Recovering energy from waste: An overview of presented business cases and models

Access to affordable and sustainable energy is key to economic prosperity and sustainable development in developing countries. Energy plays a critical role not only in ensuring quality of life at individual or household level but also as one of the factors of production whose cost affects other goods and services (Amigun et al., 2008). Access to energy or the lack of it affects all facets of development: social, economic and environmental aspects. It is the key to sustaining the livelihood of the poor as well as ensuring industrial development of a country. Energy is crucial for achieving almost all of the Sustainable Development Goals (SDGs), from eradication of poverty through advancements in health, education, water supply and industrialization, to combating climate change (UN, 2016). SDG 7 is dedicated to the access to affordable, reliable, sustainable and modern energy for all, with target 7.2 calling for a substantial increase of the share of renewable energy including power derived from solid and liquid biofuels, biogas and waste.

With the aim of achieving a more sustainable natural environment while providing reliable and affordable energy to different sectors of the economy, interest in alternative sources of energy as a means of reducing dependence on fossil fuels has grown. Studies have shown that energy demand will increase during this century by a factor of two or three while about 88% of this demand is met by fossil fuels (IEA, 2006). The negative effects of the conventional energy sources coupled with the limited capacity of current energy infrastructure and the increase in energy demand have spurred interest in alternative sources of energy which are environment friendly and renewable.

Around 3 billion people cook and heat their homes using solid fuels (i.e. wood, charcoal, coal, dung, crop wastes) on open fires or traditional stoves. Such inefficient cooking and heating practices produce high levels of household (indoor) air pollution which includes a range of health-damaging pollutants such as fine particles and carbon monoxide. About 4.3 million people a year die from the exposure to household air pollution (WHO, 2016).

Under increasing deforestation, the global waste to energy market was valued at USD 24 billion in 2014 and it is expected to reach USD 36 billion by 2020 – a growth rate of 7.5% (Figure 5). Waste-to-energy is a waste treatment process to generate energy in the form of electricity, heat or fuel from both organic and inorganic waste sources. In this book, the focus is only on cases and models targeting energy generation from biomass (organic waste). While recovering energy from organic waste streams is essential to ensure energy security and sustainable development, waste-to-energy solutions still face numerous barriers including high investment cost, inadequate policy support and insufficient revenue generation due to limited experience with business or cost recovery models. This section addresses this last void, while opportunities and barriers in the enabling environment are discussed in Chapter 19.

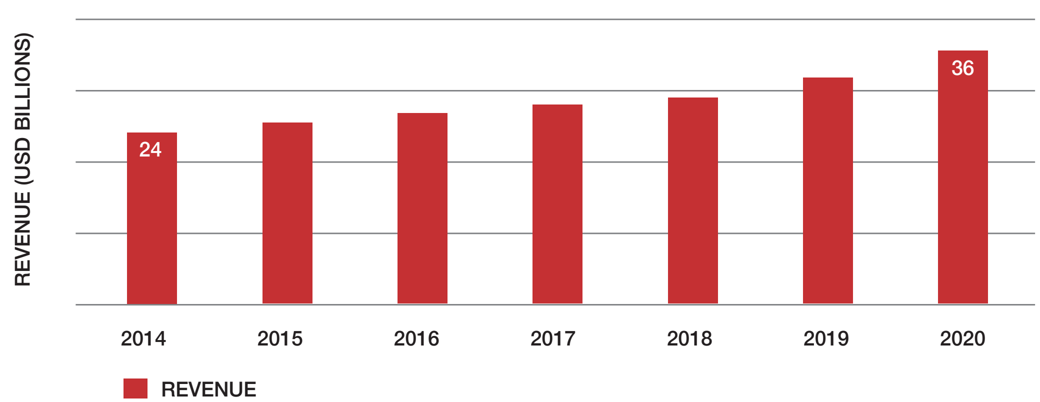
In this section of the catalogue, waste-to-energy conversion process in all the business cases and models can be broadly presented as in Figure 6. The energy recovery models and cases use one of the waste streams (agro-waste, agro-industrial waste and effluent, livestock waste, fecal sludge and organic fraction of municipal solid waste) to produce energy products in solid (briquette), liquid (bio-fuel/ethanol) and gaseous (producer gas and biogas) forms. These energy products are used to generate heat, electricity or fuel for transport.

The energy recovery chapter describes in total 9 business models derived from 19 business cases, and these 9 business models can be broadly classified into 4 categories:

- Production of Solid Fuels from Waste.
- Sustainable and Renewable Power Generation.
- Institutional (In-house) Biogas for Energy Savings.
- Emerging Technologies for Bio-fuel Production from Agro-waste.

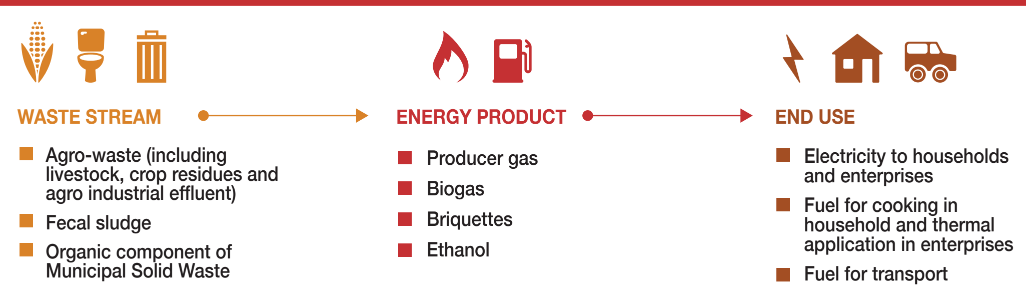
Energy products made from waste can be in one of the three physical forms and a relatively straightforward process is to convert waste into solid fuel by transforming organic fraction of municipal solid waste, market waste and agricultural residues into briquette fuel. This is an emerging scalable model in Sub-Saharan Africa particularly in East Africa and there are similar observations in Asia (**Business models 1 and 2: Briquettes from agro-waste** and **Briquettes from municipal solid waste**). Briquettes are a form of solid fuel produced by compacting loose biomass residues into solid blocks that can be burned for heat energy and can substitute traditional biomass based energy sources such as charcoal and firewood for domestic or institutional cooking as well as for industrial heating processes. The business cases highlight different strategies and processes such as simple technology for ease of maintenance, research and development (R&D) for right combination of different agro-waste to produce high calorific value briquettes as is the case in Kampala Jellitone Suppliers; franchise models to scale operations as is the case in Eco-Fuel Africa in Uganda; and implementation of a public-private partnership (PPP) to get contracts of waste collection as is the case in COOCEN, which is a women cooperative in Rwanda.

FIGURE 5. GLOBAL WASTE-TO-ENERGY MARKET, 2014–2020 (USD BILLION)



Source: ZION Research Analysis, 2016.

FIGURE 6. WASTE-TO-ENERGY PROCESS FRAMEWORK USED IN THIS SECTION



One of the most common waste-to-energy solutions that is widely implemented in developing countries is production of biogas from organic waste. Biogas can be produced from nearly all kind of biological feedstock – various organic waste streams including human waste (Holm-Nielsen et al., 2009). **Business models 3 and 4: Biogas from fecal sludge at community level** and **Biogas from kitchen waste** present institutional biogas models for energy savings. The business case examples are from India, Nepal, the Philippines, Rwanda and Kenya which highlight successful partnership with local authorities, non-governmental organizations and communities for successful implementation.

In this section of the catalogue, biogas production is demonstrated at different scales with the lowest scale of biogas production at the institutional level and large-scale production at industrial level. As the target stakeholder is industries in the later, the scale of waste generated is higher resulting in higher gas production and thus enabling to generate electricity from biogas. This is the case for livestock industry which generates biogas from manure for onsite use (**Business Model 5: Power from manure**). The case examples presented demonstrate rural electrification models from livestock waste along with innovative financing mechanisms of using carbon credits to invest in the technology. For example, Sadia, a company from Brazil, processes meat, and in order to mitigate the social and environmental impacts associated with livestock production systems, it has installed bio-digesters on the farms within its supply chain on a Build, Operate and Transfer (BOT) basis. Sadia uses carbon credit method to finance biogas systems on the farms that supply meat to the processing factory while taking the responsibility of registration of the project as a CDM and the management of the carbon credit revenues.

In addition to business models that highlight power generated from manure, there are also other business models that use agro-waste or municipal solid waste (MSW) to generate electricity (**Business Models 6–8: Power from agro-waste; Power from municipal solid waste (MSW);** and **Combined heat and power from agro-industrial waste for on- and off-site use).** Agro-processing industries, such as sugar and palm oil factories, and slaughterhouses in low-income countries, are diversifying into creating by-product value addition through co-generation and bioethanol production. The energy production technologies are either owned and operated by the factory or are installed by an external private entity on a Build, Own, Operate, Transfer (BOOT) model. These business models allow agro-industries to be self-sufficient in energy while securing additional revenue streams by exporting excess electricity to the national grid and trading carbon credits. The cases here also highlight social enterprise models for rural electrification.

In this section of the Resource Recovery and Reuse (RRR) catalogue, while the focus is on innovative energy recovery business models with relatively simple technology, there are also few business models and cases which use more sophisticated and high investment cost energy solutions. There is limited focus on advanced technologies to produce biogas, syngas and liquid fuels except in the case of **Business model 9: Bio-ethanol and chemical products from agro and agro-industrial waste** which highlights production of biofuel from cellulosic sources such as agro-waste produced from mills processing cassava, rice, wheat, coffee and so on. The model also covers processing of vinasse waste generated during ethanol production. Vinasse can be used to produce an organic binder (lignosulfonates) which has numerous applications across many industries.

Further business cases and models where energy generation plays a role are presented in the section **on wastewater treatment for reuse**.

Waste-to-energy business cases and models described in this section demonstrate improved economic viability from RRR to provide not only environmentally beneficial solutions along with increased energy access to governments, donors, entrepreneurs and non-government organizations in developing countries but also offer larger socio-economic benefits from safe waste management. By adopting these solutions, they not only help meet the ever-increasing demand for energy but also pull out millions of underserved communities from extreme poverty in an environmentally responsible manner. For increased energy security and to meet SDG 7 indicators, there is a need to triple investments in sustainable energy infrastructure per year from USD 400 billion to USD 1.25 trillion by 2030 (UN, 2016) and waste-to-energy RRR business models and cases provide a means to achieve not only SDG 7 indicators, but also, for example, SDG 12.5 to substantially reduce waste generation through prevention, reduction, recycling and reuse.

References and further readings

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