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Renewable Energy Recovery Generation for Security and Safety in Global Agriculture and Production: Justification and Outlook

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1. Abstract

Waste is problematic in agriculture, production and remote-locations. Remote power generation cost is high due to diesel fuelled gensets. With high premium on food-energy security and safety, the 330 kWe ERK®-ReGen container-power-plant improves waste management and lowers electricity prices at these locations. Standardized components installed in multiple containers enables high quality, simple-transport and rapid-installation. The objective of this study is to present this renewable energy recovery generation (ReGen) design concept from evaluated resource energy use of some remote-areas of the world. A novel technique that combines resources and energy surveys with socio-economic-analyses was adopted in the technology properties and waste to identify and justify factors for the promotion and development of such techniques.

Biomass and waste materials were identified as inevitable products of society and are available in many remote locations worldwide. Since substantial amounts of agriculture and production take place in remote areas, a major challenge of the future is to understand how to manage large quantities of waste sustainably. Therefore, waste sources, their compositions and available waste-to-energy-technology options were researched. An approach has been to minimise the amount of waste produced and to recycle larger fractions of biomass and waste-materials. Renewable energy recovery generation (ReGen) from waste can solve two problems at once; first is treating non-recyclable and non-reusable amounts of waste; and second is generating a significant (decentralised) amount of energy which can be included in the energy production mix in order to satisfy customers‘-needs while keeping costs low. Interaction between waste-management-solutions and energy-production-technologies can vary significantly, depending on multiple factors.

ReGen is independent of fluctuating fossil fuel prices meaning energy independence with reliable base load supply with the possibility of hybridisation for peak demand to simultaneously solve the problems of waste, pollution and electricity generation. The diesel fuel substitution reduces CO_2 emissions and sustainable thermal waste disposal avoids ground soil water contamination and marine pollution. The user-friendly, iconic ReGen plug and play system minimises installation time and enables relocation to new sites. Emphasis should be placed on resource and energy-management-techniques that conserve the environment, foster food-energy security and safety. Therefore, policies that protect our oceans and land through sustainable resource and energy use must be emphasised. Sustainable food–energy-production is a daunting challenge to global agriculture, industry and society and needs to be addressed in Africa and other remote-locations.

Keywords: Energy efficiency, Food security, ReGen - remote generation, Safe production, Waste to energy

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2. Introduction and Objectives

The growing world population (10 billion people by 2050), urbanization, climate change, energy demands and changes in dietary habits are among the megatrends of the future. Food and energy production in sub-Saharan Africa has not kept pace with population growth. The population is estimated to increase at about 4% annually, whereas food and energy production increases by only 2% besides the waste. There is urgent need of appropriate energy-efficient technologies that help protect the environment and conserve resources: As there is a link between resources waste and the CO_2-emissions used to produce them (Amusan, 2015). A fifth of the world's population (1.4 billion) has no access to reliable electricity (IEA, WEO 2010). More than 2.7 billion people are dependent on traditional bioenergy (such as wood and charcoal) for cooking and heating (IEA, WEO 2010) – with serious economic, environmental and health impacts. Production from known oil and gas reserves will fall by around 40-60 percent by 2030, according to the International Energy Agency (IEA, WEO 2009). Continuing to depend on fossil fuels will mean substantially higher and more volatile energy costs, driven by the increasing scarcity of oil and gas and a move to unconventional – and increasingly environmentally damaging – sources. Supply disruptions, accidents and disputes over energy resources will continue to challenge energy security. The global energy sector is responsible for around two-thirds of global greenhouse gas emissions. And its emissions are increasing at a faster rate than any other sector. “Business-as-usual” scenarios show an increase in emissions that would lead to very dangerous levels of warming, far above the threshold agreed by government of 2 degree above pre - industrial levels (WWF, 2013). The waste management sector faces a problem that it cannot solve on its own. The energy sector, however, is considered to be a perfect match, because of its need to continuously meet a growing energy demand. Waste is now not only an undesired product of society, but a valuable energy resource as well. Energy recovery from waste can solve two problems at once: treating non-recyclable and non-reusable amounts of waste; and generating a significant amount of energy which can be included in the energy production mix in order to satisfy the consumers' needs. The interaction between waste management solutions and energy production technologies can vary significantly, depending on multiple factors. Different countries across the world choose to adopt different strategies, depending on social, economic and environmental criteria and constraints. These decisions can have an impact on energy security, energy equity and environmental sustainability when looking at the future of the energy sector. If water-to-energy (WtE) technologies are developed and implemented, while following sustainability principles, then a correct waste treatment strategy and an environment-friendly energy production can be achieved at the same time, solving challenges in both the waste management and energy sectors. That the world faces an energy crisis is beyond any reasonable doubt. There's a pressing need to secure a sustainable energy supply as demand for fossil fuels outstrip environmentally and economically sustainable supplies. A lack of access to energy is one of the main causes of poverty. On top of this, the world needs to start drastically reducing carbon-dioxide emissions within the next few years if we are to have the best chance of avoiding catastrophic climate change (WEC, 2016; Amusan, 2018).

Biomass and waste materials are available in many remote locations worldwide. Waste is a problem in refugee camps, army camps, disaster relief, on islands and other remote locations. Remote power generation cost is high due to use of diesel fuels. The 330 kWe ERK® ReGen container power plant improves waste management and lowers electricity prices. Standardized power plant made of multiple containers enables high quality, simple transport and rapid installation. ERK ® ReGen can serve mine sites, islands, army base camps, disaster reflief, remote communities and farms. The objective of this study is to present this renewable energy recovery generation (ReGen) design concept from evaluated resource energy use of some remote-areas of the world. A novel technique that combines resources and energy surveys with socio-economic-analyses was adopted in the technology properties and waste to identify and justify factors for the promotion and development of such techniques.

3. Methodology

3.1 Survey Area (Africa)

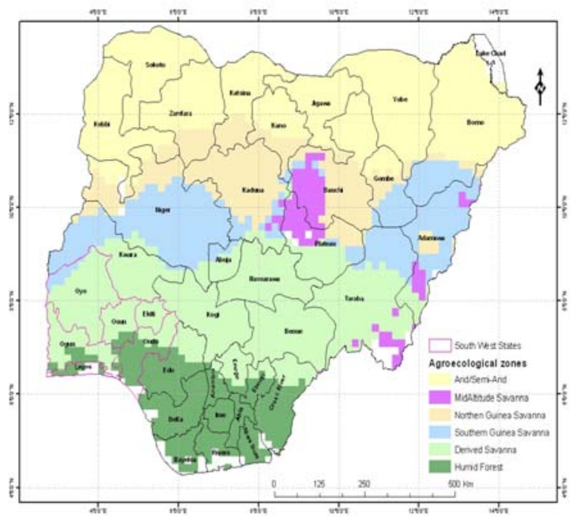

Fig.1: Africa Map indicating EU Colonial Master

Fig. 2: Nigeria Map including Agro-ecological Zones (IITA)

3.2 Survey Methods

A novel technique that combines resource and energy survey with socio-economic analyses was adopted in the properties and waste.

- African Countries and three major cocoa producing locations in Nigeria (Akure, Ife and Ibadan) with similar agro-ecological features were selected for the survey
- Socioeconomic survey covered resources quality and constraints to production
- Random selection and interviews were done using standardized questionnaires to elicit the required food and energy production information
- Key-Persons interviews, official statistics and other secondary data served as additional background industry information from the energy and agriculture sectors
- Biophysical data was obtained by analysis of soil samples taken from cocoa farms.
- Soils were analyzed for chemical analyses to assess contribution of soil to yield.
- The soils were analyzed for basic cations (determined in 1N NH4OAc), total N (Kjedahl method), available P (Bray P method), Organic C (Walkey-Black Wet Oxidation method) and pH (0.1M CaCl2).
- ReGen Design, Process, Layout and Energy Balance

4. Results

4.1 ReGen Container Power Plant Waste to Energy Technology

Biomass and waste materials are available in many remote locations worldwide. Waste is a problem in refugee camps, army camps, disaster relief, on islands and other remote locations. Remote power generation cost is high due to use of diesel fuels. The 330 kWe ERK® ReGen container power plant improves waste management and lowers electricity prices. Standardized power plant made of multiple containers enables high quality, simple transport and rapid installation. ERK® ReGen can serve mine sites, islands, army base camps, disaster reflief, remote communities and farms. Renewable Energy Recovery Generation (ReGen) is independent of fluctuating fossil fuel prices meaning energy independence with reliable base load supply with the possibility of hybridisation for peak demand to simultaneously solve the problems of waste, pollution and electricity generation. The diesel fuel substitution reduces CO_2 emissions and sustainable thermal waste disposal avoids ground soil water contamination and marine pollution. The user-friendly, iconic ReGen plug and play system minimises installation time and enables relocation to new sites.

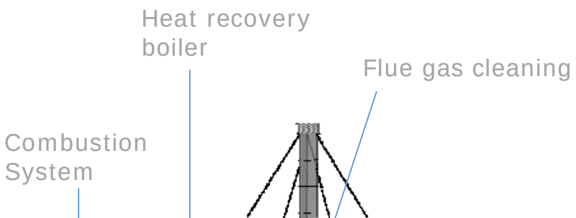

Figure 3: Renewable Energy Generation (ReGen) Plant Arrangement

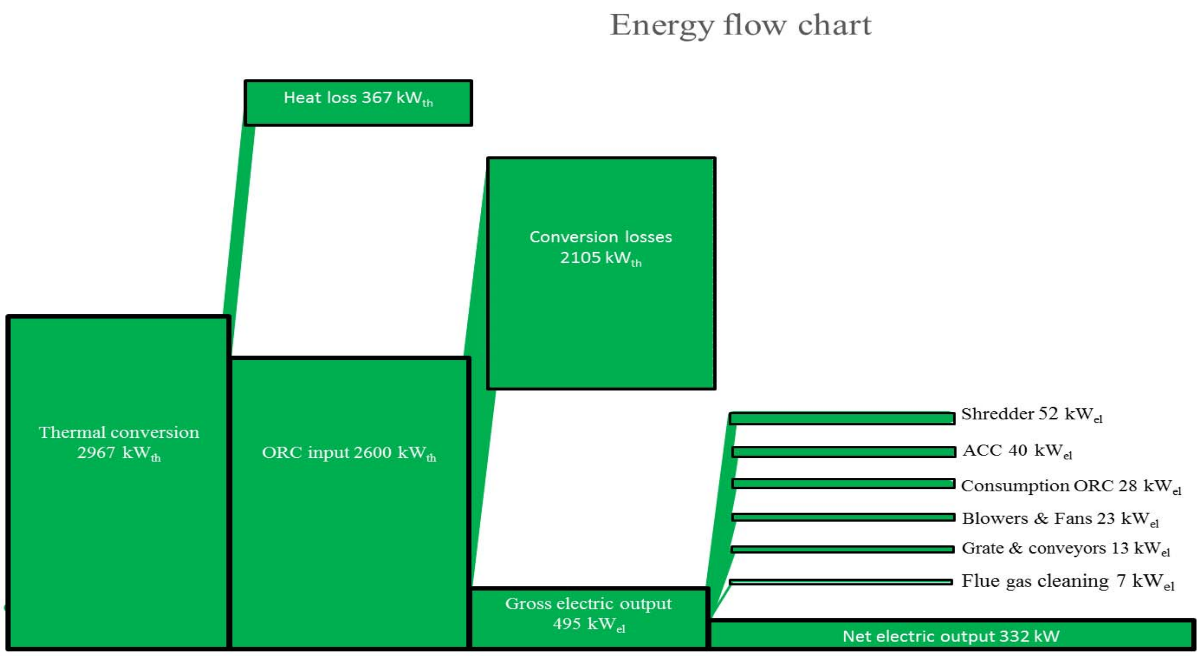

Figure 4: ReGen Container Power Plant Energy Balance / Flow Chart

4.2 Effects of Bioph

- FUEL: Biomass to MSW
- FUEL THROUGHPUT: Up to 980 kg/h
- OPERATING PRESSURE: 5 Bar
- NET ELECTRIC CAPACITY: 330 KW
- WtE PLANT EFFICIENCY: 19%
- APPLICATION: Off-Grid Power Supply

Table 1: **Multiple regression of yield versus soil and management variables** (Source: own computation)

Independent variables	Standardized β	T	Probability
Organic C	-0.05	-0.55	0.59
Age of farm	-0.07	-0.95	0.37
Plant density	0.17	2.00	0.08
Proportion Replaced	0.48	4.05	<0.01
Crop Variety	0.42	3.32	0.01
ECEC	0.02	0.20	0.85
Squared Multiple R			0.97
F Probability			<0.01

Among the variables in the model, two (Organic C and Age of farm) are negatively related to cocoa yield, whereas other variables are positively related to cocoa yield. However, soil variables are not significant to the model ($p>0.05$), whereas three management variables (plant density, proportion of dormant plants replaced and crop variety) are significant ($p<0.1$). All the variables explain 97% of the variability of yield and the model can be used to predict yield at 99% confidence level. Figure 2 further shows the relative importance of the variables as measured by the standardized β coefficients. Proportion of dormant plants replaced is the most significant management variable affecting yield, followed by crop variety (that is, F_3 Amazon).

4.3 Quality and Waste Management for Agri – Value Chain in Cocoa Production

The goal of obtaining good income for cocoa cultivation is intrinsically connected to the sustainability of this sector. This on the other hand cannot be realised without a well-laid out plan to attain quality in all the various management aspects in the long cocoa production value chain. Certain primary activities can be identified in the production chain as contributing to overall quality of production (Figure 3). These activities could be used as control instruments in the planning of efficient management on cocoa farms. Figure 3 indicates the potential of each activity on quality "deterioration".

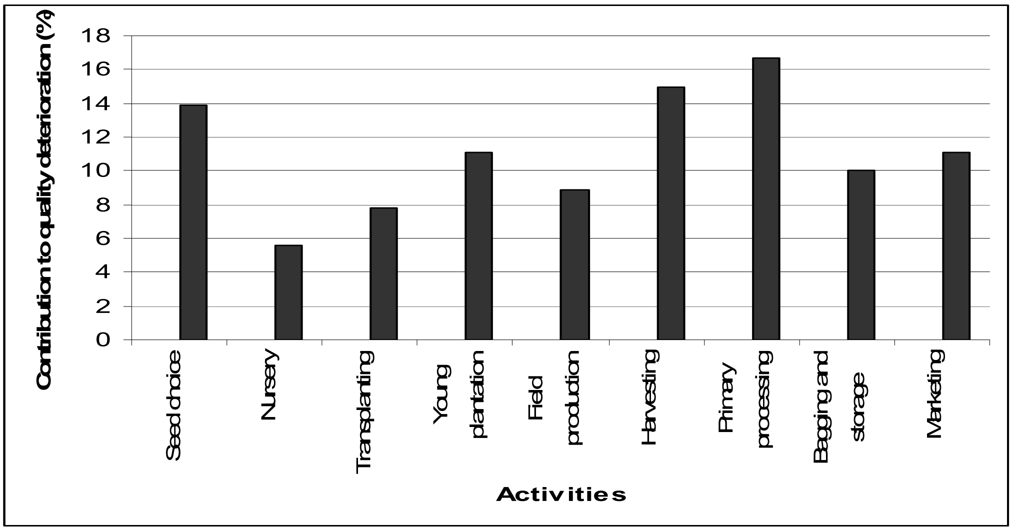

Figure 3: Factors contributing to Quality deterioration in the Cocoa Production Chain
(Source: Amusan et.al, 2009)

Energy conversion from waste can be obtained by utilizing different technologies. Each one of these WtE solutions has specific characteristics, and can be more or less feasible depending on many parameters. Factors include the type and composition of waste, its energy content, the desired final energy form, the thermodynamic and chemical conditions in which a WtE plant can operate, and the overall energy efficiency. Renewable energy recovery generation (ReGen) considered these points.

Table 2: Types and Sources of Waste (Amusan modified, 2018)

SOURCE	TYPE	COMPOSITION
Municipal Solid Waste (MSM)	Residential	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood glass, metals, ashes, special wastes (e.g. bulky items, consumer electronics, white goods, batteries, oil, Tyres), household hazardous wastes, e-wastes.
MSM	Industrial	Housekeeping, wastes, packaging, food wastes, wood, steel, concrete, bricks, ashes, hazardous wastes.
MSM	Commercial & Institutional	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes, e-wastes.
MSM	Construction & Demolition	Wood, steel, concrete, soil, bricks, tiles, glass, plastics, insulation, hazardous waste.
MSM	Municipal Services	Street sweepings, landscape & tree trimmings, sludge, wastes from recreational areas.
Process Waste		Scrap materials, off-specification products, slag, tailings, top soil, waste rock, process water & chemicals.
Medical Waste Medical Waste		Infectious wastes (bandages, gloves, culture, swabs, blood & body fluids), hazardous wastes (sharps, instruments, chemicals), radioactive wastes, pharmaceutical wastes.
Agricultural Waste		Spoiled food waste, rice husks, cotton stalks, coconut shells, pesticides, animal excreta, soiled water, silage, effluent, plastics, scrap machinery, veterinary medicines.

5. Conclusions

Since waste is an inevitable product of the society, the challenge is to manage it sustainably through appropriate energy-efficient waste-to-energy (WtE) technology and Renewable energy recovery generation (ReGen) is that appropriate WtE technology. Emphasis should be placed on resource and energy-management-techniques that conserve the environment, foster food-energy security and safety. The practise of conservation and rehabilitation agriculture should be encouraged. This involves all steps which negate the processes of degeneration and waste management on farms.
Therefore, policies that protect our oceans and land through sustainable resource and energy use must be emphasised. Sustainable food and energy production is a daunting challenge to global agriculture, industry and society and needs to be addressed in Africa as well as other off-grid remote locations of the world.

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