waste management strategies shift focus from a *disposal-oriented* approach to *a business-oriented* approach. The latter approach emphasises *value creation* and *revenue generation* (Murray and Buckley, 2010). As most cities in developing countries struggle with the challenge of energy security, recovering energy from different waste streams offers dual benefits – improved waste management and provision of reliable energy to households, institutions and commercial entities.

The International Water Management Institute (IWMI) has identified and analysed a number of waste-to-energy business cases across the globe and, based on these cases, has developed a number of waste-to-energy business models with potential to be scaled up in different settings and contexts (see link for business model profiles https://wle.cgiar.org/rrr-business-model-profiles). In this article we highlight the factors that drive but also may inhibit the success and sustainability of selected waste-to-energy business cases in different countries.

Waste-to-energy businesses can be categorised into different typologies based on such factors as type of value proposition offered by the business, the revenue generating mechanism, the type of partnership and ownership structure and the type of waste input and energy product recovered. In order to understand the waste-to-energy conversion processes, it is important to consider three components of the process: the waste stream, the energy product and the end use, as shown in Figure 1. The waste streams come in a variety of forms and have different properties that impact their use for producing energy products which come in solid (briquette), liquid (bio-fuel or ethanol) and gaseous (producer gas and biogas) form. These energy products are used to generate heat, electricity and fuel for cooking or for transport.

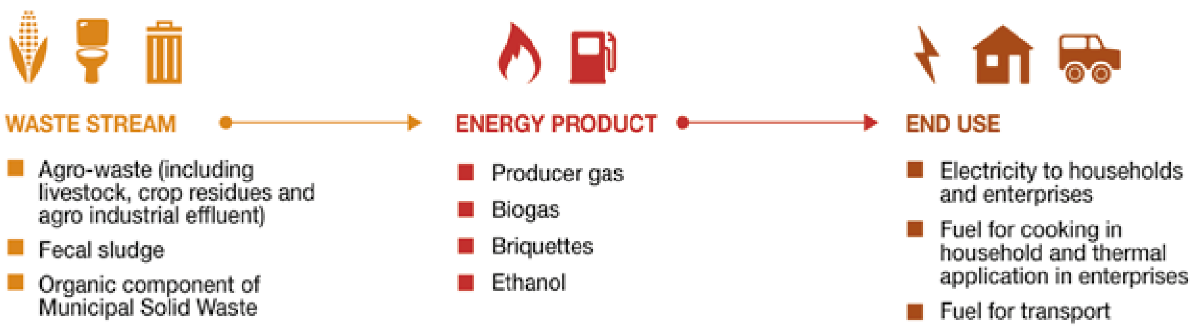

Figure 1. *Waste-to-energy process framework* (Otoo and Drechsel, 2017)

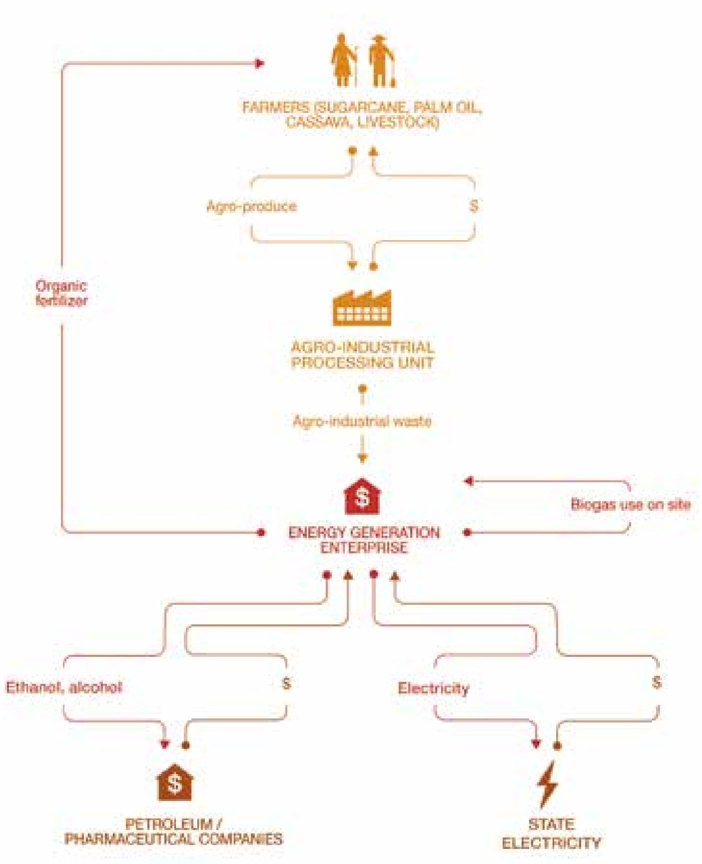

Figure 2. *Process flow for on-site energy generation by agro-industries* (Otto and Drechsel, 2017)

Different entities are developing business models around these waste streams and end products. Waste-to-energy businesses are either owned by the public sector, with the objective of cost-recovery for the sanitation sector and potential for revenue generation, or by private sector enterprises, with the objective of cost savings for profit maximisation. These businesses are also sometimes run on a public-private-partnership model or a social enterprise model, where the business is driven not by profit maximisation but by the aim to maximise social welfare. For this article, we have selected waste-to-energy business cases which also have a link to agriculture, bringing in focus the waste-energy-agriculture nexus.

Cost recovery in institutions through on-site energy generation

One of the most common waste-to-energy solutions that is widely implemented in developing countries is biogas production. While household biogas installations are very common, experience in institutional biogas systems is limited but is gradually gaining traction in Asia and Africa. Energy recovery from fecal sludge and kitchen waste through the installation of biogas systems has been a success in institutions such as schools, hospitals, prisons and other institutions consisting of large number of residents. These on-site energy generation models provide institutions the opportunity to save on energy costs by using energy produced on-site for cooking and heating (Box 1). Biogas generation for on-site use can also be coupled with digestate (the by-product of biogas generation) application on land thus, returning nutrients from waste to the soil.

Box 1

Onsite energy generation at prisons: Rwanda, Nepal, Philippines

The International Committee of Red Cross (ICRC) under its water and habitat unit has implemented numerous institutional biogas systems across prisons in Rwanda, Nepal and Philippines in partnership with local organisations. Local partners include Kigali Institute of Science, Technology and Management (KIST) in Rwanda, Biogas Sector Partnership (BSP-N) in Nepal and Practical Action consulting in Philippines. The prison biogas systems aim at reducing prison costs, reducing wastewater pollution and improving prisoners' lives through the installation of biogas systems. In Rwanda, dissemination of large-scale biogas digesters to prisons has registered significant success. The initiative by KIST won the Ashden Award for Sustainable Energy in 2005. Currently KIST has installed biogas digesters in several prisons in the country.

The key value proposition of on-site energy generation in prisons is to provide improved sanitation service to prison inmates. In the process the system provides two additional value propositions, a) biogas as a cooking fuel and b) bio-slurry (digestate). Biogas replaces firewood which is the common cooking fuel in those institutions while the digestate is used on-site for growing crops and trees. These result in savings for the running of prison operations in terms of money spent on firewood and fees for emptying sceptic tanks.

A government ban on the use of firewood (as is the case in Philipinnes) was a catalyst to innovation, while partnership with local expertise and provision of technical and business training to local communities constitute important prerequisites for sucessful implementation and for ensuring sustainability of the on-site energy generation model.

Agro-processing by-product value addition through on-site energy generation

On-site energy generation can also be implemented by agro-industries through the installation of different technologies. Many major agro-industries such as sugar processing factories, cassava, palm oil and slaughterhouse industrial factories in developing countries are diversifying into agro-processing by-product value addition through co-generation. Energy generation from agro-waste is driven

Box 2

Strict enforcement of environmental regulations as a catalyst to innovation

The Nyongara biogas plant in Kenya, where slaughter house waste is processed to produce biogas, is a good example of how strict enforcement of environmental regulations by the National Environmental Management Authority (NEMA) has induced the slaughter house unit to have a businessoriented solution to its waste management problem. The waste generated by the slaughter house units around Dagoretti, an area famous for the presence of slaughter houses on the outskirts of Nairobi, was polluting Nairobi River. As a consequence, NEMA was closing slaughter house units that were not meeting the regulatory norms of treating their waste. Thus, to manage its slaughter house waste and to comply with the NEMA regulations, the Nyongara biogas plant was established.

The biogas plant began operations in 2011 with biogas used both for heating and to generate electricity primarily for refrigeration and lighting purposes. The digestate from the biogas plant is high in nutrients and is used in cultivation of tomatoes within the slaughter house. Nyongara slaughter house is planning to scale up the biogas plant and its operations to process slaughter house waste from other slaughter house units and thereby generate biogas and sell the electricity back to the same slaughter house units.

by the need for agro-processing units to reduce their energy costs through the use of energy on-site and also to explore new revenue streams from selling excess energy in the form of electricity and ethanol (Figure 1). The energy production technologies are either designed, constructed, owned and operated by the agro-industrial processing factory or are installed by an external private entity on a Build, Own, Operate, Transfer (BOOT) model. This business model has a multi-value proposition as it not only allows agro-industries to be self-sufficient in energy while disposing of their waste sustainably, but also to secure additional revenue streams by exporting excess electricity to the national grid as well as trading of carbon credits (cgspace.cgiar.org/rest/bitstreams/119776/retrieve).

Promoting waste-to-energy businesses through a conducive investment climate

Policies, regulations and institutions play crucial roles in the successful implementation of on-site energy generation models; appropriate national policies, programs and fiscal incentives can be critical to success. On-site energy generation models in agro-industries have been successfully implemented in Latin American, African and Asian countries. For example, a number of policy reforms in the Kenyan power sector have liberalised the energy generation sector thereby paving the way for independent power producers (IPPs) such as Mumias Sugar Company (MSC) to participate in power generation. MSC took advantage of its co-generation potential from sugarcane bagasse by generating 38 MW, out of which 26 MW is exported to the national grid. Other sugar companies are expected to diversify into the use of sugar processing by-product value addition through co-generation and bioethanol production. Similarly, a number of domestic and international programmes to support bagasse-based co-generation were launched in India, which promoted the advancement of co-generation plants. These support programmes include extension of loans for co-generation by Asian Development Bank (ADB) through the Indian Renewable Energy Development Agency (IREDA), capital and interest subsidies, research and development support, accelerated depreciation of equipment, a five-year income tax holiday and excise and sales tax exemptions by the Ministry of Non-Conventional Energy Sources (MNES).

In addition to policies and regulations that promote the deployment of waste-to-energy business models, regulations related to the environment if strictly implemented by the national authorities have the potential to result in entrepreneurship in waste management (see Box 2).

The potential for waste-to-energy business models

Waste-to-energy business models have the potential to be replicated across all urban and agro-industries. To that end, there is a need for *business thinking* and *market-driven mechanisms* to motivate their reuse of waste to ensure their economic viability and long term sustainability. This presents opportunities for revenue generation and social benefits for all relevant actors and incentives for private sector participation to ensure their sustainability. Furthermore, policies, regulations and financial schemes that support the starting-up and scaling-up of waste-to-energy solutions are important in facilitating private and public sector investment in waste-to-energy business models, including those that incorporate the agriculture-waste linkage.

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