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FOSTERING RENEWABLE ENERGY GENERATION IN CAMEROON USING FOOD WASTE FROM ANAEROBIC DIGESTION

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ABSTRACT

This paper examines the current trend in waste management which is drifting towards a 'blue economy' designed to address sustainability and counter environmental pollution. It explores the prospects and challenges of developing an anaerobic digestion sector for the generation of alternative energy from food waste feedstock in Cameroon. At the present time, waste in the country is managed in a an uncontrolled manner; with small waste operators undertaking different and uncoordinated waste management activities, without real efforts designed to reap the full benefits that could be garnered from sustainably managing food waste. However, harnessing this sector with dedicated structures to oversee its activities will contribute to transforming not only lives, but the whole environmental and economic strata of the country. In focusing on food waste transformation for biogas generation and digestate production, the country could create jobs, reduce pressures on natural resources and uplift most of its youthful population from the throes of poverty and underdevelopment. With the energy sector facing real pressures as a result of the growing population, growth in the industrial sector without a corresponding investment in the country's energy infrastructure, lack of real political will to tackle the energy problems and other crisis that have come to bear on the country, the need to diversify the energy portfolio is now very critical. By generating methane and carbon dioxide for heating, cooking and electricity for its fast growing population, anaerobic digestion also has the added potential of providing the rural agricultural sector with digestate that has little or no negative environmental effect as compared to artificial imported fertilizer that the country has come to depend on so heavily, with its antecedent impact on the country's ecosystem. The proposal is that government should diversify its energy portfolio by investing in the transformation of food waste as a means of supplementing its current weak energy sector.

Fostering Renewable Energy Generation In Cameroon Using Food Waste From Anaerobic Digestion

I. Introduction

Food waste as defined by the Food and Agriculture Organization (FAO) is 'edible material intended for human consumption that is discarded, lost, degraded or consumed by pests between harvests and reaching the consumer.'[1] This also includes food that is fit for humans but intentionally used as animal feed. FAO makes a distinction between food losses and food waste. Food losses usually occur at the production, harvest, post-harvest and processing phases due to poor infrastructure, low levels of technology and low investment in the food production system. On the contrary, food waste is more of a problem in developed or industrialized countries, most often caused by both retailers and consumers throwing perfectly edible food stuffs into trash.[2]This view, however, of food waste being a developed or industrialized countries' problem is gradually being toppled by current trends in developing countries where food waste is increasingly becoming a huge public crisis. Households in Cameroon are increasingly having more discretionary income, leading to the production of more household wastes, including food waste. With increasing power to spend, more consumers are using catering services for social events, are eating out in restaurants (both well-structured and road-side joints); thereby generating another avenue for the production of food waste. Even more troubling is the staggering volume of food waste being generated by agro-industrial companies like the Cameroon Development Corporation (CDC), PAMOL Plantations Plc. (PAMOL), Africa Food Industry, S.A (AFISA), Companie Fruitiere, HPDP in Njombe, and the many food manufacturers and food retailers that are benefitting from a growing class of 'nouveaux-rich.' Food wastes from these new avenues and other commercial waste sources have only come to add to the traditional production, harvest, post-harvest and processing phases of this waste stream.

With the world's population growing fast and expected to reach 9 billion by 2050, FAO has highlighted the worrying problem of the state of world food outlook; with poor cereal yields and shortages in other crops.[3] In addition, the UK Government Office for Sciences' *Foresight Report* predicts that it will be challenging to grow food sustainably for the world's growing population and feed it in the next 40 years. It is also estimated that about 925 million people suffer from real hunger and another one billion are currently in need of basic nutrients in their diet in developing countries.[4] On the other hand, in most developed countries, close to a billion people are over-consuming, thereby putting pressures on the global food system. Because of this dichotomy and disparity in food production and consumption, NGOs like Friends of the Earth, Waste and Resources Action Programme (WRAP), Carnegie Corporation for International Program, World Food Programme (WFP), including many other agencies, are making efforts to scale back on the high amount of food being wasted. Also, programs like the United Nations Millennium Development Goals (MDGs)[5] aimed at cutting by half the number of people

[1]Food and Agriculture Organization (FAO), "Food Loss Prevention in Perishable Crops" FAO Agricultural Services Bulletin, 1981, No.**43.**

[2] Food and Agriculture Organization (FAO) Cutting Food Waste to Feed the World, over a Billion Tonnes Squandered each Year" 2011. Available at:http://www.fao.org/news/story/en/item/74192/icode/ May 2011

[3] Food and Agriculture Organization (FAO), "Growing Food for Nine Billion" 2010 Available at: http://www/fao.org/decrep/013/am023e/am 023e00.pdf May 2011.

[4] UK Government Office for Sciences, "The Foresight Report' 2011: Project on Global and Farming Futures" Available at: http://www.bis.gov.uk/assets/bispartners/foresight/docs/food-and-farming/sythesis/11-627-C7-reducing May 2011

[5]United Nations Millennium Development Goals, "Goal number one hopes to bring down the poverty and hunger levels by halve

currently suffering from hunger and poverty by 2015, - and efforts by the United Kingdom intended at reducing undernourishment to 8% by 2015,[6] have also helped ease food waste volumes.

At the national level, Cameroon has not yet started making real efforts destined at reducing waste as a whole, and food waste in particular. Rather, it is still engrossed in waste collection and disposal, without any real efforts aimed at minimizing waste generation from all waste streams in the first instance. Although the problem of food waste generation is now mostly an urban problem, the issue of food losses is mostly seen in rural areas where most food is produced and brought to urban centers that have huge populations that are increasingly becoming affluent and gradually engaging in the same waste generation practices that industrialized countries have been struggling to curb in the last four decades. The thought is that if the government does not implement concrete waste minimization strategies, it will be overwhelmed by this fast growing waste stream which its steadily affluent and youthful bourgeoisie class is now fully basking in. Indeed, food waste is on the upward trend, influenced by the fast growing population, a dynamic young and affluent class, high demand for food by householders with young children, high prices of foods on the markets- leading to discard of unsold food, energy crisis, as well as global food wastage; with one third of the food produced in the world for human consumption every year-1.3 billion tonnes, getting wasted.[7] Improvements seen in living standards, fostered by the growth of world economies, is propelling huge energy consumption, thereby placing huge burdens on worldwide energy demands.[8] Unfortunately, there is disparity in world supply of fossil fuel reserves- with close to 65% of natural gas found in the Middle East; 27% in Russia; 11.7% in Europe and Eurasia; 9.5% in Africa; 8.6% for Central and South America; 5% for North America and 3.4% for Asia and the Pacific.[9]

Indeed, anaerobic digestion by-product such as biogas is increasingly being used as alternative energy and could as well help alleviate the energy burden that is currently being experienced in the country. Therefore, food waste can be harnessed to solve the country's energy crisis and also provide the country with an edge in the production of digestate which is badly needed to furnish the agricultural industry and improve yield. Harnessing food waste transformation with other efforts could help move Cameroon's economy from purely agrarian to a veritable blue economy that meets its aspirations to attain emergence by 2035.

II. Energy Situation in Cameroon

Cameroon, like most African countries, is suffering from an energy crisis that is hampering the transformation of the country into an emergent energy-sufficient economy. Cameroon possesses 1.3GW (TW) of installed power capacity; based on large-scale hydropower and hydrocarbon plants with three main grids: the Southern Interconnected, the East Interconnected and the North Interconnected Networks.[10] In 2014, the Southern grid transmitted 5,698GWh, the Northern grid produced 329GWh and the Eastern grid only 56GWh. These grids are based on hydropower, with the major dam in the North being the Lagdo; to supply the three northern regions, Memve'ele for the South and Center Regions; and Lom Pangar dedicated to the East. Other dams are the

between 1990 and 2015"

[6] UK Government Office for Sciences, 2011 *Supra.* 4

[7] Food and Agriculture Organization (FAO), 2011*Supra*. 2

[8] The Global Education Project. "World Energy Supply: World Reserve of Oil, Coal, and Natural Gas"(n.d) Available at:http://www.theglobaleducationproject.org/earth/energy-supply.php *August 2011*

[9] Escobar,J.C.,Lora,E.S.,Ventuini,O.J.,Yanez,E.E.,Castillo,E.F.,Almazan,O ,. "Biofuels: Environment, Technology and Food Security" 2009 **13**(6-7),1275-1287

[10] M.I.F Fotsing, Njomo, Donatien,Tchinda Rene and Hamandjoda.O., "Impact of Sustainable Electricity for Cameroonian Population through Energy Efficiency and Renewable Energies" *Researchgate* January 2019

Songloulou (River Sanaga in Edea), and Nachtigal which is still under construction, but envisaged to supply about 420GWh to help reduce pressures on the constrained energy sector. These hydropower plants are capable of producing only electricity, leaving energy for transportation, heating, and cooking totally within the realm of the National Oil Refinery (SONARA). Even so, some of the dams like Memve'ele are not producing at full capacity. Memve'ele that was designed to generate 210GWh is currently generating just 60GWh, leaving most areas in the Southern grid still in dire need of electricity.[11] And the inability of the Memve'ele dam to run at full capacity is increasingly being viewed as a 'white elephant project,' as with most other dams in the country which are facing serious electricity transmission wastage of up to 40%, dilapidated infrastructures as well as serious deficit in maintenance.

In spite of government's best efforts, in 2012, only 21.93% of Cameroonians were using non-solid fuels such as cooking gas and kerosene stoves for cooking, while the rest of the population used firewood, charcoal, sawdust as the only available fuel- with the negative environmental and human health impacts of these solid fuels already well known. Although access to power has steadily improved, from 29% in 1990 to 53.7% in 2012, there is a big urban/rural divide. By 2012, 87.5% of the urban population compared to 18.5% of the rural population had access to electricity. Unfortunately renewable energy from wind does not look too promising as wind power is just around 5-7 m/s, mostly present in the Northern and Littoral regions. Worstill, only about 5% [12]of the country's energy is currently being sourced from solar energy in spite of its great potential.

Nonetheless, the government envisages an expansion in its renewable energy sector through the adoption of a Nationally Defined Contribution of 25% by 2035,[13] translated in the form of the Rural Electrification Master Plan (Plan Directeur d'Électrification Rurale)–PDER[14]- which foresees the development of 12 mini-grids powered by hydro; with a combined capacity of 24.5MW, 7 mini-grids powered by biomass with a combined capacity of 2.5MW and 8 mini-grids powered by hybrid solar and diesel systems, with a combined capacity of 550kW to boost coverage to about 54% by 2035.[15] This serious and phlegmatic energy crisis could be alleviated with the introduction of anaerobic digestion from food waste into the energy Master Plan of the country's energy mix.

III. Expose on Anaerobic Digestion

The oil and gas industry in Cameroon is at the current time overstretched; with oil fields aging and reserves drying-up,[16] yet the energy demands of Cameroonians is steadily rising. In fact, as more Cameroonians notice an increase in their personal wealth and income, the need for a better lifestyle is putting pressures on natural resources like oil and gas, a problem which could be countered using anaerobic digestion. Anaerobic according to Hughes 'implies the absence of oxygen, usually by the strict exclusion of air.' Digestion 'is the breaking down and assimilation of food by all living creatures.' Therefore, 'anaerobic digestion' is the process of breaking food

[11] African Development Bank, "Country Priority Plan and Diagnostic of the Electricity Sector- Cameroon" Available at: https://www.afdb.org/sites/default/

[12] Climatescope, "Bloomsberg.NEF, Cameroon" - 2022 Available at: Https://www.global-climatescope.org/markets/ December 2022

[13]Business in Cameroon: Ministry of Energy reveals progress in the elaboration of national renewable Energy Master Plan. Available at: https://www.businessincameroon/energy/ December 2021

[14]African Development Bank, "Project to Strengthen and Extend the Electricity Transmission and Distribution Networks in Cameroon" Available at: htttps://www.afdb.org/fileadmin/uploads/afdb/

[15] USAID, "Off-Grid Solar Market Assessment" https://pdf.usaid.gov/pdf October 2019

[16] Oil and Gas Statistics of Cameroon at the height of Cameroon's oil and gas production in 1977, the country was producing about 100,000 bbd, but today the production is less than 66,000 bbd.

or other biodegradable products by the absence of air. Or anaerobic digestion (AD) 'is a natural biological process carried out by bacteria in the absence of air, by which organic material is broken down into stable fertilizer and useful biogas.'[17] Williams states that 'increasingly anaerobic digestion is being used to expedite both the biodegradation of Municipal Solid Waste (MSW) and industrial waste.'[18] Anaerobic digestion mostly makes use of the Organic Fraction of Municipal Solid Waste (OFMSW) which could be in the form of proteins, carbohydrates and lipids or fats. Proteins are large complex materials with thousands of amino acids, while lipids (fats) are materials that contain fatty acids, and carbohydrates which constitute the largest part of biodegradable materials, are made up of cellulose starch and sugars.

Figure 1 Anaerobic Digestion Process

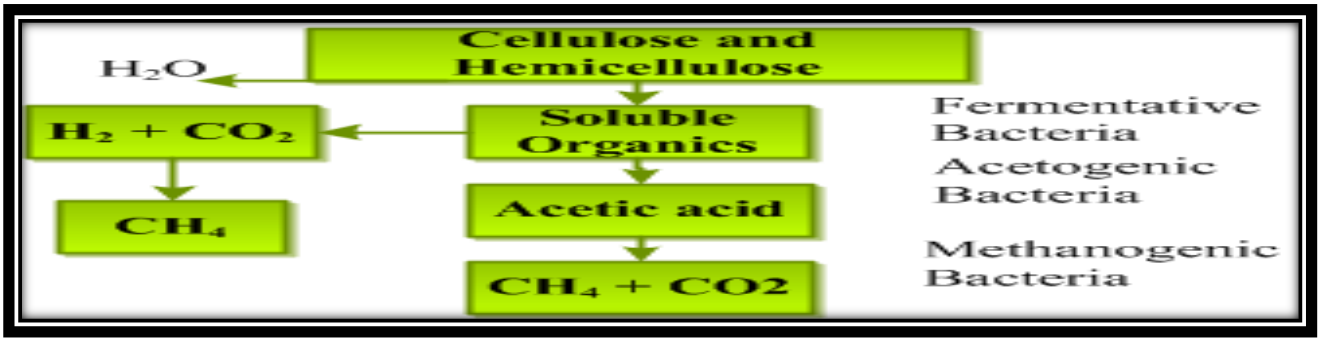
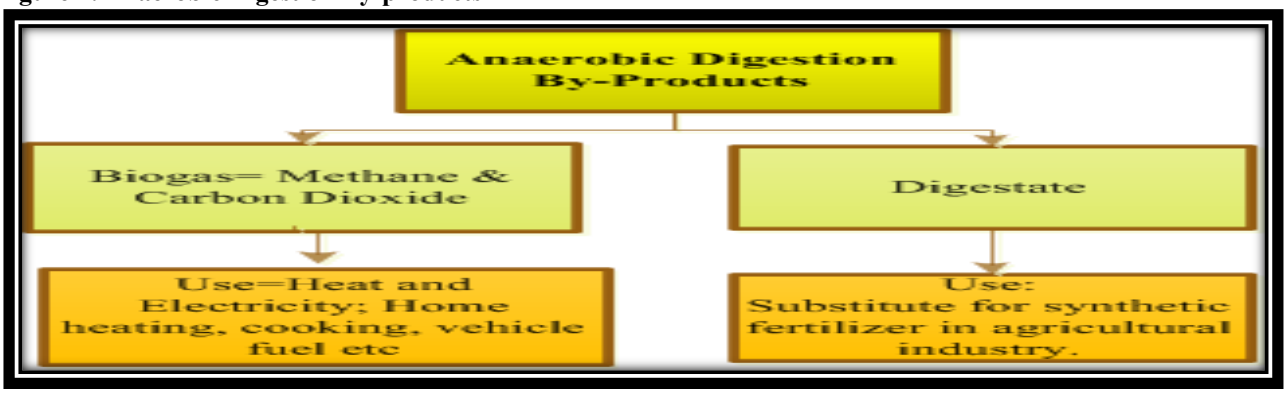


Figure 2: Anaerobic Digestion By-products



Pfeffer,1979

Li points out that anaerobic digestion is not a new process, but has been used to stabilize organic and inorganic compounds for the treatment of sludge, diluted organic waste as well as contaminated ground waste for years.[19] According to Renewable Energy Association (REA), in the past, AD has depended a lot on sewage sludge and agricultural manure for feedstock. Unfortunately these materials are not as high yielding of biogas (methane and carbon dioxide) as food waste. For this reason, energy crops such as silage have been grown and added to the animal components of food waste feedstock to help bolster the by-product generation.[20] Furthermore, Liu found that food waste significantly produced a high yield of methane (90%) when it was combined with 70%

[17]P.Hughes, *Ethics and Social Change* 1971,Sage Issue 14, 1
[18]P.T.Williams, *Waste Treatment and Disposal*. Wiley, 391-396 1988
[19]P.I. Li, *Energy,Technology,and the Environment.* ASME PRESS, 245-249 2005
[20]*Renewable Energy Association (REA), "Anaerobic Digestion Overview" 2009 Available at:*http://www.r-e-a.net/biofuels/biogas/anaerobic-digestion August 2011.

food waste, 20% fecal matter and 10% green algae and digested together at 39^0C.[21] The conclusion is that food waste is a reliable source of high biogas yield for anaerobic digestion.

Pfeffer explores the anaerobic digestion process which begins with the breaking down of large compounds (polymers) to small compounds (monomers) by anaerobic microbes producing amino acids, fatty acids and cellulose starch and sugars. The small compounds further break down into hydrogen, carboxylic acids and carbon dioxide. At the next level, acetogenic microbes are downgraded to acetic acids, carbon dioxide and hydrogen. With degradation of the hydrogen and carbon dioxide constituents in the process, there is a surge in the production of methane gas at the methanogenic stage.[22] Methane (about 60%) could be collected and used for fuel production and carbon dioxide (about 40%), could be used for heat generation and electricity.[23]

IV. Prospects of Anaerobic Digestion Growth in Cameroon

A. Setting-up of Digestion Plants

The anaerobic digestion industry shows great potential for growth with increased organic waste volumes being generated from homes, commercial units and agricultural establishments. In the United Kingdom, anaerobic digestion is used as a viable energy generation option. To this end, French highlights the positive signals for growth of the industry, with plans to build 1000 biogas plants by 2020.[24] Local Authority Waste and Recycling (LAWR) reports that many AD plants are currently being built to bolster the growth of the industry, with Shanks (a waste company) granted permission to build a second AD plant, with a third application for another AD plant in East London. The £11 million plant located at Buckinghamshire is using food waste feedstock from both the retail and the catering industries to sustain its 48,000tpa (throughput per annum) capacity plant which produces about 2MW of renewable energy yearly.[25]

Waste Management World reports that Covanta Energy Group, a waste management consortium, submitted plans to build a 75,000tpa facility in Merthyr Tydfil, South Wales. This £400 million project, the largest in UK, adds to the growing list of energy from waste plants constructed in the country.[26] Three other AD plants were granted planning permission to operate in Kent, Doncaster and Immingham, with the plant at Ashford-Kent to process about 20.000 tonnes of waste.[27] The plant at Doncaster will cost £12 million, treat 45,000 tonnes of food waste yearly and produce 2.8 MW of renewable heat and electricity annually.[28] Greenergy (a transport fuel supplier) and Brocklesby Limited (a specialist in food waste) have formed a partnership to begin producing biofuel from food waste, to produce 20 million litres a month of biodiesel using used cooking oil from food pro-

[21]Y. Lui, Park, S.Y and Zhu, J., "Solid- State Anaerobic Digestion for Methane Production from Organic Waste" Renewable and Sustainable Energy Reviews, **Volume 1,** Issue 1,821-826 2010

[22]J.T Pfeffer, "Anaerobic Digestion Processes" In: Stafford, D.A, Wheatley, B.I and Hughes, D.E (eds.) *Anaerobic Digestion*. Applied Science Publishers Ltd, 15-16 1979

[23] P.T.Williams, *Supra.*1988, 398

[24] C. French, "In a Very Positive Place" *The Chartered Institution of Wastes Management, CIWM* .**November** 2010, 30-31

[25]Local Authority Waste and Recycling,(LAWR), "Shanks gets Thumbs up for Second AD Facility" 2010. Available at: http://www.lawr.co.uk/news/news_story.asp January 2011.

[26] Waste Management World (WMW), "UK's largest Waste to Energy Facility Plans Submitted amid Controversy. 2010(a) Available at:http://www.waste-management-world.com/index/display/artilce-dispaly/0345148054/ January 2011

[27]Waste Management World (WMW), "Anaerobic Digestion Plant given the green light in Kent" 2010(b). Available at: http://www.waste-management-world.com/index/display/article-display/2682040573/articles/waste-management-world/biological-treatment/2011/04/anaerobic-digestion-facility May 2011

[28]Waste Management World (WMW). "Food Waste Anaerobic Digester under Construction in Doncaster" 2011(a) Available at:http://www.waste-management-world.com/index/display/article-display/3721616997/articles/waste-management-world/biological/treatment/2011/04/food-waste-anaerobic May 2011.

ducers as well as from high fat foods such as pies, sausage rolls, pastry and crisps.[29]

At the moment, 37 large-scale commercial plants are currently operational with 60 planned or under construction and DECC and DEFRA (Department of Energy and Climate Change and Department of Food and Rural Affairs) have shown their support by relaxing some of the stringent regulatory constraints that AD plants had hitherto been subjected to.[30]

On the contrary, Cameroon has invested heavily on hydropower plants to satisfy its energy needs, with dams strategically located to meet the needs of the different regions. However, the dams have been expensive, with Lom Pangar financed by both the World Bank ($132m)[31] and European Investment Bank (EURO 306m). In approving the loan, the World Bank stated that: "*Africa's energy deficit suppresses its growth and deepens poverty, and…Cameroon has the third largest untapped hydropower potential in Sub-Saharan Africa*."[32] Unfortunately, the country's investment in hydropower has not benefitted the country much in terms of job creation and even the generation of electricity itself. There are no real jobs left after the dams are built, as all that is left behind from the mammoth installations is a few technical staff employed at the plants, with no real impact in terms of direct employment and subsidiary jobs being created. On the contrary, an anaerobic digestion plant is a lifetime investment in the generation of jobs as the supply chain created for the production, collection, sorting, treatment, transmission of biogas and digestate will impact the community where the plant is located for as long as the plant exists.

At the present moment, the Cameroon government applies tax exemptions (VAT) and import duty reductions on some agricultural and renewable energy products, but has objected to repeated demands by economic operators to consider feed-in-tariffs and other incentives to promote the growth of the renewable energy industry. The government could consider the feed-in-tariffs and incentives options which have both served the UK in its drive to bolster its AD industry. Through this approach, the UK government introduced the Waste Strategy for England, 2007, in addition to the Biomass Strategy of 2007 with its focus on Renewable Obligation Certificates (ROCs)[33] which has helped to foster the growth of AD infrastructure for the treatment of both commercial and municipal food waste.[34] Since the introduction of ROCs in 2002, there has been a significant increase in energy from renewable sources from 1.8% to 6.64% with the program hoping to last until 2037.[35] With the renewable

[29] Waste Management World. (WMW), "Food Waste to transport Fuel as Pie completes the Circle" 2011(c).http://www.waste-management-world.com/index/display/article-display/9472106739/articles/waste-management-world/waste-to-energy/2011/05/food-waste-to-transport- May 2011

[30]Department for Environment, Food and Rural Affairs (DEFRA), "Anaerobic Digestion: Realizing the Potential: Government Invites Discussion on the Future of Energy from Waste" 2010(b). Available at: http://ww2.defra.gov.uk/news/2010/07/06/anaerobic-digestion January 2011.

[31] World Bank, " World Bank Approves Cameroon's Lom Pangar Project to Boost Economic Growth and Provide More Reliable Power for up to Five Million People." March 2012

[32]European Investment Bank, " Cameroon's Lom Pangar Hydropower project receives EURO 306m" https://www.eib.org/en/press/all/2012-115-cameroon

[33]Department for Energy and Climate Change, DECC, "Feed-in Tariffs"(n.d)Available at:http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/feedin_tariff/feedin_tariff.aspxJanuary 2011

[34] Office of the Gas and Electricity Markets (Ofgem), "Feed-in Tariff Adjusted rates" 2011.Available at: http://www.ofgem.gov.uk/sustainability/environment/fits/documents1/feed-in%20tariff%20year%202%/
With this strategy, AD plants can band ROCs and be eligible for two ROCs per KWh as of 1st April 2011- 31st March 2012; getting 12.1 pence per/KWh for small scale suppliers with less than 5MWh and, 9.4 pence per KWh for facilities with more than 5MWh.

[35]Apart from using ROCs, the UK government also introduced Feed-in tariffs (FITs) for small scale, low carbon electricity generation plants with less than 5MWh capacities through the Energy Act 2008. It pays incentives to ordinary users who generate their own elec-

energy law still being drafted under the Master Plan, fears are that it should not mirror the Electricity Sector Law of 2011 which stipulates the purchase of excess energy produced by small scale renewable energy producers by the main power grid, but fails to provide for either a feed-in tariff framework or real revenue-based incentives for small scale renewable energy producers to get involved in supplying to the main grid, which could help increase interest in renewable energy generation.

B. Legislation relating to Food Waste and AD plants

An important variable in the growth of the AD industry in the UK is the European Union Waste Landfill Directive, 1999[36] which requires European Union member countries to reduce the amount of biodegradable waste sent to landfills by 75% in 2010, 50% in 2013 and 35% in 2020 of the 1995 levels.[37] In essence, with reduction in the amount of biodegradable waste going to landfills, there may be an increased amount of this waste going to AD plants and composting stations. Another legislation that affects the UK is the Kyoto Protocol,1997 which calls for a '12.5% reduction of greenhouse gas emissions (GHG) based on the 1990 levels during the period 2008-2012.'[38] The UK government has committed to exceed the European Union target by aiming to achieve a 60% reduction of GHG emissions by 2050. In order to meet these targets, more wastes have to be treated sustainably in order to cut back on greenhouse gas emissions.

Furthermore, the Food Labelling Legislation, 1996[39] has become a prominent source of food waste in recent years, in that, it affects the way most consumers use and dispose food. The legislation stipulates that food labels must indicate the food origin, manufacturer's name, provide guidance notes on storage, name of the food, list of ingredients used, allergens, as well as appropriate durability indication (sell-by-date and use-by-date). Nevertheless, some families are confused between 'sell-by date' and 'use-by date' and tend to throw everything close to their 'use-by-dates' for fear of food contamination. WRAP noted that £10 billion worth of food gets thrown away due to misunderstandings of food labels and misconstrued food storage guidance.[40]

In addition, The Environmental Permitting (England and Wales) Regulations, 2010[41] regulates issues relating to the co-digestion of sewage sludge with other biodegradable wastes like food waste, which affects the application of such digestate to agricultural land. This means that any digestate intended for agricultural land use cannot be co-digested with sewage sludge and biodegradable waste in AD plants.

Nevertheless, the main legislation in the UK relating to food waste for anaerobic digestion is the Animal By-Products Regulation (ABPR) of 2003[42] as amended in 2005[43] and 2009.[44] The Environment Agency defines Animal By-Products as 'animal bodies, parts of an animal or products of animal origin that are not intended for

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tricity with a capacity of less than 5MWh. Electricity from wind, solar, photovoltaic (PV), hydro, AD and domestic scale microCHP (2kW or less) fall within this category.

[36] European Union Waste Landfill Directive, 1999 (1999/31/EC)

[37]Department for Environment Energy and Rural Affairs (DEFRA), "Landfill Allowance Trading Scheme" 2011 .Available at:http://www.defra.gov.uk/environment/economy/waste/landfill-scheme/ May 2011.

[38]Zglobisza,N.,Castillo-Castillo,A., Grimes,S and Jones,P, "Influence of Energy Policy on the Deployment of Anaerobic Digestion" 38,(10),5988-5999 2010

[39]Legislation UK, "The Food Labelling Regulations" 1996. Available at: http://www.legislation.gov.uk/uksi/1996/1499/contents/made April 2011

[40]Waste and Resources Action Programme (WRAP), "Household Food and Drink Wasted in the UK" 2009(a)Available at: http://www.wrap.org.uk/downloads/Household_food_and_drink_waste_in_the_UK_-report.033ff72e.8048.pdf June 2011.

[41] Chartered Institute of Water and Environmental management (CIWEM), 2009"Co-digestion of Sewage Sludge and Waste"

[42] Animal By-Products Regulation (ABPR), 2003

[43]Animal By-Products Regulation (ABPR), 2003 as amended in 2005, SI 2347

[44] Animal By-Products Regulation (ABPR), 2003 as amended in 2009, SI 1119

human consumption.'[45] In effect, any product of animal origin listed in the ABPR (manure from farm, fish/animal carcasses or parts etc.) cannot be used in anaerobic digestion. The Animal By-Products Regulation does not apply to raw food sold directly to consumers, liquid milk and colostrum disposed of or used on the farm where it was produced. This means AD plants have to meet the parameters set by the ABPR in table.1 below:

Table 1:Animal By-Products Regulation (ADPR), 2003

System	Minimum temperature	Minimum time at minimum temperature	Maximum particle size
Composting (closed reactor)	60^0 C	2 days	400mm
Biogas	57^0 C	5 hours	50mm
Composting(closed reactor)or biogas	70^0 C	1 hour	60mm
Composting (housed windrow)	60^0 C	8 days (during which windrow must be turned at least 3 times, and no less than 2 days)	400mm

Source: (DEFRA 2008b) [46]

Cameroon could therefore benefit from the many regulations that are already applicable within the European Union and the UK to guide her draft its own legislation to address food waste for AD plants. Anaerobic digestion could be both a viable source for food waste management and renewable energy generation, but there are some hurdles which must be surmounted in order to achieve this.

V. Challenges/Impediments to AD Growth in Cameroon

a) Sustainability of Food waste feedstock

The anaerobic digestion industry shows great potential for growth but the sustainability of food waste feedstock for the AD industry is still uncertain. Food waste as feedstock to run AD plants is facing some challenges even in the UK as over 40 major retailers in the country signed the Courtauld Commitment Phase 1 and Phase 2, to harmonize efforts to reduce household food waste to about 155,000 in 2010 against the 7.6 million tonnes wasted in 2009.[47] Furthermore, the UK government is working in consonance with WRAP and Food Standards Agency (FSA) to increase consumers' understanding of food labelling (sell-by-date and use-by-dates) and storage guidance to reduce food waste. It even adopted the 'Zero Waste Society' strategy to foster a detrimental effect on all aspects of waste in the country, including food waste.[48] With these concerted efforts between the government and these organizations, the question of food waste as sustainable feedstock for anaerobic digestion plants becomes pertinent. AD plants in Cameroon could also face the same feedstock challenge, but the prospects of significant food waste reductions being achieved in the country in the near future to frustrate AD plants are slim. This view is shared by Parfitt who asserts that without proper investments in the food supply chain by increasing the shelf life of food and lack of adequate policy changes by governments worldwide, talk

[45]Environment Agency, "Animal By-Products and Food Waste" 2010 Available at: http://www.environment-agency.gov.uk/netregs/63501.aspx.Accessed January 2011.

[46]Department for Environment, Food and Rural Affairs (DEFRA), Guidance on the Treatment in approved Composting or Biogas Plants of animal By-Products and Catering Waste" 2008(b). Available at: http://archive.defra.gov.uk/foodfarm/byproducts/documents/compost_guidance.pdf/ May 2011

[47]Department for Environment, Food and Rural Affairs, DEFRA, "Anaerobic Digestion" 2010.

[48]*The Guardian* ,"Caroline Spelman calls for 'zero-waste' society to end landfill" 2010 Available at: *2011.*

of a dramatic scale back in food waste generation still remains unrealistic.[49]

b) Chemical and Biological Inhibitors

The challenge of anaerobic digestion (AD) technology as a source of energy generation has a couple of inhibitors chief amongst which are; 'ammonia, sulphide, light metal ions, heavy metals, and organics.'[50] However, Liu asserts that anaerobic digestion can achieve a maximum efficiency through the 'removal of the dissolved oxygen, heavy metals and sulphides from the gains. The cleaned biogas could then be dried, compressed and sold for commercial or home use in place of natural gas from fossil fuels.'[51]

c) Inadequate Collection Strategy

Co-collection which is still a standard method of food waste collection is another hurdle to the growth of the industry. The Organic Fraction of Waste needed by most AD plants sometimes gets contaminated by plastics, bottles, metals, toxic chemicals, etc., due to co-collection issues. In essence, the collection of food waste alongside other waste poses a challenge to AD plants since they have to spend enormous resources to retrieve the clean organic fraction of the waste. Co-collection contamination can therefore be minimized through better strategies being put in place.

d) NIMBYism (Not in my Back Yard Sentiments)

AD plants are also facing stiff opposition from some pressure groups that see the growth of AD plants as injurious to their local environment, with the idea of NIMBYism (not in my backyard). Some opponents argue that having AD plants in their neighborhoods will bring down property value due to noise pollution, smell, environmental degradation and the vast land occupied by these commercial concerns (considering their large throughputs). These worries are responsible for AD plants going through a grueling planning permission process from the Environment Agency in the UK. It took Countryside Recycling Limited almost five years to have planning permission granted for its plant at Kent. Shanks and Covanta also had to go through the same lengthy and sometimes frustrating process.[52] In Cameroon, Environmental and Social Impact Assessments (ESIA)[53] are undertaken for all large scale projects; and Establishments that are considered hazardous and injurious are also prevented from being set up near human habitation.

e) Lack of Political Will

In Cameroon, the main challenge at the moment is lack of political will to expand the energy sector to accommodate other sources to supplement the fledging energy sector. Even more disconcerting is that there is neither a food waste regulation nor a clearly defined food waste strategy. With no strategy to either manage food waste or minimize its production in the first instance, it is not surprising that food waste continues to rise and the management of it inconsistent. This legislative deficit and absence of a clearly defined food waste management strategy requires the government to give consideration to the development of an AD industry in order to help her combat this fast growing scourge that may soon engulf the county if concrete steps are not taken as a matter of urgency. As an emergent economy with increasing demand for energy, this source of energy could help sup-

[49]J. Parfaitt, Barthel, M and Macnaughton,S, "Food Waste within Food Supply Chains: Quantification and Potential for change to 2050" Philosophical Transactions of The Royal Society of Biological Sciences.Vol **365**,1554, 3065-3081 .3079

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ply the many small industries that are being created by young and dynamic entrepreneurs who currently face the perennial problem of electricity shortage and high energy prices. And there is no better class to help the government tackle this problem than the same class of affluent youths who are the prime drivers of the increasing volume of waste being generated in the big cities. This class of young people is enthusiastic, ambitious and entrepreneurial. Involving them in issues of waste management will certainly help change the dynamics of waste management in the county in favor of developing a blue economy.

I. Conclusion

In order to transform the economy to a blue one that meets current world standards, food waste could be used as a viable source to counter the energy crisis, tackle unemployment and minimize pressures on natural resources. One key route in the proper management of food waste is the use of anaerobic digestion with its by-products proven to be useful to tackle energy shortages and improve agricultural yields. In addition, an anaerobic digestion plant is a lifetime investment in the generation of jobs, especially as the many hydropower plants have not benefitted the country much in terms of job creation. Moreover, proper investment in food waste management means that there is less need for the over-exploitation of other natural resources, like huge volumes of water that is needed to run its many hydropower plants. Apart from reducing pressures on water, anaerobic digestion as a green source of energy could help the country meet its commitments with international environmental conventions. Indeed, waste minimization through anaerobic digestion should be a key priority for the government which is steadily being overwhelmed by the large volume of food waste that its overcrowded cities are generating.

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