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Business models and innovativeness of potential renewable energy projects in Africa

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ABSTRACT

This study provides an overview of potential renewable energy (RE) projects for Africa. Pan African University master students were asked by their lecturer to characterize African projects they had in minds in uniform tables. Items of the project investment plan include project synopsis, the sponsors, market analysis and strategy, project scope, regulation and environmental information, project costs, financial projections, business model, and project innovativeness. Students' RE projects are assessed with emphasis put on employed business models and project innovativeness. Criticalities for the implementation of these projects are discussed in African contexts providing outlook for future investment opportunities in the African continent. The work provides insights from the local students' perspective for the various stakeholders interested in RE project investments in Africa. Useful suggestions formulated directly by young Africans are presented which may contribute to improved risks management when these or other potential RE projects will be deployed. Inputs from local people on how they understand the process of implementing RE projects in Africa might be interesting for investors seeking information about suitable ways for RE project deployment. Students characterize local contexts and identify numerous barriers for deployment of RE systems in Africa. Overall, this study explains the potential lying in renewable energy harvesting in Africa, seeks to emphasize major barriers for implementation of RE projects as well as investigates investment opportunities to implement economically feasible RE projects for cleaner and climate friendly energy future of this continent.

1. Introduction

Africa integrates three major opportunities that can make renewable energy (RE) projects economically viable: (1) very high potential of renewable energy sources, (2) high energy prices in local energy markets and (3) growing demands due to accompanying population and economic growths in almost all countries. Besides, human capital is available in place for labor intensive RE

Abbreviations: AD, Anaerobic Digestion; CHP, Combined Heat and Power; CPV, Concentrated Photovoltaics; DNI, Direct Normal Irradiance; EIA, Environmental Impact Assessment; EKN, the Royal Netherlands Embassy; FiT, Feed-in Tariff; GDP, Gross Domestic Product; GHG, Greenhouse Gas; GIZ, Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH; IEA, International Energy Agency; IRENA, International Renewable Energy Agency; IRR, Internal Rate of Return; LCA, Life Cycle Assessment; MSW, Municipal Solid Waste; NPV, Net Present Value; O&M, Operation and Maintenance; PPA, Power Purchase Agreement; PV, Photovoltaics; R&D, Research and Development; RE, Renewable Energy; UV, Ultraviolet; IASS, Institute for Advanced Sustainability Studies; SREP, Scaling-up Renewable Energy Program; MEMD, Ministry of Energy and Mineral Development; NCE, New Climate Economy; REFiT, Renewable Energy Feed-in Tariff; GETFiT, Gobal Energy Transfer Feed-in Tariff.

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projects. The environment is still relatively clean, hence implementing clean energy sources will bring co-benefits such as ecotourism, sustainable agriculture, cleaner water resources etc. [1]. The use of renewables can also reduce poverty and improve sanitation which are extreme problems in many African countries, especially in sub-Sahara. A major issue is very limited access to electricity for people in sub-Saharan African countries and this problem can be largely mitigated by developing RE systems. Moreover, there seems to be international political goodwill for supporting African continent development in a climate friendly way, e.g. by putting emphasis on increased low-carbon renewable energy penetration [2,3]. Other driving factors facilitating deployment of renewables in the African continent include: (1) domestic availability of resources, (2) potential to reduce import bills or increase revenues from export, (3) cost-competitiveness compared to newly-built fossil fuel power plants, (4) capability to displace expensive and polluting diesel-based micro-grids, (5) faster deployment of RE projects compared to nuclear and fossil fuel projects, (6) job creation and socio-economic development including poverty reduction especially in rural areas, and (7) low-carbon energy and environmental co-benefits, such as improved local air quality and water security [4].

In view of these drivers for economically viable development of RE projects in Africa the current RE penetration seems far from saturation meaning that there is a huge potential market. But the progress of development of RE systems in Africa is still slow. According to [5], over the period 2000–2012 sub-Sahara African per capita energy consumption was roughly constant even though per capita gross domestic product (GDP) growth in this time period was 3-fold. It means that per capita GDP growth did not trigger energy consumption growth in this period. Nevertheless, if funding is available and suitable policies are created RE deployment may accelerate on the long run. International Renewable Energy Agency (IRENA) expects that between 2013 and 2030 African modern renewable energy utilization will grow from 1.1 to 9 EJ/yr [6].

In this context, the current study has been undertaken in order to investigate and highlight business opportunities associated with RE projects in Africa. The research synthesizes project proposals suggested by Pan African University master of energy students. Some of these projects have attractive business models and are potentially innovative. It is important that most promising RE projects should be implemented first, because of good economic prospects and low associated risks. The implementation of the best energy projects might contribute to the economic development of Africa. Investments in these projects will contribute to infrastructure development [7] which can be shared for other uses. The more RE projects are deployed, the easier it is to deploy next projects. Consequently, development of many RE projects can trigger sustainable economic growth in Africa while enabling the continent to reduce greenhouse gas emissions as well as promoting climate change mitigation. In addition, the involvement of Pan Africa University students in this research initiative contributes to their training as future RE project developers, project skilled staff, supporters of policymakers and people influential in renewable energy matters. These young enthusiastic students also bring local knowledge from all parts of Africa thus enriching this RE projects overview with improved understanding of African contexts. All five economic regions of Africa have been represented by students with RE projects in Kenya, Rwanda and Uganda from the Eastern region of Africa, Cameroon from Central Africa, Ivory Coast, Nigeria and Senegal from the Western region, Egypt in the Northern region, and Zambia in the Southern region. The RE projects whose potential is analyzed include: solar, biomass, hydro and wind. Thus, the research highlights how various African RE projects can become economically viable options for investors and other stakeholders.

2. Research methods

During the academic course titled “Energy economics, finance and management” held at Pan African University, Institute of Water and Energy Sciences (including Climate Change), Tlemcen, Algeria [8], first year master students 2015/2016 (energy engineering track and policy track) obtained an assignment from their lecturer. The students were asked to describe one renewable energy (RE) project in an African country that may be considered as a business opportunity in the short and long runs and is potentially innovative. The students were asked to fill Table 1 describing items of the project investment plan and send it back to the lecturer.

Students participating in the course filled Table 1 and sent it back to the lecturer during the course. Some of these outcomes are utilized in this paper. Selected twenty students' RE projects are provided in Appendix 1.

In the next step the projects are assessed and outcomes are presented for each item of the project investment plan. Further, criticalities for the successful implementation of these and other similar RE projects are analyzed considering African contexts. Finally, the research is summarized by providing major concluding remarks and outlook for the future.

3. Assessment of Pan African university students' renewable energy projects for Africa

The students presented a large variety of RE projects, see Appendix 1 for detailed project descriptions. The suggested projects use different RE technologies and resources available across different African countries. The projects are of Solar, Bioenergy, Wind, and Hydro power. Most project ideas suggested by students are of Solar and Bioenergy. The total number of selected projects is 20. A total of 10 projects relate to Solar, 8 to Bioenergy, 1 to Wind, and 1 to Hydro. Solar projects present multiple investment opportunities and these projects can be quickly implemented and thus, if funding would be available, they could meet growing power demands in Africa. Bioenergy projects offer energy provision together with a productive solution to the increasing amount of waste in Africa mainly from agriculture, businesses such as mining and wastes generated by quickly increasing urbanization. Further, Africa has abundant solar and bioenergy resources, solar radiation are good for PV and CSP and bioenergy potential varies from industry to industry.

Many RE projects are intended to improve energy access for people living in both rural and urban areas and this will support economic development of the regions they are created for by using RE sources. Further, RE if utilized will support business development, improve productivity and promote green growth. Africa has vast market for RE projects and the projects presented here are the first of their kind in the regions they are suggested for, meaning they are potentially innovative. This comes with many benefits such as limited competition but also with challenges such as lacking sufficient infrastructure and policies.

Many African countries are truly open to foreign investments and have put in place policies to create a friendly environment for investors. Uganda for example has a Renewable Energy Investment Guide created by the Republic of Uganda's Ministry of Energy and Mineral Development in partnership with the Royal Netherlands Embassy (EKN, the Netherlands) and Deutsche Gesellschaft Für Internationale Zusammenarbeit GmbH (GIZ, Germany) [9]. This guide advises what every potential investor of Uganda must know and must have while planning their investment. It also gives a general overview of the country's geographic, political, economic and administrative environment outlining the status quo of the energy sector including the RE sector, the financial sector and the

Table 1
Table filled by first year master students 2015/2016 at Pan African University, Institute of Water and Energy Sciences (including Climate Change), Tlemcen, Algeria as an assignment during the course titled "Energy economics, finance and management". The students used this Table to describe one renewable energy project in an African country that may be considered as a business opportunity in the short and long runs and is potentially innovative.

Items of the project investment plan	Description	Comments and justifications
Project synopsis	Concise project description, e.g., technology, partners, investment cost, etc.	
The sponsors	The parties to be involved: major stakeholders in financial success. Who will provide how much funds and why?	
Market analysis and strategy	Who needs your project? Who are major competitors? Why does it meet current and future demands?	
Project scope	Description of the technical aspects of the project. Indicate the vendor. Comment on O&M aspects and skilled staff availability. Explain project management.	
Regulation and environmental information	Environmental issues associated with the project. Why the project is sustainable? Key regulations and permissions required.	
Project costs	Estimated cost of implementation.	
Financial projections	Conclusions from the financial documents: (i) cash flow statement, (ii) balance sheet, and (iii) income statement.	
Business model	Describe the basic business model of your project. Explain who is paying whom for what and why? Why this business model is to be successful in Africa? Why it offers a competitive advantage?	
Project innovativeness	Why the project is innovative and worth funding? Why the proposed technology, site or other business issues are exceptional?	

regulatory framework. It shows the prospects of the future market development including for example the power sector investment plan and rural electrification plan.

Similarly, countries like Zambia have introduced the Global Energy Transfer Feed in Tariff ("GET FiT") schemes to promote investment in the energy sector for a market of about 200 million people living around the country. GET FiT Program is an initiative launched by KfW, whose purpose is to fast-track a portfolio of a number of RE generation projects (1–20 MW) promoted by private developers.

Rwanda in 2014 in collaboration with African Development Bank (AfDB) and the World Bank Group (WBG), including the International Finance Corporation (IFC) has developed Scaling-up Renewable Energy Program (SREP) Investment Plan for Rwanda [10]. These and similar documents for other African countries guide investors and other stakeholders through the investment process. They also present the current overview of the countries while specifying country's target as well as their vision.

The assessment of students' RE projects for Africa is presented below. Each item of the project investment plan is evaluated in a separate Section. Sections 3.8. and 3.9. Evaluate business models and innovativeness which receive the most significant attention in this current article.

3.1. Project synopsis

Concise project description, e.g., technology, partners, investment cost, etc.

3.1.1. Solar technology

Solar technologies in favorable African conditions are characterized by relatively attractive economic parameters. For example: for on-grid solar PV, investment cost is often well below 3500 USD/kW, capacity factor 0.2, and associated LCOE is often close to local electricity tariffs. This creates attractive investment opportunities for the following solar African projects:

1. Making use of the rooftop car park with 0.5–1 MW solar PV in Kisumu, Kenya.
2. Using 30 kVA solar PV for powering telecom base masts in all regions of Uganda to replace the currently used diesel generators; a sample project for 1 telecom base mast station.
3. Development of 1 MW grid connected solar photovoltaic (PV) systems in Isa, Sokoto state of Nigeria.
4. Utilization of very high solar potential and the very suitable range of (Direct Normal Irradiance) (2000–3000 kWh/m2/year) for delivering 50 MW power using the CPV technology for electricity generation in Kuraymat, Egypt.
5. 1 MW Photovoltaic plant for Ainamoi area, Kerio Valley Kenya
6. Hybrid Solar photovoltaic (33 kWp) and a generator plant (70 KVA) that depends on biofuel from the seeds of palm oil tree in Tiagba village, Ivory Coast.
7. Introduction of the solar dryer technology to the farmers in Uganda in order to improve agriculture through an initial installation of 137 dryer units to be sold around Uganda. This post-harvest handling is important in reducing wastage as well help farmers sell off their products during periods of scarcity.
8. Installation of a 5 MW solar farm in the energy poor gold mining region of Mubende district in Uganda to provide alternative energy for socio-economic development of the region.
9. Installation of a 3.2 kW photovoltaic project to serve a small community in Lafia, Nasarawa, Nigeria with solar insolation of 6.15 kWh/m^2/day to bring about economic growth in the area.
10. Use of Solar maize dryer for 45 tons to improve agriculture sector in Rwanda by saving time in the drying process as well as prevention of direct exposition to the solar radiation (UV) in order to reduce the risk of mold and aflatoxins.

3.1.2. Bioenergy technology

Bioenergy is the most important energy for many African citizens who rely on using traditional biomass. About 70% of African population still use wood as fuel for heating and cooking and this, following population growths, has threatened forest resources. Bagasse is the main bioenergy source used for electricity generation. Bioenergy technologies present an important investment opportunity for biogas, bio-diesel and biomass briquettes from agriculture, saw and municipal waste. Biomass (bagasse boiler) investment costs are roughly 2500 USD/kW, capacity factor of 0.5, fuel cost 0.5–3 USD/GJ while for biomass co-combustion in coal-fired power plant the investment costs are roughly 1250 USD/kW,

capacity factor 0.75, fuel cost 1–5 USD/GJ. Therefore, some bioenergy projects may offer attractive investment returns in Africa and this study analyses the following projects:

1. Use of organic wastes under anaerobic digestion (AD) with combined heat and power (CHP) for energy generation (electricity 85 kWel, biogas 5000 m^3, heat) and improved local sanitation in Nyabihu district, Rwanda.

2. Production of electricity from biogas for cooking and utilization of plant effluent for making fertilizer in order to increase the social economic gains of Katanga slum residents in Uganda by utilizing human waste as an alternative energy source and agricultural soil amendment.

3. A 9.4 MW hybrid gas and incineration plant by use of solid wastes at the Kangoki landfill in Thika, Kiambu county, Kenya through a well-managed landfill technology which will see the use of landfill gas in steam generation of which turns turbines to generate electricity.

4. Utilization of a mixture of human excreta and household biodegradable waste to produce biogas (300 m^3) in order to provide energy to 3 schools in the southern province of Rwanda and increase socio-economic gains of the population around these schools.

5. The abundant agricultural residues and waste such as banana peels, rice husks, coffee husks, straws, etc. conversion into bioenergy in rural communities around Africa.

6. Utilizing of feedstock from sawmills on the Copperbelt province to produce electricity public institutions in Zambia that currently depend on wood fuel for heating at an estimated consumption of 19.4 million m^3.

7. Installation of a 6.5 MW biogas and syngas power plant project incorporating a dual technology based on methanization of organic waste liquids and solid waste gasification to be implemented around a highly-populated area in Cameroon in the neighborhoods of the university of Ngaoundere.

8. A 458 kW_{el} biogas CHP plant from MSW for Arua Municipality in Uganda to generate electricity to be fed to the grid under Renewable Energy Feed-in Tariff (REFiT) and Gobal Energy Transfer Feed-in Tariff (GETFiT) programs. This project will save the high costs currently incurred by the authority in charge of waste management in this area amounting to USD 30 120 per year.

3.1.3. Wind technology

Onshore wind have investment cost of around 2000 USD/kW, capacity factor between 0.25 and 0.4 may result in sufficiently low LCOE in African most windy areas. Therefore wind energy investment opportunities such as the installation of a 15 MW wind farm in Saint Louis (Senegal), in an area with good wind speeds of about 7 m/s at just 10 m high to supply the national grid are being considered in African contexts.

3.1.4. Hydro technology

Small hydro (0.1–10 MW) projects may have an investment cost of between 2000 and 4000 USD/kW, capacity factor of 0.5, and electricity price of 0.09–0.18 USD/kWh. Therefore also hydro project attracts investor interests:

1. A Smart Village mini hydro project of 0.2 MW will be developed to contribute on existing capacity by providing energy which is affordable, accessible and sustainable to a rural area of Rwanda for poverty alleviation, improvement of health and education, and reduction of greenhouse gas emissions.

3.2. The sponsors

The parties to be involved: major stakeholders in financial success. Who will provide how much funds and why?

The prospective sponsors for the investigated RE projects are different depending on the type of the project, country and the project site. The sponsors are expected to be:

- the National Ministries of Energy of Egypt, Ivory Coast, Kenya, Mali, Nigeria, Rwanda, Uganda and Zambia and other related government entities such as the Ministry of Agriculture and Workforce Development Authority (WDA) of Rwanda,
- local governments and local councils within the countries of the project locations,
- the National Banks of the project implementation countries,
- key financers of sustainable energy projects in Africa such as African Development Bank (AfDB), World Bank and Centenary Rural Development Bank,
- private companies such as SolarAfrica and SolarCentury,
- consumer companies such as Telecom companies for example MTN telecom company in Uganda,
- international cooperation currently in partnership with African entities specifically involved in developmental projects such as Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH,
- donors and various organizations that support renewable energy such as New and Renewable Energy Authority (NREA) in Egypt,
- the local population/communities of the project locations can also support the projects for example through village farmers' cooperatives,
- private sector organizations who are mandated to spur economic development in their respective areas such as Kerio Valley Development Authority in Kenya,
- companies with energy related products and services such as Siemens and Safaricom,
- non-governmental organizations (NGO's), research and academic institutions,
- private project initiators or owners and potential venture capitalists, etc.

3.3. Market analysis and strategy

Who needs your project? Who are major competitors? Why does it meet current and future demands?

The RE projects are needed in Africa especially in rural locations which are the biggest area, still with high population compared to urban areas. Sub-Saharan Africa as of 2012 had only 35.3% of the population with access to electricity with very few exceptional countries such as Nigeria with 55.6% population accessing electricity [11]. Major competitors are other currently existing independent or governmental power producers.

Currently, existing solar projects are very few standalone home systems and few micro grids which are only afforded by the high-income earners. But with economic growth in Africa and with suitable policies for private sector investment, more and more off-grid systems especially solar home systems could be installed. Following the reduction of prices of PV and CSP infrastructures traditional fossil based power producers will be competitors in grid systems. In the biomass energy field competitors are not many because large companies are competing in solar energy more than in waste biomass due to limited development of cost effective waste biomass management. Provision of RE power will help in displacing the widely used traditional biomass especially for cooking which will, in turn, reduce deforestation.

RE projects are to mostly benefit the local populations and local businesses through residential, retail and office development, factories, telecommunication companies, slums and densely

populated areas and public institutions. These projects will attract investments in other nascent sectors in Africa such as the mining, telecommunication and agriculture sector.

Farming is a major economic activity all over Africa and farmers will benefit very much from majority of the RE projects because of better technologies that will increase farm output through utilization of organic fertilizer from bioenergy projects, quality of farm products and farm productivity in general for example by utilization of solar food dryers to facilitate food preservation. In addition agricultural irrigation is a very promising field for RE projects.

The independent power producers that are to own some of these projects will also benefit through high profits due to cost reflective tariffs and the existence of little competition. The governments will benefit too, given the general economic development and tax incomes that will follow after. This will help them achieve the poverty reduction goals.

The projects meet the current and future demands because majority guarantee more job opportunities and a self-sustainable green community as well as cleaner environment. Growing populations in most African countries contribute to increased energy demand which necessitates the increase in energy supply creating potential for RE projects deployment. Installation of RE projects will also bring about advancement in R&D. Improved R&D infrastructure created by RE industry will be shared with other industries which will reduce overall R&D costs for the African governments.

3.4. Project scope

Description of the technical aspects of the project. Indicate the vendor. Comment on O&M aspects and skilled staff availability. Explain project management.

Local governments and authority, national utility companies, private companies, project initiators/developers and implementing organizations will help to secure the projects, create a management team, facilitate distribution of products (electricity, biogas and fertilizers), provide guarantees covering power, equipment performance, and will be responsible to ensure operation and maintenance of the system. Their staff are normally trained in various areas including technology, finance and procurement by high-level experts. Competent local labor and from neighboring towns of the projects can be utilized if the required skilled staff is missing. The labor force for RE projects is made up of highly skilled technicians as well as semi-skilled workers. Both experts and labors with basic knowledge from universities are required for most projects. The key required labor force are project managers, project engineers, accountants, supervisors, and technicians. Solar PV technicians for example can readily be obtained from polytechnic schools. Also, local people will participate after training as welders, masons, fitters, carpenters and plumbers. The project management team may take the initiative to train and sensitize farmers and other locals on how to use the project products and services.

Wind turbines, generators, photovoltaic panels, inverters, prepaid meters and other technical equipment would be often supplied by international suppliers such as the PERKINS ENGINES, Vestas, Chinese Solar PV Ltd, ABB, Siemens, Safaricom telecommunication company and SMA Solar Technology. Other specialized companies and local partners such as TANTY (Cameroon), TRANSA (France), Centro Solar, the Asantys Systems and African Solar Designs may be contracted in the planning and designing. The research and academic institutions can be incorporated in some project designing. Some project devices could be manufactured locally bringing additional economic benefits to the local communities.

3.5. Regulation and environmental information

Environmental issues associated with the project. Why the project is sustainable? Key regulations and permissions required.

Generation and sale of electricity requires an operation license from the electricity regulatory authorities. Other required licenses are the Power Purchase Agreement (PPA), the local trading licenses, generation permits, feasibility study reports, Environmental Impact Assessment (EIA), business registration, working licenses, land rights, and contract negotiations. The governing regulations and requirements are national energy policies, renewable energy policies, import and export regulations and landfill waste water treatment policies. The projects may therefore require approvals from regulatory bodies such as the ministries of energy, national environmental management authorities, departments of natural resources, the County Councils, local government and the organizations where the project will be implemented. Involvement of local government and ministries assures compliance with national and regional regulations.

All projects are using renewable, abundant and environmentally friendly natural resources. Biogas generated is capable of displacing wood and firewood and therefore minimize deforestation. Bioenergy projects improve waste disposal which will lead to the improved sanitation and reduction of diseases caused by poor sanitation. Waste will instead be collected and used for energy harvesting. There will be diversification in electricity production. Reduced utilization of diesel and petrol generators for households and industries will decrease health threats by air pollution, cost of maintaining generator sets, reduced concerns about the environmental impact of the use of fossil fuels and the fluctuating price of fossil fuels since customers reduce the demand for generator systems. There will also be decrease in the depletion rate of conventional energy sources thus contributing to sustainability and GHG reduction issues.

The projects are sustainable because there will be employment of local people, time management, creativity, innovation and team work. Utilization of resources that would otherwise be dangerous to environment such as the case of bioenergy from saw dust. Preservation of species for example the Goliath frogs used as bioindicator of water quality will allow at the same time to sustainably manage these protected species whose flesh is highly prized in some regions. Some projects might create the opportunity for free access to recycled water. Also, acquisition of environmentally inert building materials at lower cost is a plus. There will be improved food security by making use of food-bioenergy opportunity such as producing more food and using obtained residues as bioenergy resources. Some projects will replace kerosene lamps with modern energy sources which are cheaper and provide healthier lighting, e.g. by reducing harmful indoor air pollutants causing eye and respiratory diseases.

3.6. Project costs

Estimated cost of implementation.

The estimated costs of implementation of solar energy projects range between USD 150,000 to USD 5,138,234 (1000–9300 USD/kW).

The estimated costs of implementation of bioenergy projects range between USD 100,000 to USD 75,000,000.

The estimated cost of implementation for the wind energy project is USD 20,640,000 which is 1376 USD/kW.

The estimated costs of implementation for the hydro energy project is USD 686,750 which is 3434 USD/kW.

These projects' implementation estimated costs above include the capital costs, operational costs, costs of replacement of parts

such as batteries and inverters, land cost and preparation where necessary, equipment and installation costs, balance of system costs, project development and feasibility studies, and other periodic costs.

3.7. Financial projections

Conclusions from the financial documents: (i) cash flow statement, (ii) balance sheet, and (iii) income statement.

All projects are claimed to be financially viable. They all have positive Net Present Values (NPVs). Income will be generated from the sold products of the projects, mainly from electricity but also from biogas, fertilizers, dried materials, farm products and other inorganic products from gasification. Some projects will run up to 50 years thus making capital investment less impactful compared to yearly cash flows. The debt repayment period of the projects ranges between 3 and 10 years. Internal Rate of Return (IRR) ranges between 4.2% and 36.4%. Estimated total annual incomes range between USD 31000 and USD 133 Million. There is also expected income from greenhouse gas (GHG) reduction in some projects. Each project has unique cash flows, balance sheet details and income statements details, some comments on these financial documents are provided in Appendix.

Investment decisions therefore can be considered depending on how financially attractive each of the projects is. Some of the projects with longer repayment period may be delayed or alternative financing mechanisms considered depending on the importance of the project in social terms. The cash flows and cost benefit analysis of the various projects can be found in Appendix.

3.8. Business model

Describe the basic business model of your project. Explain who is paying whom for what and why? Why this business model is to be successful in Africa? Why it offers a competitive advantage?

An attractive RE project requires a very good business model. There must be something exceptional in the employed business model that truly makes the specific project economically beneficial. For example, most of the students' bioenergy projects are built next to the large source of raw materials, i.e. near biomass collection or processing centers. This assures availability of raw bio resource and provides numerous co-benefits for the society and economy through improved utilization of bio resources, especially bio wastes. The major products of these projects are biogas, electricity, fertilizers, dried agricultural products, gasification products, biofuels, bioplastics, biopolymer, biowax, biolubricant as well as residues (slag) sold as raw materials for construction of roads and other infrastructures [12]. These products can be bought off by the consumers either directly from the production plants via mini grids and central distribution systems or from the conventional national grid system. The variety of products from a single production unit assures access to various markets and therefore diversifies project incomes with minimal waste.

Some projects utilize improved energy management and efficiency techniques such as the net metering systems, use of prepaid meters (project A9 and A12). Another unique payment model is described in project A10 where consumers pay against a determined subscription period; price changes depending on power required by the consumer and the consumer's consumption habits. This payment system may assure both energy efficiency and benefits to the power producing company and consumers. Variability in the production factors of the electricity do not affect the profits due to dynamics in the selling price. Some projects such as A4, A6, A14, A17, and A18 sell electricity directly to the grid depending on the feed in tariffs which assures infinite market for the product. Because current FiTs are very attractive in many African countries, e.g. in Kenya, this business model is currently relatively convincing. Nevertheless, in future FiTs may become less attractive so business models allowing for income diversification, accessing new markets, and further production cost reduction will be beneficial.

Use of local artisans in many bioenergy projects and in project A3 for example, avails less operation costs due to cheaper labor and increases involvement of the community which minimizes risks of rejection of the project or theft of project materials.

Business models should seek exceptional opportunities for displacing present-day expensive solutions by renewable energy solutions. For example, the diesel generators currently used to power telecom masts can be displaced by solar PV systems (project A3). It minimizes fuel costs and reduces the risk of diesel thefts.

Business model of project A6 relies on a multi-player format, involving many partners to ensure that the project is managed better at all levels for sustainability. Government is to pay for the expansion of the necessary infrastructure, i.e.:

- transmission lines from the landfill to the closest grid connection,
- construction of an all-weather road from the main road to the landfill site,
- any project initiation displacement and resettlement claims of local street families. Developer is to pay for the putting up of the:
- power generation plant and operational equipment e.g. bulldozers, tractors and wheel loaders,
- waste water treatment plant construction and necessary linings of the landfill,
- licenses and approvals,
- operation and maintenance costs of the landfill, electricity generation plant and waste water treatment plant. Utility company commitments include:
- the feed in tariff payment as per the PPA,
- carbon trading reclaiming agreements with the developer. Independent waste disposal companies' responsibilities include:
- paying an affordable low cost annual and monthly subscription fee. This acts as a revenue collection to service some of the annual and company rates. It ensures a sense of ownership of the project for these stakeholders.

Overall, the proposed African projects use interesting business models contributing to their economic viability. Additional comments on business models are provided in Section 4.1.

3.9. Project innovativeness

Why the project is innovative and worth funding? Why the proposed technology, site or other business issues are exceptional?

All RE projects are based on sustainable clean renewable energy resources which are abundant in Africa and especially can be harvested in the respective suggested projects sites.

Project A1 introduces a relatively new technology in the region not currently being implemented. The project gives multi products and is intended to improve life standards.

Project A2 is focused on use of renewable energy that has high impact on economic growth.

The diversity of sources in project A3 assures improvement of energy security. Cost of operation and maintenance is lower compared to the diesel engine alone.

Project A4 focuses on direct sales of electricity into the grid system which reduces the cost of replacing a storage battery for normal personal home cases. Situating the project in a region that receives a high solar radiation (6.25 kW/m^2/day) all year round thus

maintaining high efficiency of panels. Cost of personally owning a PV system is avoided as the consumers of electricity just pay bills as normal consumption is being operated.

Project A5 uses a new and clean energy technology of wind turbine in the area. The project relies on wind speed being high in this region that can be a useful argument for the sustainability and to find stakeholder for the project.

Project A6 focuses on uniqueness of products and technical solutions applied.

Project A7 introduces a new technology in the region. It is meant to encompass a hybrid system of both recovered syngas from the landfill and an incineration plant. It will encompass energy efficiency both in generation using latest technology and in reduction of transmission losses to the grid system as well as provide empowerment to the street families by providing employment both directly and indirectly to them. It is expected the women youth will be the most beneficiaries since they will be used in manual sorting of the wastes therefore eventually raising their standards of living. The access to employment, environmental sustainability and generation of clean reliable sustainable and cost effective electricity are other advantages.

Project A8 focuses on use of fuel from waste material meaning that the fuel will be at minimal cost mainly incurred from the running of the machinery and human labor for sorting. The targeted Power Purchase Price is 0.14 USD/kWh to the utility company i.e. Kenya Power making the project economically feasible to the investor.

Project A9 also focuses on the introduction of a relatively new technology.

Project A10 matches with today's need of society and mission of different government and donors.

Project A11 has unique products from variable biomass resources.

Project A12 would make it possible to provide energy in energy poor areas where it will be implemented.

Project A13 also has unique products and will contribute towards energy security. Project A13 is clean energy based and is a milestone to climate change mitigation as it does not emit CO_2 and also preserves the carbon sink which is the forest by reducing on wood harvesting for heating.

Project A14 gives unique CHP products for the region from biomass energy.

Project A15 would encourage start-ups of other related projects and ensure sustainability.

Project A16 would use Francis turbine technology which has more efficiency compared to other types of turbine. The mini isolated hydro is new in the country and investment costs are reduced compared to centralized hydro because the transmission will be made locally minimizing transmission costs. The project will also contribute to skill development in the area by providing training opportunities.

Project A17 would use new and more efficient technology and also strengthen the private sector and rural retail structures. The project will work closely with the government to develop policies and regulations in long-term.

Project A18 is meant to realize immediate economic growth of the whole district by assuring power access throughout the region, thereby increasing opportunities for viable economic activities, infrastructural development and improved livelihoods of the inhabitants.

Projects A19 and A20 are both based on new technologies for their regions and are meant to improve the local energy mix.

Overall, there is a lot innovative aspects in the proposed African projects. Comments on innovativeness are provided below in Section 4.2.

4. Criticalities for the successful implementation of renewable energy projects in Africa

The implementation phase of renewable energy projects in Africa needs to overcome several critical barriers. The success will require at least availability of (1) reliable, flexible and dedicated business models, (2) innovativeness, (3) risks management fitting African contexts, (4) economic incentives for first RE projects, (5) skilled staff, (6) infrastructure, and (7) solutions to social challenges. If these and other essential criticalities are properly addressed by African policymakers, investors will be more willing to bring lacking know-how and seeding funding while financial institutions will be able to provide funding for financing this challenging transition to green growth.

4.1. Business models

This section analyzes business models in a broad perspective. There is some theory introduced and also new but relevant business models not mentioned by students are explained.

Business model is interface between company development and market. It is dedicated to value proposition, creation and capture. Business model is thus more than a simple pricing policy of a company. Business model may by itself be a disruptive innovation if new products, services or markets are created.

Many RE projects in Africa could not be implemented without suitable business models capable of overcoming existing barriers. In order to develop business models, it must be made clear what services are to be sold and to whom (value proposition), how will the products/services be created and provided (value creation), and how the value will be monetized (value capture). Such business models involving renewables may facilitate to adapt conventional energy business models of utilities and enable them to remain competitive on the market [13].

Good business models are required to facilitate market price oriented renewable energy harvesting. With good business models costs for governments due to economic incentivization will be reduced. Attractive business models should exploit synergies within economies that facilitate value creation.

A successful renewable energy enterprise running or essentially contributing to a project depends on support and business understanding from several stakeholders such as: (i) African Union, (ii) national government, (iii) regional and municipal authorities, (iv) media, (v) grid operators, (vi) consumer organizations, (vi) end users/consumers, etc. A good business model therefore establishes a partnership from a core group of stakeholders.

Business models need to relate to near-term cost effective niche markets. Lessons learned from these successful projects will support long term RE development and create opportunities for alternative projects. Economic incentives are essential for all business models of underdeveloped markets such as many present-day RE markets in Africa. Actually, technology specific economic project incentivization instruments rather than technical considerations shape projects markets and dictate which technologies are adopted and developed first [14]. Therefore, stable energy policies put in place are essential for facilitating development of adequate business models for African RE projects.

Business models need to consider that international standards will apply and they will allow incremental revisions as renewable energy technologies mature over time. The usefulness of renewable energy is region-specific. Its end use should take into account regional characteristics such as current and future energy supply mix and demand profiles, resource availability, regulatory and market structure, pricing structure for energy and power services, status of existing and planned infrastructure investments,

including those for transmission and distribution grids, current level of and future needs for energy system flexibility. Therefore, business models need to flexibly consider expected changes in business environment in order for the projects to remain economically sustainable in the long run.

Government and donor bodies through their initiative of empowering people can be involved by paying for the expansion of the infrastructure, transmission lines from the landfill to the closest grid connection, construction of all-weather roads from the main road to the project sites and any project initiation displacement and resettlement claims of local street families. In addition, developers or contractors can be responsible for managing the power stations, paying for all costs such as putting up the power plants, licenses, approvals, operation costs, maintenance costs and carrying out sensitizations. Under such business models involving various stakeholders RE projects have reduced capital costs making them more economically viable.

While developing business models for Africa it is important to ensure that all project partners have clear benefits, including financial benefits and that risks are adequately distributed and where possible managed. For example, utility companies and distribution companies can participate in carbon trading markets. FiTs and PPAs need to be beneficial for utilities in the short and especially in the long run.

Usually, feasibility of most grid connected power generating projects is strongly dependent on FiTs put down by the governments. To minimize the cost for the government over time, development of business models that exploit many co-benefits for project sponsors and stakeholders are essential. Considering the whole project lifetime economically sustainable projects can survive even though FiTs are reduced or completely removed in future.

Good business models usually include infrastructure sharing, i.e. project infrastructure is also used by other companies and/or the society. For achieving improved economic performance also project infrastructure whenever possible should play certain economic roles. Example includes PV panels on roofs that at the same time serve as a parking site for cars.

Socially responsible business models cannot overlook local human capital. Use of local people as technicians shall promote sense of ownership which is a good aspect for security. Policy processes supporting RE projects will be strengthened in case society is aware that projects bring clear social benefits.

Environmental aspects should be also tackled through sustainable business models. If a RE project has a positive impact on the environment, the society may have many other benefits such as eco-tourism, improved water access, etc.

Demand side management of energy, consumer management and financial management are all essential for developing good business models for RE projects in Africa. The models need to be regionally specific so it is usually not possible to relocate the model from one region to another. The business model must be 'fit for purpose' - developed and adjusted for a specific RE project. This creates a lot of space for business model developers and emphasizes the importance of this current article.

A business model may consider that a project will be handed over to the community management team after running for some time. Such as business model will allow to engage policymakers and community managers in order to make the project sustainable and economically reliable, especially in the long run.

In case grid development is limited a business model involving off-grid projects is the most relevant [15]. Within such a business model there is a large market to replace diesel generators with RE sources. Also solar lighting systems providing outside (public) lighting attract attention in Africa.

Since investors wish to minimize risks while maintain chances for profits a good business model may rely on employing government bonds at an interest rate comparable with IRR of projects in Africa but relatively short time horizon (2–3 years) and with option to renew. Under this business model investors would have confidence that policy risks are minimized because local policymakers are truly involved in the whole business by sharing the financial responsibility.

Because of many economic issues and financial limitations existing in Africa, many of the African population may focus first on the affordability of a product before quality. In many African locations, therefore, it will be common in the beginning of most projects that the consumers may not easily adjust to the new products because of financial constraints and other more urgent needs. An attractive business model for the African context may have to start by offering very good products at very low prices to compete with almost all existing similar products. This may have the business operate initially with minimum profit margins. However, the target market will easily buy into the new product because it is much cheaper than anticipated and will therefore get familiar and hooked to the new product. Once this happens, the business owners can then gradually raise the price of the product until it finally generate expected profits for investors. The African population is growing very fast with a high increasing rate of the middle class [16]. There is also still less competition in many businesses and services compared to other continents. Because of these two factors, many businesses have a high chance of prospering in this market after being well established with time.

4.2. Innovativeness

This Section analyzes innovativeness in a broad perspective. There is some theory presented and also innovative aspects not mentioned by students are approached.

An innovation is the implementation of a new or significantly improved: (1) product (good or service), (2) process, (3) marketing method, or (4) organizational method in business practices, workplace organization or external relations. The minimum requirement for an innovation is that the product, process, marketing method or organizational method must be new (or significantly improved) to the enterprise [17,18].

Useful innovation has to bring commercial benefits to the enterprise in the long run and if possible also in the short run. Therefore, project innovativeness is essential for the commercial success of the project itself and of the enterprise fully or partially owning the project.

For RE projects in Africa innovativeness may arise from shared infrastructure, new technology implemented in the region, utilization of local people, use of exceptional local resources, producing high-value co-products, positive environmental impact, climate change mitigation etc.

Most projects employ relatively new technologies in their respective regions. Since these technologies and projects are currently nonexistent, their implementation can be considered innovative yet they match the current needs of both the local society and international sustainability goals.

Projects can be unique by means of diversity of products. They can increase energy security. They therefore have a high impact on economic growth and improved livelihood and life standards of the people. The projects will strengthen the private sector and rural infrastructures. Since most projects work closely with the government, this favors policy development and regulations in long-term. This context shows that RE projects are capable of truly integrating local stakeholders which requires innovative approaches by itself.

Cost of operation and maintenance of some projects is lower compared to the currently used conventional energy sources, for

example replacement of solar energy for diesel engine in telecommunication systems. This type of innovation is based on adding renewable energy solutions to existing energy systems. It often brings innovative aspects, especially if RE harvesting techniques are efficient thus enable to benefit from abundance of RE sources in Africa.

There is high demand for electricity in Africa which assures market for electricity generating projects. Many projects are replicable and will encourage start-ups of other related projects. Rapid development of technological innovations reduces investment costs and makes clear benefits for power generating RE projects.

Africa is a continent with abundant renewable energy resources. By supporting the innovative ideas to promote the use of these available resources, it will help to sustain economic development of Africa continent.

4.3. Risks management

Many RE projects are very promising in Africa but investors need to pay attention to high risks associated with RE project development in this continent. High risks translate to the need for higher economic benefits from invested capital. Expectations for IRR in African RE projects are much higher than in developed countries, IRR 15–20% is considered attractive while in developed countries sufficient IRR level can be about 10% or even less in major stable economies such as Germany.

Major risks for RE projects in Africa include:

- Political risks due to unstable political systems and associated policies.
- Unstable currency markets.
- Theft/vandalism for example theft and vandalism of expensive solar PV panels. Security services in some projects would be necessary which would increase O&M costs thereby reducing project profitability.
- There might be high levels of corruption within some of the administrative offices. This may cause delays in legalities and subsequently possible extra costs for project developers and owners.
- Delay in acceptance of some projects due to social and cultural beliefs that may be against some new technologies for example use of waste for electricity production.

Contingencies measures to mitigate these risks are essential prerequisites to successfully implement African RE projects. A risk management process including risk identification, evaluation, control, and feedback [19] need to be designed accounting for African specificities. Investors in Africa need to put much attention on essential elements of project development such as site, resource, off-take, permits, technology, team and capital in order to secure their business [20]. Energy markets are not mature in many African countries with often leading role of governmental bodies. Hence, investors need to carefully use approaches mitigating market and political risks already in the project planning.

4.4. Economic incentives

Economic incentives are essential part of policies for RE project implementation in Africa [21]. In an early phase RE projects have significant risks which increase financial costs of projects. Therefore, first projects will require economic incentives from governments or specialized organizations. When RE market matures, the next projects will likely require less or no economic incentives to achieve commercial viability.

In Africa, economic incentives need to be high and guaranteed by governments or truly responsible institutions. Feed in tariffs and tender systems are two incentivization measures that fit current African contexts.

FiTs' long term stability is attractive from the business perspective. From the government perspective FiTs can be regarded as effective but rather costly thus most suitable for aggressive RE policies at a very early stage that could trigger investors' interest.

Tenders (or auctions) mobilize investors to invest in RE assets with long-term incentives from the government. Tenders rationalize energy markets and governments can shape energy markets. Tenders are receiving increasing interest as tools for RE projects in Africa [22].

Donations help to familiarize governments with technologies and demonstrate market viability of RE options. However, excessive donations without any cost recovery for RE projects for example in the form of large capital cost subsidies and/or donated equipment are found to destroy markets and should thus be discouraged in Africa [23]. Consumers to some extent may start to rely on donations and wait rather than create privately owned projects and pay for provided energy services. Free installations and products are normally not well maintained by consumers because people generally do not take good care of things they get for free. It is therefore important that relevant business models that make these projects financially attractive are developed and social consideration such as culture and participative planning for projects are adopted to improve on the acceptability of projects and guarantee socio-economic sustainability.

4.5. Skilled staff

Highly qualified human capital is essential for successful African RE project development. There are many initiatives that focus on raising qualifications in Africa by applying learning by doing approaches. For example, the GIZ Energy Program in Uganda, which is a bilateral development partnership between the German and Ugandan governments, hosted in the Ministry of Energy and Mineral Development. The GIZ Energy Program works in the areas of energy policy, biomass technology and markets, climate change and rural electrification and creates qualifications for African needs.

There are several initiatives focused on training skilled labor to run African RE projects. One of such institutions is the Pan African University with its branch located in Tlemcen, Algeria. It is focused on training African experts in all fields of development with emphasis on energy engineering and energy policy. However, Africa is facing a challenge of migration of academic and skilled labor force to other continents. Skilled migration from Africa is encouraged by factors such as higher wages, relatively better working conditions, more availability of job opportunities, and existence of selective immigration policies designed to attract the best academic and skilled professionals from Africa [24]. It was estimated that between 1985 and 1990 Africa lost close to 60,000 professionals including engineers [25]. In the context of this human capital flight RE projects can have access to all types of required skilled labor within Africa if the working conditions of these projects are similar to those offered in the rest of the world. Thus, it's important that work conditions are improved to guarantee job and financial security to African experts in the diaspora in order to prevent brain drain and as well train African experts to manage African projects and create a truly motivating environment.

4.6. Infrastructure

Insufficient infrastructure is another critical barrier that limits more rapid implementation of RE projects in Africa. Some RE

projects require less infrastructure or infrastructure is already available in respective project sites. These projects should therefore be prioritized. Other projects that lack sufficient infrastructure locally need to be developed with participation of public investors supported by governments.

The undeveloped infrastructure is a challenge for RE projects but is also an opportunity for Africa to develop sustainable infrastructure to meet the needs of the 21st century. Lacking infrastructure presents an opportunity to operate localized off-grid systems that are economical and present various economic and ecological benefit achieved locally. The presented African RE project overview takes into consideration the role of infrastructure and the local infrastructure needs to be carefully considered while developing project investment plans.

The limited infrastructure in many parts of Africa as well provides an opportunity to build robust and flexible systems enabling infrastructure integration and incorporation of renewable systems in a more sustainable way by making provisions for future changes.

4.7. Social challenges

There are numerous socio-cultural challenges which need to be addressed in Africa. For example, a significant part of sub-Saharan Africans live without access to electricity (in 2012 it was more than 75% of population in more than 15 countries) [26]. For sustainability of delivering energy three major issues must be addressed in Africa: (1) energy equity, (2) energy security and (3) environmental impact. However, due to social factors such as high levels of poverty, people in many areas find it hard to pay for electricity which would require taking consideration while RE projects are being implemented in such poor regions. In many rural areas of sub-Saharan Africa as much as 90% of rural people rely on traditional biomass utilized mainly for cooking. These rural people with their very low incomes are not able to pay for electricity and therefore will not be able to benefit from RE project implementation. Even in urban areas many people do not connect to power grids because they cannot afford paying for electricity. Full removal of these type of social barriers will take years even in steadily growing African economies.

The governments have in many cases provided subsidies in order to meet the needs of the poor or utilize loans that are repayable by the entire population to put in place capital projects. However, governments need to rethink sustainable mechanisms of empowering people through education, healthcare and supporting productive activities to guarantee a bigger tax base and increase purchasing power to guarantee affordability of energy services and stability of the economy as well as reducing the country's debt burden.

Possible present-day solutions facilitating development of RE systems in poor areas may rely on innovative payment systems for electricity, e.g. including mobile phones for small purchases by employing net metering and prepaid meters. If local people are employed and earn from local RE projects they can have increased purchasing power and thus contribute to projects economic sustainability.

5. Conclusions

The current research allows to draw the following main conclusions:

- Africa has very high potential towards renewable energies, still high electricity prices in local markets, and growing demands due to accompanying population and economic growths in almost all countries. These opportunities facilitate development of economically sustainable RE projects.
- The implementation of RE projects will positively affect agriculture, reduce deforestation, clean ultimate disposal of waste, provide jobs for installations, operations and maintenance, increase tax revenues, provide energy for factories and other businesses, improve societal health and contribute to achieving clean environment.
- The criticalities for successful implementation of RE projects in Africa include: (1) reliable, flexible and dedicated business models, (2) innovativeness, (3) risks management fitting African contexts, (4) economic incentives for first RE projects, (5) skilled staff, (6) undeveloped infrastructure, and (7) solutions to social challenges.
- Business models need to be made available that are sufficiently flexible to changing market situations and political risks.
- Project innovativeness is essential for commercial success and hence each project idea need to maximize locally available benefits and exploit synergies.
- There are significant risks to investors that would have to be appropriately measured and mitigated by applying tools fitting African contexts. African policy related stakeholders need to closely cooperate with investors for risk management.
- Extended policies economically incentivizing especially first-of-a-kind RE projects need to be adopted.
- Highly qualified human capital is a prerequisite for implementing African RE projects and hence academic education and learning by doing initiatives need to be prioritized. Besides human capital flight need to be minimized by ensuring attractive salaries for African project employees.
- Undeveloped infrastructure needs to be seriously considered during site selection. Shared infrastructure between RE projects and the rest of the economy brings essential benefits to societies and should be reflected by policies and project business models.
- Synergies with existing industries may boost African economy if it deploys renewable energy. Also, the financial loop between the local society and project owners would be beneficial to enable the creation of stable power markets involving local people earning from projects as employees and paying for electricity as consumers.
- The RE projects are beneficial to both the local people and the governments. Involvement of the responsible ministries guarantees compliance with national regulations and the laws and security against political risks that may otherwise affect the projects.
- Donors will also benefit from international cooperation as well as fulfil their agenda of supporting clean energy initiatives. However, direct donations should be displaced by more sophisticated mechanisms that do not destroy energy markets.
- Utilizing the available business opportunities for RE project development Africa can build a sustainable economy and offset the disadvantages arising from the use of conventional energy sources as well as create avenues for mitigation of climate change of which consequences are particularly harmful for Africa.

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Appendix 1. Pan African university students' renewable energy projects for Africa

The tables sent by some of the students as their assignments are presented below. The contents were revised by some students upon comments from the lecturer.

Table A1
Investment plan for the project: "Utilization of organic wastes for energy harvesting in Rwanda (electricity 85 kWel, biogas 5000 m^3, heat)".

Items	Comments and justifications
Project synopsis	This project will apply anaerobic digestion (AD) with combined heat and power (CHP) which are mature technologies. Partners are Ministry of Energy of Rwanda, Rwanda Environment Management Authority (REMA), GIZ, local government and local community. The project is suitable for delivering electricity, biogas and fertilizer in rural areas.
The sponsors	Ministry of Energy of Rwanda as it is in charge of distributing electricity in the country and reducing the amount of wood or firewood used. African Development Bank and World Bank as they are financing implementation of renewable energy project in order to minimize GHG emissions. Other sponsors include GIZ and local government. The total of external funds will be about 60% of the project cost.
Market analysis and strategy	The project is needed for the whole country but mainly in rural areas. Currently, competitors are not many because large companies are competing in solar energy more than in waste biomass while waste biomass can compete in electricity, biogas and fertilizers prices. A significant part of Rwandan population are farmers, meaning that animal and agricultural waste are available at a high rate. Also, currently only 23% of Rwandan households have access to electricity and 85% of primary energy of the country is traditional biomass used for cooking. In addition, the project will use human and residential wastes which are sometimes improperly disposed in the environment. The project will thus improve waste management and by displacing traditional biomass will reduce deforestation.
Project scope	The project can be implemented in rural areas, schools, institutions and prisons but at the first time it will be implemented in the Rambura Sector, an area located in Nyabihu district in the west of Rwanda. Biogas' experts are required, labors with basic knowledge from universities are there and some local people also will participate and training have to be provided. Local government will help to secure the project and facilitate distribution of products (electricity, biogas and fertilizers).
Regulation and environmental information	Biogas generated by this project is capable of displacing wood and firewood thus can minimize the release of carbon from the forest stock. Also in some place waste are improperly disposed but after implementing this project, those wastes will be collected and used for energy harvesting, which will lead to the improved sanitation and reduction of diseases caused by poor sanitation.
Project costs	700 000USD
Financial projections	CAPEX 450 000USD, OPEX 250 000USD, income will be the money coming from the sold electricity, biogas and optionally fertilizers.
Business model	Some biogas plants will be constructed near toilets and for others collection and transportation of waste are required. There will be 3 biogas plants where 2 of them will produce biogas and fertilizers and another one will be connected to a CHP unit for electricity and heat product with fertilizers. Jobs creation for local community, waste arrangement will be co-benefits. This business model will likely be successful because raw materials are available, government and other sponsors are ready to finance it because of numerous co-benefits for the society and economy. The products (biogas, electricity and fertilizers) will be sold to the community at a low cost. The implementation of the project with this business model will positively affect agriculture, reduce deforestation, improve societal health and contribute to achieving clean environment.
Project innovativeness	Currently, in Rwanda anaerobic digestion products (biogas) is used for cooking and lighting. CHP is still relatively new in Rwanda and can be considered innovative. The project is also innovative through generating good quality fertilizers compared to industrial ones as they don't affect the soil. People will gain some knowledge relating to the biogas technology, benefit from jobs creation and using biogas instead of traditional biomass will result in improved life standards.
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Table A2
Investment plan for the project: "0.5–1 MW solar car port at Garden City Mall in Kenya".

Items	Comments and justifications
Project synopsis	The project is a solar farm in Kisumu, Kenya. It will make use of the rooftop car park with solar PV installed capacity of between 0.5 and 1 MW. The use of solar PV was chosen as a way of producing clean energy; a sustainable alternative to grid energy. Given that the location of the area is around the Equator, there is an excellent solar irradiation that averages 6.44 kWh/(m^2 day). Given suitable energy feed-in-tariff of 0.12 USD per kWh, the project will be capable to pay itself through selling the electricity produced.
The sponsors	The potential sponsors for the project are SolarAfrica and SolarCentury. They have already undertaken several solar PV projects in Kenya including installing the largest solar carport at Garden City Mall in Nairobi of 858 kWp, and are also involved in the development of 1 MW rooftop solar in London Distillers Ltd using dual-technology. SolarAfrica provides advisory, technical and financial support. SolarCentury is involved in design and installation of the hybrid system (three power sources, solar electricity, the grid and diesel generator).
Market analysis and strategy	There is increasing development of residential, retail and office development in Kisumu. The project will provide a sustainable solution to produce clean power. Establishment of SolarAfrica in 2013 to promote solar energy commercial scale projects across Africa fitted the Garden City strategy. The devolved system of government in Kenya has also prompted County Governments such as Kisumu to seek international LEED (Leadership in Energy and Environment Design) certification.
Project scope	The solar system is of 0.5–1 MWp. SolarAfrica will provide guarantees covering power, equipment performance, and will operate and maintain the system for approximately 12 years depending on the contract agreement.
Regulation and environmental information	There are no known environmental effects of the project as it produces green energy. The project is sustainable given the development of regulations that support development of solar energy.
Project costs	Estimated cost of implementation is about $1200 per kW.
Financial projections	The repayment period of the project is about 6–10 years. It is becoming shorter given the dropping price of PV modules. There is also zero import duty on solar modules and associated equipment in Kenya.
Business model	It's a solar hybrid system using dual-mode technology. It minimizes use of electricity from the grid leading to cost savings. The present-day retail cost of electricity in Kenya is 0.19 USD/kWh while the feed-in-tariff for commercial solar PV projects is 0.12 USD/kWh. The project thus operates under the retail price regime as it aims to save the cost of electricity purchase.
Project innovativeness	The project is innovative as it taps into the renewable energy using the dual-mode technology. The cut on carbon emission and savings as well as revenues on use of electricity are significant. Such projects are often awarded Vision 2030 status by the Government of Kenya due to the impact they have on economic growth of the country.
Student	Eric O. Akumu, email: otea.akumu@gmail.com

Table A3
. Investment plan for the project: "30 kV A solar PV for Telecom masts in Uganda".

Items	Comments and justifications	
Project synopsis	This project aims at using solar PV for powering telecom base masts in Uganda. Currently MTN-Uganda which is the biggest telecommunications company has 498 telecom base stations in Uganda each using 30 kV A standalone diesel generators to power the masts [27]. However, the use of diesel generators has high OPEX coupled with issues such as diesel theft. Uganda has high solar insolation of 5.1 kWh/(m^2 day) which makes it economically feasible to power the masts with solar PV [28].	
The sponsors	The initial investment shall be a loan from Centenary Rural Development Bank. The investor can be MTN-Uganda as the masts owner.	
Market analysis and strategy	The telecommunication company provides ready market for power from solar PV. No grid in the area and high potential of solar insolation of 5.1 kWh/(m^2 day), most of the sites are in rural areas where it is easy to acquire land for installation. This sample project is just for one station that can then be used as a module for other stations with similar conditions. The use of solar PV instead of diesel generators can be incorporated in the marketing strategy of the telecom company as clean energy harvesting may improve company's perception by clients. MTN-Uganda is the sole customer for the project. The only competitor is the national electricity grid which is not yet present in most rural areas (given 7% electricity access in rural areas) where the targeted telecom masks are located [29]. This project meets the current and the future demands due to reliable and high insolation in the area.	
Project scope	The electricity shall be produced from solar through photovoltaic technology. The existing diesel generator shall be used for back up only on the overcast days. The project shall use the maximum power point tracking. For use in the night the energy shall be stored in Lead acid battery. Automatic switching of power shall be used to ensure that there is no black out in power. The solar panels shall be cleaned of dust and checked every evening to ensure there are no cases of shading. Refilling of the battery, periodic replacement of batteries, and invertors after 8 years. Technician employed to carry out operations and maintenance. Solar PV technicians can readily be obtained from the polytechnic schools within the district.	
Regulation and environmental information	Currently there are no environmental regulations against the use of solar PV in Uganda. Generation and sale of electricity in Uganda requires an operation license from the electricity regulatory authority. This license is obtainable within 2 weeks at no cost. The environmental sustainability aspects of the project include zero emissions GHGs during electricity generation using solar PV, no noise production and that solar energy is inexhaustible. At the end of the project the solar panel wastes shall be sold to a solar PV panel plant for recycling.	
Project costs	The costs of implementing the project are as shown below: - CAPEX $ 34,176 - Annual OPEX 11,052 - Cost of Replacing batteries/invertors after 8 Years is $ 3000 - Annual Debt Payment cost $ 11,050 - Installed cost of electricity $ 1139/KW.	
Financial projections	Balance Sheet as on the first day of the project	
	Permanent Asset	34,176
	Solar PV Panels, Batteries, invertors	34,176
	Total Assets	(33,894)
	Long Term Liability	(282)
	Initial Capital	34,176
	Current Liability	
	Interest payable during construction	
	Total Liabilities	
	Income Statement for Year 1	
	Income	12,489
	Saving on diesel	12,489
	Total Incomes	2762
	Expenses	8152
	Operation and maintenance	342
	Debt Payment	11,256
	Depreciation	1233
	Total Expenses	
	Operating Result	
Business model	Solar PV Technicians and local artisans from the polytechnic institute in the area shall be used during installation, operation and maintenance of the project. This shall promote sense of ownership which is a good aspect for security. The routine maintenance and operation shall be done by one technician who shall be paid a monthly salary. Theft and vandalism of solar PV panels is common in Uganda; security services shall be hired from the local private security companies such as G4S to ensure that the power site is secure. The initial investment shall be a loan from Centenary Development Bank because they have flexible disbursement plan compared to the other banks in the country. The power station shall be managed by the contractor but with frequent monitoring by the telecom company representative as the sole buyer of electricity. The lower cost of operation makes it to out compete the diesel generator. Currently the grid has not reached most of the areas of the telecom masts and there are no independent power producers also.	
Project innovativeness	Use of solar system with back up from the diesel generator improve energy security due to diversity of sources. Cost of operation and maintenance is lower compared to the diesel engine alone. The telecommunication company can incorporate the use green energy in their sustainability marketing strategy as such getting more customers since many people like to associate with environmentally friendly technologies. The use of the solar power plant as a learning site for the neighboring schools can earn extra revenues.	
Student	Yunus Alokore, email: aloxius@gmail.com	

Table A4
Investment plan for the project: "1 MW SOLAR4ALL Project (Location: Sokoto, Nigeria)".

Items	Comments and justifications
Project synopsis	SOLA4ALL is an independent power project aimed at developing 1 MW grid connected solar photovoltaic (PV) systems in Isa, Sokoto state of Nigeria. The project is a quick response to the decree issued by the federal government of Nigeria to all independent power providers to have 50% participation of renewable energy resources in power mix. The proposed site, Isa, is one of the important regions in North Western Nigeria very famous for the high temperature it receives all year round. Isa gets a monthly average daily irradiance and sunshine duration in the range 18.29–24.33 MJ/m2/day and 7.09–8.99 h respectively, indicating a very high resource for solar PV technology. The project began with a prefeasibility study of a 1 MW grid-conducted solar PV system using RETScreen software. The overall investment cost is estimated as USD $5,000,000 and is expected to be funded by The Nigeria Ministry of Energy, African Development Bank and GIZ with different monetary donations. The major benefactor of this power project is the local Isa population as well as neighboring communities. Generated power shall be sold directly to the grid at the tariff rate provided by the government. However, due to the limitation in getting the feed-in tariff rate as at when this report was made, an amount of USD $0.2/kWh was assumed to calculate the payback time and rate of return (hence it should be noted that this is actually not the case).
The sponsors	SOLAR4ALL has the following stakeholders: • The Nigerian Ministry of Energy who is posed with a higher responsibility of addressing a fast-growing electricity demand. However, due to other important ongoing projects in the country, financial aid from the government may not be so high. The financial contribution expected from the ministry of energy is USD $100,000 • The African Development Bank (AFDB) one of the important financers of sustainable energy projects in Africa will contribute USD $2,200,000 • German sponsors, GIZ, is an international cooperation currently in partnership with Nigeria to finance sustainable economic development in the country. They will contribute a sum of USD $2,700,000.
Market analysis and strategy	• Electricity access in Nigeria was about 55.6% of the population as of 2012 [11]. The current generation is 1,400 MW (2016) which is so insufficient to cater for 170 million population. SOLASOK1 identifies the electricity-starved population as the major benefactors of the project. • The Federal Government of Nigeria whose short-term goal is to increase access to electricity by the participation of renewable energy sources also fulfils its objective with the execution of this project. • AFDB and GIZ are able to meet sustainable goals as supporters of this project which is an important social fulfilment. There are no competitors to this project at the moment. This is because the Nigerian Government is in need of more participation of Independent Power Producers to ameliorate energy challenges currently affecting the country and in the northern region today the existing solar projects are a very few standalone home systems which is only afforded by the high-income earners.
Project scope	The estimated electricity that would be generated having accounted for possible losses and capacity factor (13.2%) of the panels is 1160 MWh/year. A total of 2270 panels (250 Wp each) is used to generate the required output power considering a derate factor (inverter efficiency) of 80%. Photovoltaic panels would be supplied by Chinese Solar PV limited. The labor force is made up of highly skilled technicians as well as semi-skilled labor force. The project manager is responsible for the overall supervision of operations on site. Due to the durability of solar panels (longevity of 25 years), there is a minimal maintenance required. Since battery is not needed in the setup, cost of replacing battery is taken care of thus reducing maintenance cost. The maintenance required would be cleaning of the panel surface.
Regulation and environmental information	The galloping demand for electricity in Nigeria makes it a viable market for potential investments. Over the years, most businesses have been centered on provision and sales of diesel and petrol generators for households and industries. Recently, due to health threats from air pollution, cost of maintaining a generator set, concerns relating to the environmental impacts of the use of fossil fuels and the fluctuating price of fossil fuels, customers have reduced the demand for generator systems. SOLAR4ALL is a sustainable project, one that uses renewable, abundant and environmentally friendly solar energy for power generation.
Project costs	The estimated cost of the project as projected with RETScreen software is USD $5,000,000
Financial projections	• Economic analysis of the project was carried out to assess the cost and intended benefits. It was done with RETScreen software. With overall estimated cost for installing the PV systems is USD $5,000,000. Module and Inverter costs alone makes up 76% of this overall. The operation and maintenance cost is estimated at USD $0.01/kWh • Electricity export rate (for bulk generation) is USD $0.08/kWh • Discount rate is 10% and IRR is 4.2%
Business model	The model is set up in such a way that the feasibility of the project is strongly dependent on the feed-in-tariff put down by the government. For the purpose of this report, a low tariff of USD $0.2/kWh was assumed. This indicated the profitability of the project and obtained a payback time of 21years consequently. However, this is the maximum payback period assumed, in the practical sense it is much lower. Thus, the project is competitive with other renewable energy generation sources. There is also an uninterrupted electricity supply as solar radiation remains relatively high all year round. Lastly, the typical characteristics of a solar PV system is the high cost of installation but a lower maintenance cost compared with conventional fuel technology.
Project innovativeness	The innovations in the project are seen in the following: • Direct sales of electricity into the grid system which reduces the cost of replacing a storage battery for normal personal home cases • Situating the project in a region that receives a high solar radiation (6.25 kW/m^2/day) all year round thus maintaining high efficiency of panels • Cost of personally owning a PV system is avoided as the consumers of electricity just pay bills as normal consumption is being operated • The project keeps on yielding income as long as demand for electricity in the country grows or remains the same
Country - Nigeria	Student name: Samuel O. Babalola, email: babalola_sammie@yahoo.com

Table A5
Investment plan for the project: "Utilization of human waste as an alternative energy source and agricultural soil amendment in Uganda".

Items	Comments and justifications	
Project synopsis	Urbanization is increasing worldwide in developing countries and an estimated 50% of the population of sub-Saharan Africa will be living in urban areas by 2030 [30]. This rapid population growth necessitates sustainable planning to meet demands of the populations with limited available resources. It is essential to note that at least a percentage of 60 of the urban population of Uganda lives in slum areas [31] and they are faced with problems like improper sanitary infrastructures amidst the prevalent poverty. There is a general widespread use of latrines in Kampala with the highest concentration in slums. This is mainly due to the poor sewer coverage of Kampala with less than 10% of the city being served by the central sewer system [32]. It is observed that in the slums there are more users per pit latrine than in other areas of Kampala. More often than not, the few available pit latrines are shared between families and communities in these slums. The limited existing public ones require payments before use, this makes the low-income earners in the slum to resort to easier means (disposal). In addition, providing adequate and appropriate sanitation facilities in most of Kampala suburbs still remains a major challenge for local governments and urban authorities [33]. It is not surprising that inadequate and inappropriate sanitation facilities contribute to a large extent to environmental health problems facing many parts of Kampala with adverse effects on both human and economic developments [34]. Although pit latrines are the dominant fecal waste disposal facilities in Kampala city slum areas, most of them are in a poor state, either filled or almost filled up and therefore there is a need for a sustainable fecal waste management system in these areas. Utilizing the fecal waste as an energy source through biogas systems and a fertilizer source can be a better way to solve the problems associated with waste disposal and to boost people's incomes. This interest in nutrients recovery is driven by several factors including scarcity and high costs of artificial fertilizers, public awareness and advancements in nutrients recovery technologies. The nutrients in fecal sludge that are economically feasible to recycle include; nitrogen, phosphorus and potassium [35]. The goal of the project is to increase the social economic gains of Katanga slum residents by utilizing human waste as an alternative energy source and agricultural soil amendment. It will involve production of electricity from biogas, biogas for cooking and utilization of plant effluent for making fertilizer. Institutional set up in Uganda consist of Ministry of Energy (responsible for licensing energy projects through the electricity regulatory authority), Ministry of Agriculture (regulation in the agricultural sector and licensing of imported agricultural inputs), Local Government (has both the political and technical arms and is majorly responsible for governance and service delivery and acts as watchdog for government sponsored programs at local council and district level. They also offer local trading licenses) and National Environmental Management Authority (responsible for regulation of human activities that are considered environmentally unsustainable).	
The sponsors	The project will cost about 4,089,000 USD which is expected to be contributed by various stake holders as follows: (1) Ministry of Energy (30% capital contribution), Ministry of Agriculture (15%), Local Government (15%), Donors (40%).	
Market analysis and strategy	Katanga slum has about 20,000being densely populated and housing the urban poor in social and economic isolation [36] coupled with irregular land ownership and low standard of sanitary and environmental conditions. The access to water, electricity, sanitation, and other basic services and infrastructure is limited. On average, five homesteads in Katanga with about 5 persons per home stead have access to one stance of pit latrine [37]. Moreover, these latrines are supposed to be paid for in most cases. This implies that human waste disposal is still a very big problem. This project therefore seeks to improve the situation by ultimately disposing and treating the human waste in the most sustainable manner possible through conversion into electricity from biogas and also formulation of fertilizer by utilizing wood ash and urine. Competition from diesel generators which are quite expensive option. Also, artificial fertilizer is quite expensive compared to the fertilizer made by this project. The project is sustainable for now and the future due to: (i) its easily replicable due to availability of raw material, (ii) it's an ultimate disposal of human waste. Sustainable sanitation and energy access will continue to be challenges that will necessitate creative solutions both now and in the future.	
Project scope	The project will run for 5 years before being handed over to the community management team. It will involve the rehabilitation of current sanitation infrastructure, construction of new Urine Diversion Toilets (UDT's), construction and installation of a biogas plant, installation of electricity biogas generation and distribution system and fertilizer processing and packaging plant. The expected results after the 5 years are; improvement of sanitary infrastructure in Katanga slum, increase in incomes of Katanga slum residents and an increase in toilet use in the slum.	
Regulation and environmental information	Uganda has in place the national energy policy 2002 and renewable energy policy 2007 which entails the regulatory processes of the energy sector. The project will obtain a permit to develop biogas and fertilizer from the Ministry of Energy and Mineral Development (MEMD), Ministry of Agriculture (MoA) and conduct an Environmental and Social Impact Assessment (ESIA) in accordance with the regulations of National Environment Management Agency (NEMA). The project supports the main policy goal of the Ministry of Energy and Mineral Development, namely "To establish, promote the development, strategically manage and safeguard the rational and sustainable exploitation and utilization of energy and mineral resources for social and economic development". Regulatory bodies include: - Ministry of Energy: Responsible for licensing energy projects through the electricity regulatory authority - Ministry of agriculture: Regulation in the agricultural sector and licensing of imported agricultural inputs - Local government: has both the political and technical arms and is majorly responsible for governance and service delivery and acts as watchdog for government sponsored programs at local council and district level. They also offer local trading licenses - National Environmental Management Authority: responsible for regulation of human activities that are considered environmentally unsustainable The project contributes to sustainable development in Uganda in the following ways: - In comparison with other energy sources, Bioenergy presents various environmental benefits. It for example results into reduced atmospheric emissions and emits less residuals that have impact on the soil, vegetation, drinking water among others. - The project will result in additional employment opportunities, during both construction and operation phase. - Project developer will build a fence along the vulnerable areas the project will stimulate bioenergy industry in Uganda; reduce Uganda's increasing energy deficit; and reduce import dependency.in addition to diversification of Uganda's energy mix which mainly comprises of hydro power, petroleum and diesel generated electricity.	
Project costs	The estimated project capital investment is 4,089,000 USD.	
Financial projections	Total Initial Cost	4,089,000 USD
	Operation and Maintenance Cost	3,309,800 USD
	Total Annual Incomes	4,750,324 USD
	NPV	4,927,716 USD

(*continued on next page*)

Table A5 (*continued*)

Items	Comments and justifications
	IRR 35.14%
Business model	The project will involve generation of electricity from human waste as well as utilization of the waste effluent and wood ash to make fertilizer. Electricity generated will be sold to locals at subsidized price through a mini grid system. The effluent from the digesters will be treated with wood ash to for a semi-solid soil conditioner/fertilizer which will be used in agricultural fields to increase agricultural production. The stakeholders will contribute as follows: Ministry of Energy (30% capital contribution), Ministry of Agriculture (15%), Local Government (15%), Donors (40%). This will be contribution to initial capital. The ministry of energy will benefit from production of affordable reliable energy for the people Ministry of Agriculture will benefit from fertilizer production. The local government will benefit from local employment of constituents, availability of electricity, increased tax revenues, reduced environmental pollution, clean ultimate disposal of human waste and wood ash among others. Donors will benefit from international cooperation as well has fulfil their agenda of supporting clean energy initiatives. The project is competitive and provides multiple solutions essential to promotion of human wellbeing. The project does not only provide sustainable sanitation option but also affordable electricity and other benefits such as jobs for local people. The project will engage various beneficiaries such as the locals in various activities which will act as a source for employment, train farmers in the best agricultural practices to boost agricultural production. The project provides for stakeholder participation through working with both the farmers and local people which enhances it acceptability. Involvement of the responsible ministries guarantees compliance with national regulations and the laws and security against political risks that may otherwise affect the project.
Project innovativeness	The project will increase levels of sanitation and also provide affordable clean energy for the local people. The project has three major results with particular focus on enhancing its sustainability (i) increased peoples through employment and provision of cheap energy alternative for production, (ii) improved sanitation infrastructure, and (iii) improved food security through enhancement of agricultural production by utilizing the effluent and wood ash as an alternative agricultural soil amendment. This project thus presents a unique and means of ultimate disposal of human waste through energy and fertilizer recovery there by fostering environmental sustainability and increasing the social economic benefits for the people in Katanga slum.
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Table A6
Investment plan for the project: "9.4 MW Hybrid gas and incineration plant by use of solid wastes as fuel, Kenya".

Items	Comments and justifications
Project synopsis	The use of a hybrid gas and incineration plant by use of solid wastes as fuel at the Kangoki landfill in Thika, Kiambu county. The landfill is on 20 acres. Most of the solid waste generated by inhabitants and industries of Kiambu end up in the dumpsite daily. With the rate of urbanization in the area, it is approximated the total population will double by 2050 meaning the rate of solid waste generation will increase significantly. Proposed technology: The use of a well-managed landfill technology which will see the use of landfill gas in steam generation of which turns turbines to generate electricity. Partners expected: IPPS, County government of Kiambu, National Environmental Management Authority (NEMA), higher learning institutions (Universities and Polytechnics) and Ministry of energy. Sponsors: International sponsors e.g. World Bank Investment cost: Approximately 15 Million US$ (±20%). The site is exceptional due to the fact that: 1. It is located close to the city. This means less electricity transmission losses to grid will be incurred thereby increasing efficiency. 2. Little initial investment costs will be incurred due to availability of already set up infrastructure e.g. roads, transmission lines, labor … etc. 3. The land is already designated as a landfill site by the county government.
The sponsors	Major stake holders in the financial success include: 1. World bank. Will be used in sourcing majority of the 20 million US$ funds. Reason is the project lies in the criteria of fundable renewable energy projects because it promotes biodiversity, job creation, women, youth and children empowerment as well as energy and environmental sustainability in climate change adaption and mitigation. 2. Government of Kenya. Participate in offering grants and favorable feed in tariffs so as to help in the running and initial cost setup. This is due to the fact that the current national energy policy supports the development of renewable energy projects. The county government will also support in development of the infrastructure in the site due to the fact that this is their duty in solid waste management of which requires a participatory approach in order to set up a well-managed waste disposal system in order to ensure sustainability for the expected rising waste in the city.
Market analysis and strategy	Who Needs the project: 1. Government of Kenya. Both national and county so as to meet the demand of energy and solid waste disposal. 2. Local street families and residents. Currently there are thousands of them relying on the dumpsite due to lack of formal employment will be employed in running of the plant. The local residents will also benefit from a well-managed system improving air quality, security among other benefits. 3. Independent power producer a.k.a. the developer. He will earn an income eventually. Major competitors: 1. Other independent power producers. 2. Local non-governmental and illegal organized movements that run the day to day operations in the dump site. Why it meets current and future demands: 1. Due to the current high rate of generation and disposal of solid wastes/day. 2. Growing rural-urban migration as well as current high birth-rate leading to more waste generation per year. Population is approximated to double by year 2050.
Project scope	Technical aspects of the project: Plant to generate 9.4 MW of power from a hybrid system of incineration and use of land fill gas. It will run on a General Electric (G.E) Steam turbine due to the availability of a reliable G. E. Service team in Kenya.

Table A6 (*continued*)

Items	Comments and justifications
	1. The operation and maintenance. Operation shall be at full capacity and ensure maximum possible operating efficiency of plant is attained. Maintenance will be divided into monthly quarterly, semi-annual and annual depending on the schedule advice of the equipment supplier. A budget shall be drawn for each service upon proper professional consultation with suppliers. 2. Staff required: competent skilled staff shall be hired in both the operation and maintenance of plant and equipment. In areas where additional skilled has to be outsourced the company shall contract the jobs to qualified suppliers and contractors. The continuous skills development of staff shall be done through trainings. Please note: Project will give preference to competent local labor where applicable. 3. Management of the project: A proper efficient structure will be formed upon the consultation of shareholders and management professionals. Every person required to fill this management position has to be competent in terms of team work, strategy and leadership, integrity and problem solving and group development.
Regulation and environmental information	Environmental issues associated: 1. Land fill waste water treatment. 2. GHG's emissions into the atmosphere. I.e. methane emission due to lack of trapping of gas and uncontrolled anaerobic and aerobic reactions before plant is set up and incineration plant flue gas emissions during operations. 3. Solid waste accumulation leading to affecting of the different economic sectors. Project is sustainable because: 1. The growing population will lead to growing solid waste generation. This will make the fuel for incineration and biogas generations readily available. 2. The continuous formulation of favorable policies in both energy sectors and environmental sectors to encourage the development of innovative projects with good I.R.R due to good feed in Tariffs, grants and subsidy availability, carbon trading and capturing … etc. 3. The development of modern efficient technologies that ensure the energy conversion and power generation and waste water treatment increase with the use of less fuels/energy respectively. Key regulations required: 1. National Environmental Management Authority approval. 2. Power Purchase Agreement between the IPP and the utility company i.e. Kenya Power. 3. Kiambu County Council approval. 4. National Construction Authority approval.
Initial project costs	Approximately 15 Million US$. (±20%)
Financial projections	As per the calculations the initial costs are expected to be 15 Million US$ (±20%). The debt ratio of the 25year project is expected to be 70% with an interest rate of 10% and a debt term of 10 years. The inflation rate as per central bank of Kenya will be 7% and a discounting rate of 9%. The plant is expected to run 330 with 34 days' disruption for maintenance in a year and produce a total projected export capacity of 95,431.44 MWh/year and rate of 1400 US$/MWh resulting to an income of 133 Million US$/year. There is an additional GHG reduction income of 1.2 Million US$ for the whole 25 years. The operation and maintenance costs and debt repayment are expected to be 52 Million US$/Year. The fuel escalation rate is expected to be 9%. The projected Pre-tax IRR- Equity is 2.0%, Pre-tax IRR- Assets is 2.1%, After-tax equity is 2.1%, After-tax IRR- Assets is 2.1%, Simple payback period is 0.2 years, Equity payback is 0.1 years, NPV will be 311.2 Million US$, Annual Life cycle savings 31.6 Million US$/year, Benefit-Cost ratio 72.05, debt service coverage 49.61, Energy production cost 1123.61 $/MWh and GHG reduction cost (2,626) $/t$CO_2$.

Business model	Business model:
	So as the project to be successful and offer a competitive advantage, the four main shareholders (1–4) have to be involved and function as one. -Payments shall be paid as follows:
	1. Government: Is to pay for the expansion of the infrastructure i.e.
	  1. Transmission lines from the land fill to the closest grid connection.
	  2. Construction of an all-weather road from the main road to the landfill site.
	  3. Any project initiation displacement and resettlement claims of local street families.
	2. Developer: Is to pay for the putting up of the:
	  1. Power generation plant and operational equipment e.g. bulldozers, tractors and wheel loaders.
	  2. Waste water treatment plant construction and necessary linings of the land fill.
	  3. Licenses and approvals.
	  4. Operation and maintenance costs of the landfill, electricity generation plant and waste water treatment plant.
	3. Utility company:
	  1. Should pay the feed in tariff as per the Power Purchase Agreement.
	  2. Carbon trading reclaiming agreements by the developer.
	4. Independent waste disposal companies:
	  1. They will pay an affordable low cost annual and monthly subscription fee. This will act as a revenue collection to service some of the annual and company rates. It will also give a sense of ownership to them too.

Project innovativeness	The project is innovative in that it will encompass a hybrid system of both recovered syngas from the landfill and an incineration plant. It will encompass energy efficiency both in generation using latest technology and in reduction of transmission losses to the grid system as well as provide empowerment to the street families by providing employment both directly and indirectly to them. It is expected the women youth will be the most beneficiaries since they will be used in manual sorting of the wastes therefore eventually raising their standards of living. The access to employment, environmental sustainability and generation of clean reliable sustainable and cost effective electricity will enable Kenya to attain its vision 2030 of becoming a middle-income economy. Business Innovativeness The project will source fuel from waste material meaning that the fuel will be at minimal cost mainly incurred from the running of the machinery and human labor for sorting. The targeted Power Purchase Price is 0.14 US$/KWh to the utility company i.e. Kenya Power making the project economically feasible to the investor as shown above in the financial records.
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Table A7
Investment plan for the project: "50 MW CPV technology for electricity generation in Kuraymat (Egypt)".

Items	Comments and justifications
Project synopsis	The proposed project is a 50 MW CPV power plant in Kuraymat area, Egypt (isolated grid) (20 years' lifetime). It uses the very high solar potential and the very suitable range of (Direct Normal Irradiance) (2000–3000 kWh/m^2/year) for that kind of technology. The technology of Concentrated Photovoltaic (CPV), in contrary to conventional Photovoltaic systems, uses curved mirrors and lenses to focus sunlight into small but highly efficient multi junction (MJ) solar cells and also more efficient with a lower LCOE than CSP technology that is applied in Kuraymat currently. The use CPV is proposed as a way of producing clean energy by utilizing that great available solar potential for the over energy consuming factories in the industrial zone in south Cairo. There has been a decision taken by the ministry of energy and electricity that the electricity over consuming factories have to buy part of their electricity from renewable energy suppliers (companies). The proposed technology is exceptional due to its suitability in application to regions that have a high annual direct normal irradiance of $\geq$2000 Kilowatt hour (kWh) per square meter or more and that makes it very suitable for Egypt and the whole north African region. Future of Energy Corporation as a very big renewable energy company in the Egyptian market will finance and operate the project. The capital cost needed is approximately 1.5$ for each Wp will be produced. The factories will use the energy generated by the project during day hours which represents more than 50% of their need and from the grid during night hours.
The sponsors	New and Renewable Energy Authority (NREA) as the representative of the Ministry of energy and electricity, is in charge of spreading renewables in Egypt and facilitate utilizing the available renewable energy resources. NREA is very important in encouraging investors to invest in renewable energy projects in Egypt, by setting rules that allow high consuming industries to be getting a certain amount of its electricity demand from the national grid and the rest should be bought from renewable energy providers. This initial capital from an investor or as a grant will help in selling the panels, the control systems and the land of the project whose price will be reduced by the government as an encouragement for investor in the field of green energy. Factories' owners are among the beneficiaries of the project due to being provided with energy that makes them satisfy their factories' energy demand and also not to be subjected to black-outs due to high energy consumption.
Market analysis and strategy	The project is satisfying the energy demand of those over consuming factories which are very important for the Egyptian economy. It is very important for private investors as the main beneficiaries who are investing their money in heavy industries in Egypt. The project is needed for releasing the burden from the national grid and encouraging generating green energy in the Egyptian market. CPV is not widely used in the Egyptian market and the project will be a gate for spreading that technology and utilizing the unique solar potential.
Project scope	The project will be implemented in Kuraymat area of approximately 1.5 km^2. The vendor of the product of the project will be a private company of an investor and it will be responsible for operations and maintenance with the assistance of Orascom (one of the biggest contracting companies in Egypt). The price at which the electricity products will be sold to the factories is 0.12$/kWh. The project will offer too many job opportunities for Egyptians. The skilled staff will be mainly from the owner company of the project.
Regulation and environmental information	Solar projects are known that they are zero emission projects, so that Kuraymat CPV plant will be approximately without environmental risks. The sustainability of the project comes from offering clean and better energy for the consumers and also basing on utilizing renewable potentials to decrease the depletion rate of conventional energies. NREA will promote the project and will permit and help the private investor in renewables to invest more in renewables and reaching 20% share of renewable in 2020 according to its energy policy.
Project costs	The capital cost is 75 million $ which will be covered by a company (private investors). CPV hardware (solar collector and tracker), power systems and Balance of system (BOS) are all included in the capital cost. The company might ask for soft loan from (JICA) Japanese International Co-operation agency because the project is matching with that seeks certified emission reduction of GHG.
Financial projections	The projects will produce approximately 90 million kWh/year that will give an approximate annual income of 10 million $ from selling the electricity product. The operating expenditures and the maintenance of the project represent 1% of the capital expenditure, and it is a very good advantage that the costs of operating and maintaining the project are low over the project's lifetime. The annual cash flow (income revenue) will be around 9.25 million $. The payback time will be 9.2 years.
Business model	It's a solar CPV system which is making an isolated grid for providing the over energy consuming factories with electricity. The model is intended to fill key electricity industrial gaps by providing clearer insights to regulators, utilities, developers and customers, about the system-level technical and economic effects of increasing solar CPV at the distribution level. Optimizing and capturing the value of solar CPV and the better alignment of the interests among key stakeholders is a very important part of the business model of this project. Finally, the most important part of the business model is organizing and facilitating with the help of NREA sending electricity to the factories through the isolated grid and starting making profits from selling the electricity product at 0.12 $/kWh to the factories. So long as the over energy consuming factories have to buy part of their electricity from renewable energy suppliers which might reach 50% of their electricity demand, the competitive advantage of the project is that the price of the electricity product from a renewable source is not high like many other renewables and will attract the factories' owners to complete satisfying their electricity needs from the project's production.
Project innovativeness	It will be a very unique project in Egypt and will open a gate for renewable energy projects in general, and in particular, CPV and CSP projects due to the suitable climate conditions in Egypt. The project's innovativeness comes from utilizing the unique potential of solar (DNI $\geq$ 2000 kWh/m^2/year) with an efficient way technically, environmentally and economically. Technically, by using this technology we will be able to maximize the energy output without many losses, more than CSP and conventional PV. Environmentally, clean energy will be produced with zero GHG emissions and that might attract funds from the international bodies which seek for clean energy usage. Economically, the project also has an economic objective, not only achieving the environmental objective of the project. Contrary somehow to CSP in Egypt, the economic feasibility of the project will come from the good LCOE (0.08$/kWh) and also the electricity selling price of 0.12$ at which the energy product of the project will be sold to the beneficiaries and will make them avoid outages that happen when the load is high. However, in general the costs of installing renewable energy technologies such as CSP, PV and CPV are decreasing, which will increase reliance on green energy technologies in energy supply.
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Table A8
Investment plan for the project: "Biodegradable household and human excreta wastes an alternative source of electricity and soil amendment in three schools (Southern province, Rwanda)".

Items	Comments and justifications
Project synopsis	The mixture of human excreta and household biodegradable waste will be used as Bio-gas production input to the system. The project is planned to be implemented in Rwanda, specifically in three schools in southern province. This place is exceptional because the resources needed in the project are in abundant there due to the big number of students and the fact that those schools are very near one to another. The project will provide enough energy to satisfy schools energy demands and increase in socio-economic gains of the population in area of schools. The partners are schools themselves, farmers, local government, Ministry of energy, ministry of agriculture, donors and research Institutes. The investment cost is USD 150000.
The sponsors	To implement this project, it needs the participation of different institutions which makes them to be part of stakeholders: Ministry of Energy: The project will produce energy through biogas plants; this will contribute to electricity provision (clean energy) which is part of the functions of this ministry. Ministry of Agriculture: The project will produce alternative fertilizers which will contribute to food security. This is in support of the ministry goals. Local government: due to the employment and infrastructure, those will contribute to the development and security of the area. Ministry of energy, agriculture and local government need to prove the project in different ways by certifying the product and provide some other funds to the project Three schools where the waste will be coming from. And it's for them where electricity will be sold firstly. Farmers: they will gain affordable and quality fertilizers. But they have to pay for it. Research institutes: this project will open avenues for more research and hence more jobs. Donors: the implementation of this project by use of clean energy that will be in support of environment sustainability. Also, the project will improve the standards of living which are among the targets of the donors. The financial fund of USD 100000 is expected to come from them where 50000 is considered as credit from bank and remaining ones is incentives.
Market analysis and strategy	Schools and farmers are most beneficiaries of the project, but also local people needs it because they will be employed and may benefit to that electricity too. major competitors are existing companies delivering the same product, it meets the current and future demands because it uses renewable resources friendly to environment.
Project scope	Project manager: Responsible for planning and executing a project. Project engineer: Head of the technical department in charge of design, construction, commissioning and day to day maintenance of the system. Accountant: the person will be in charge of preparing accounts, tax returns, administering payrolls in consultation with project engineer, compiling reports and auditing project finances. Supervisor: supervise day to day activities of fertilizer production, quality control of fertilizer, assign work to the skilled labor and ensure tasks are completed as per the project engineer's specifications. Skilled labor: locals trained as welders, masons, fitters, carpenters and plumbers by the project management.
Regulation and environmental information	The project is sustainable due to the use of renewable resources: human waste and biodegradable household so no emission that can harm the atmosphere. Employing local people, time management, Creativity, innovation and team work will be key regulations of the project. Permissions required are from ministry of energy, agriculture to prove our fertilizer, local government to allow the project to in the land, the schools where the project will be implemented.
Project costs	The estimated cost of implementation is USD 150000
Financial projections	The key points from income statement is based on electricity and fertilizer that will be sold, from cash flow will deal with everything regarding to money in or out while the project will be running while from balance sheet summarizes a project's assets, liabilities and shareholders' equity each year will be summarized.
Business model	The farmers are to pay for fertilizer, the schools and local people are to pay for electricity. The business model is to be successful because it will satisfy the needs of the community and due to low price on electricity and good quality of fertilizer those offer competition advantage to the business.
Project innovativeness	The project is innovative because it targets to turn any kind of waste into useful good quality of products. It will contribute less to the environment pollution and it targets increasing population's living standard.in addition to that It matches with today's need of society and mission of different government and donors.
Project title	300m^{3}Bio-gas production using household and human wastes mixture
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Table A9
Investment plan for the project: "1 MW PV plant for Ainamoi area, Kerio Valley Kenya".

Items	Comments and justifications
Project synopsis	The project is a 1 MW PV plant for Ainamoi area, Kerio Valley Kenya Ainamoi is an area in Kerio Valley, Keiyo District Kenya at the floor of the Rift Valley having considerably huge solar potential and among the areas with largest portion of the year having clear skies. The main income generating activity in the area is grain, horticulture and livestock farming [38]. However, the community sells the produce as it is without further valorization. Kenya's electricity access to electricity is at 23% with percentages being higher (50%) in Urban areas and lower (5%) in Rural areas [39]. Ainamoi doesn't have access to electricity or clean drinking water, although the Kerio River flows near the area. The 1 MW PV plant is meant to increase the electricity access to the areas while ensuring the area has supply to clean drinking water. With the energy and water available it will be possible to increase the standard of living of the area while spurring economic growth. The PV plant will provide energy to the area for lighting and also for a processing plant for their horticultural products e.g. powering cold room for the community. The plant will depend on funding from the SOS international and well-wishers and therefore maximize on the finances
The sponsors	The project helps to increase electricity access in the rural areas but also comes to provide access to clean water and spur economic development. As such the following sponsors will be sought to materialize the project; 1. Kerio Valley Development Authority-mandated to spur economic development in the Kerio Valley and maintain liaison between it, Govt., Private sector and other agencies (KVDA 2015), they will be able to coordinate its implementation 2. Solar Africa- they will be able to provide the technical know-how in the management of the project to make it profitable and viable. It will also be responsible for 30% of the funding of the project

(*continued on next page*)

Table A9 (*continued*)

Items	Comments and justifications
	3. Siemens and Safaricom will supply the prepaid meters 4. Solar Century-They will provide the technical knowhow in collaboration with Solar Africa and will be the doing the installation as well a maintenance and repair 5. African Development Bank- They will be responsible for financing 40% of the project
Market analysis and strategy	The area has low penetration of electricity as is characteristic of Kenyan rural areas, below 5%. Most of the homes and commercial enterprises in the area use kerosene for lighting and some resort to using generators. As such, shops close early. Provision of electricity to the area will not only light homes, but increase the business activity in the area. The area being a hub for horticultural production, grain and livestock farming, small plants have been set up in the area e.g. for mango processing. Some still use diesel generators which is exorbitant and polluting. The clean electricity will revolutionize the area and open up for future investment. The residents are able to pay as shown level of incomes and diversification in the area In the future, the electricity access through the grid system may be integrated with this solar plant under the net metering mechanism to boost reliability.
Project scope	The Solar modules are supplied by Centro Solar, the Asantys Systems together with the local partner African Solar Designs are involved in the planning and designs while SMA Solar Technology provides the inverters. The batteries for storage are supplied by ABB. The system once installed will be managed by Solar Africa. The system designed has low maintenance costs although the Technicians are not locally available in the area and have to be sourced from the neighboring town of Eldoret. This is because there are still few trained solar technicians in the country There will be fitted prepaid meters supplied by Siemens in collaboration with Safaricom (Telecommunication company)
Regulation and environmental information	There are various regulations that should be adhered to before, during and after a project in Kenya. 1. Feasibility Study Report-this is a requirement to ascertain the feasibility of the project and is also a necessity in applying for the power generation permit from Energy Regulatory Commission (ERC) 2. Environmental Impact Assessment-EIA is a statutory requirement to be able to understand the effect of the project on environment, society and economy of the community. This will be carried out by NEMA (National Environment Management Authority) 3. Generation Permit- A project of power generation capacity 1 MW and below requires a permit from ERC for it to commence operation. A project of capacity higher than 3 MW requires a license. 4. PPA-The power purchase agreement will have to be signed with KenGen. This will ensure that when it is supplied to the residents, since it is off-grid, the agreement has been signed.
Project costs	The total cost of the project is estimated to cost USD 1.2 M with the cost of the PV modules and batteries costing 60% of the total price.
Financial projections	Considering a discounting rate of 10%, the project is projected to have a debt ratio of 82% with the loan being paid off by the 7th year. The internal rate of return on equity is 20.7% and about 8% on assets. This translates to an overall levelized cost of electricity (LCOE) of USD 90/Mwh. The project is therefore deemed financially viable based.
Business model	The electricity supplied will be in an off-grid system. The power will therefore be distributed to the clients directly via a central distribution system. Some clients have been noted to have solar systems but with ineffective storage capacities. As such they will be encouraged to install the net metering systems and connect to the mini-grid so as to utilize the central storage system installed. Future additions by households would employ the same formats. The meters that will be installed are prepaid meters in collaboration with the very mature mobile transfer network MPESA. In this regard the clients will be able to load their electricity units as and when they require. It helps to make them aware of efficiency as well as avoid huge bills being accrued. KenGen will get their share from revenue collected which has audit traceability
Project innovativeness	The project is set up to provide utilities in the area which is devoid of clean reliable energy access as well as clean water for drinking as well as for irrigation. The project comes to offer three solutions. 1. The area has a high production capacity for potatoes. However, the farmers in the area sell the potatoes as they are therefore fetching low market prices. The area being warm also makes them not store the produce for long before they get spoilt. The plant will provide energy to the potato chip processing industry that will add value to the crop [38]. The excess power during the day will be used to pump water to the community and remaining power stored 2. The area will be able to have access to clean and reliable source of power in their households The project is therefore expected to improve the livelihood of the area while opening up the area for investment and growth.
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Table A10
Investment plan for the project: “Sustainable electricity generation (33 KWp, 70 kVA) for rural and suburban populations in Africa by developing the Glob - energy concept in Ivory Coast”.

Items	Comments and justifications
Project synopsis	Glob-energy concept is a hybrid system comprised of Solar photovoltaic plant combined with generator group. The particularity of this concept is the generator group function with biofuel provides by the seeds of oil palm. This project will be implemented in TIAGBA village in Ivory Coast (west Africa). The capacity of solar plant is 33 KWp and for the generator group is 70 kVA. The main partners on this project will be African Development Bank (AfDB), Pan African University's students, CIE (Ivorian Company of Electricity), which will be the recipient of the plant and will be responsible for its operations and its management. Besides the AfDB, the other project partners are: Ivory Coast ENERGY and ANARE (The National Authority of Regulatory of Electricity sector in Ivory Coast). This project is a good partnership example between private sector and public sector. Sponsors of this project are AfDB and Ministry of energy sector of Ivory Coast. It financed at 60% by AfDB and 40% By Ivorian government through the mix of energy development program in Ivory Coast and renewable energy. Total cost is 4 million EUR apportioned as following: 2.4 million EUR financed by African Development Bank 1.6 million financed by Ivorian government.
The sponsors	Major stakeholders in financial success are: 2.4 million EUR financed by African Development Bank. This is part of the response to the recommendations of the Millennium Development Goals (MDGs) and the World Summit on Sustainable Development (WSSD), which recommended the expansion of energy to cover all rural and suburban populations ACP (Africa Caribbean pacific), most often affected by lack of access to electricity with the result, a weak development.1.6 million financed by government of Ivory Coast. It is in the rural electrification program and increasing the rate of access to clean energy. Also, the promotion of renewable energy and energy efficiency are, according to the Ivorian ministry of Energy, a major challenge of the Ivory Coast Government policy.

Table A10 (*continued*)

Items	Comments and justifications
Market analysis and strategy	This project will benefit TIAGBA populations because the project would give electricity access to populations in this village. There are not competitors because this project is a partnership between private sector and public sector. It meets current and future demands in the struggle against poverty in TIAGBA village.
Project scope	This is CIE (Ivorian Company of Electricity), which will be the recipient of the plant and will be responsible for its operations and management. Maintenance and management system of this plant will be coordinated by CIE. This national company has highly qualified personnel to support, ensuring the proper functioning and sound management of the plant. Connecting to networks and demand demarcation will be made at CIE. Annual revenue updated after the costs of maintenance and operating will be used for the education of young students from the village of TIAGBA.
Regulation and environmental information	The energy produced by this plant is clean energy because the effects of pollution on the environment or the atmosphere are minimized. Our generator works with Biofuel so we by production of greenhouse gases. This project will be supported as part of the spread of the energy mix. This project is sustainable because it highlights TIAGBA village of darkness and develops the economic activities of the TIAGBA village. The population will enjoy better care of health by the electrification of infirmaries and maternities. And also, electrification will put an end to unemployment, from the young to the gold sites and the rural exodus to the capital Abidjan.
Project costs	Total cost of project is 4 million EUR
Financial projections	For cash flow, according to the Article 1 the ministerial decree No. 017 EPROM/MEF of 4 April 2012 amending prices of electricity: The wholesale price of electric energy produced, imported, transported and distributed by the Ivorian Company of Electricity (CIE). This ministerial decree is attached to a single price of € 0.05/KWh for the customers of least of 80 KWh per two months. So, depending on consumption, each customer will receive an invoice with the maximum consumption in kWh, the amount paid and the payments delay this bill. After this deadline, a penalty of 10% will be allocated. The period of each invoice will be 2 months is to say, all subscribers receive their consumption bill all every two months. A general assessment of the company will be made in December of each year. The balance sheet will be increased generally on the sale, management, managerial system, expenses etc. After this assessment, the business income will be determined.
Business model	First business model is defined as the systemic and synthetic representation of the origin of the added value of a company and it's sharing among different stakeholders over a period and for a range of clearly identified activity. This is also the strategy implemented by a company to make money. This is a necessary step in creating the company. For our project is solid, the economic model will be created consistently on the basis of the existing business model. There will be a mixture of two models. The first is the subscription model of simply sell electricity against a determined subscription period that is to say, the customer can cancel his subscription. For example, if you move, the customer will be obliged to make the cancellation of his subscription. The second is that adaptation is based on the price changes depending on the power required by the customer and the customer's consumption habits. That is to say, large consumers of electrics will have a price of KWh higher compared to small consumers. In this model, the consumer will pay its consumption after consume. Every two months of consumption, an invoice will be sent to him. This business model is successful because consumer consumption is taken into account; the time interval between two bills is 2 months to allow consumers to have the financial resources for the payment of their bills. This business model provides a competitive advantage because the company does not have the monopoly of the market and the customer is free to make his subscription or not and also free to terminate service.
Project innovativeness	This project is innovative because it's a concept names “Glob energy” which provides a clean energy without environment and atmosphere pollution with combination of generator group function with biofuel provides by the seeds of oil palm and solar photovoltaic plant. Also, it's a system decentralized production of electricity. This project should be financed because with electricity of TIAGBA, the dream of the people has become a reality, and with electricity, the informal sector largely opened, with electricity yet, this is the end unemployment in TIAGBA and development of economic activities in the region.
Student	Gnamien C. Kouakou, email: kouakou.gnamien@yahoo.fr

Table A11
Investment plan for the project: “Bioenergy centers for bioenergy production in rural communities”.

Items	Comments and justifications
Project synopsis	Many of the countries in Africa are considered lowest per capita energy consumers in the world. In all sectors, such as in industry, transport, agriculture, commercial and household, there is a lack of minimum energy inputs that leads to continued low productivity and an impaired economic growth. This has trapped millions of African people into abject poverty. Majority of people in various rural Africa still depend solely on wood and other biomass fuels to meet most of their energy needs at both household level, and income generating activities. Therefore, introduction of new options for energy access and sustainable livelihoods such as small scale bioenergy production can have great positive benefits to rural communities especially for rural women and girl children. This can be achieved with a holistic appropriate approach, one that integrates small scale agriculture is considered. In addition, conversion of agricultural waste into bio energy is a potential source of profit. Many developing countries have ample agricultural wastes and residues such as coffee or rice husks, nut shells, fruit shells, fruit seeds, straws, plant stalks and stovers, banana peels, green leaves, molasses. Poor disposal of these leads to undesirable effects such as waste accumulation, poor hygiene and greenhouse gases that contribute to global warming and subsequently, climate change. It is therefore desirable that rural communities effectively harness agricultural residues and other waste bio-materials for bio-energy production.
The sponsors	The main sponsors are; the local farmers through the village cooperatives, donors and the government. Other potential funders may include for example the Swedish International Development Cooperation Agency (Sida). There exists the Bio-resources Innovations Network for Eastern Africa (Bio-Innovate) aimed at providing training and technology to agricultural factories to help them generate their own power in a bid to save on electricity and cut down on emissions/climate change.
Market analysis and strategy	The major competitors are other fuel sources mainly fossils. Farmers need a reliable cheap clean power source for efficient processing of their products preservation through powering post-harvest technologies. This project guarantees more job opportunities and a self-sustainable green community as well as environment.
Project scope	To turn the underutilized agricultural waste into biofuels, farmers will stop depending on fossil fuels and this help utilize waste as well ensuring less emissions to the environment. The project aims at setting up bioenergy centers at the different agricultural products processing points. The biofuels produced from the bioenergy centers will be used to power the processing technologies. The project management will take the initiative to train and sensitize farmers on how to use the waste to produce biofuels.

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Table A11 (*continued*)

Items	Comments and justifications
Regulation and environmental information	To add to the project's green credentials, the project will incorporate solar panels in the system to ensure a constant availability of energy. The project produces clean energy with relatively low emissions from the biofuels compared to the diesel from fossils. Also, the project takes part in waste treatment and utilization hence reducing green gas emissions. The project is sustainable because it uses agricultural bio waste as the main energy source.
Project costs	The project costs include setting up pyrolysis bio reactors and portable refineries for purification of the biofuels. Also, operating costs and transportation costs of agricultural waste from farmers' gardens/farmland are part of the costs. Project assets include property plants, solar modules and other equipment totaling to about 100,000 $.
Financial projections	An income of close to 35,000 $ is estimated to be earned per year under the business as usual scenario. 9000 $ is estimated to be spent on operation and maintenance costs every year.
Business model	Communities of Farmers will carry their produce to the bioenergy centers (where processing equipment are located) for processing and value addition. In this way, they will be paying a subsidized fee per kilogram of process. Also among other funding sources are the donors and the government through its initiative of empowering rural communities to earn from agriculture.
Project innovativeness	The growing energy demand in rural Africa is expected to have an effect on the nutrition and food security in different ways. The environmental degradation due to cutting of trees for firewood has a negative impact on climate, availability of food for human consumption and for use as animal feeds. As such incorporating bio-energy production on farm scale presents an opportunity to reduce the reliance of agricultural sector on fossil fuels while boosting the energy security in rural areas, generating job opportunities as well as ensuring environmental sustainability.
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Table A12
Investment plan for the project: “Bioenergy from feedstock of sawmills for public institutions in Zambia”.

Items	Comments and justifications
Project synopsis	Biogas for public institutions: Public institutions such as prisons, boarding schools and colleges depend on wood fuel for heating estimated at 19.4 million m^3 wood fuel consumed in 1996 [40]. Therefore, considering the amount of waste generated in these public institutions and the amount of firewood, it is feasible for a biogas project to supply biogas for cooking and to reduce on over dependence on forest resources. This project will supply biogas to the public institutions and also run generators for supply of electricity. The major sponsors in the project and investors will be foreign companies such as SNV and Hivos, as well the ministry of energy and Zambia Electricity Supply Company can invest approximately $16 million to develop these projects in at least five provinces of the country. Zambia currently has a stable political environment that favors an energy policy which promotes renewable energy development and especially bioenergy and biomass-based electricity generation. This project seeks opportunity utilizing of feedstock from sawmills on the Copperbelt province.
The sponsors	Potential sponsors for this are the non-governmental organizations, research institutions, academic institutions, Zambia Electricity Supply Cooperation, Government ministries, local communities. The government will provide a loan of 60% of the funds to facilitate the development of these projects and encourage a platform for investors to partners up with the government.
Market analysis and strategy	The project is a milestone to the public institutions which use a lot of traditional biomass for cooking and also electricity supply for waste water treatment in the city. Therefore, the project will supply clean energy to the current generation and future generation. The major competitors are the suppliers of traditional biomass to these institutions. Further the project will bring about advancement in research and development especially in designing the prototype steam turbine using saw dust.
Project scope	The project utilizes the local skills, through capacity building and skill training. The local people will be trained in biogas constructions and thus provide them with employment in constructing the digesters in these public institutions. Go Green society Zambia will take charge in vending these products. The trained artisans from these public institutions will be in charge of maintenance and operation of these technologies. The research and academic institutions will be incorporated in designing a biomass electricity generation plant using saw dust. A prototype design will be designed by a group of engineering students in a joint project. This will create opportunities for the students after graduation to manage these projects and continue with the research and development.
Regulation and environmental information	The project will comply with the environmental regulations of the country. This project will recycle waste from the public institutions and feed in the biogas digester to produce biogas for heating. The project takes into consideration both social, economic and environmental aspects. The social aspects are that it provides employment and clean energy to the institutions. The economic side is that the project will reduce on the cost of fuel for the institution by only limiting to in-situ usage. Further the environmental aspects such as pollution will be reduced through recycling of wastes from the public institution and using them for their digester. Another aspect is that the prototype design for the steam turbine will use the saw dust which have become an environmental concern in Zambia.
Project costs	The project capital cost of $16 million for the five provinces and 10 public institutions. The cost for the digester of 180m^3 is at $2000/m3. For five digesters of 180m3 the total cost will be $9million. The $7million will be allocated for designing the prototype for the steam turbine using saw dust as fuel.
Financial projections	The project has an estimated capital cost of $16million for the entire five provinces in 10 public institutions. That's $360 000 for 180m3 digester. The operation and maintenance costs are estimated at $2000/year. The gas prepaid meter will be fixed at gas will be charge $1.50/m3 and an estimated usage of 270m3 per day. Therefore, the estimated income from these digesters per year is around $100 000.
Business model	The business model for this project is debt finance which is 60% and 40% is a grant of $6.4million from donors like Swedish embassy, GIZ and USAID. The government loan at 15% with a payback period of 15years will be sourced to finance the project by paying for the project cost such as construction and maintenance. The major challenge is the cost of electricity for a costumer is 3–4 US cents/kWh (low). The project has a competitive advantage over wood biomass which requires transportation and storage thus a lot costs and also smoke free is another advantage of biogas project.
Project innovativeness	The project is a unique idea for providing clean energy to public institutions using waste to produce biogas. The biogas will be used for providing to the institution energy for heating and cooking and thus reduce on usage of wood fuel. This project is a milestone to climate change mitigation as it does not emit CO_2 and also preserves the carbon sink which is the forest by reducing on wood harvesting for heating.
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Table A13
Investment plan for the project: "6.5 MW Biogas and syngas power plant project in Cameroon'.

Items	Comments and justifications
Project synopsis	Project location: The water, energy and food nexus project is planned to be implemented in the department Ngaoundere III, more precisely Bini along national road n° 3 of Cameroon. This area hosts the university of Ngaoundere around which more than 60 000 people live. The project will be implanted on a plot of 3 Ha with an existing access road leading to the site of the project central. This area is always exposed to long period shortage leading to limited access to services like photocopiers, printers, non-availability of safe drinking water, and food insecurity despite huge quantity of sweet potatoes produced. Moreover, there are poor management of waste although Cameroon's hygiene and healthiness ("Hygiene et salubrite du Cameroun") company is working. Technology: A dual technology based on methanization of organic waste liquids and solid waste gasification is to be implemented Purposes: - Energy production in the form of biogas and syngas. The biogas will be sold for domestic purposes (cooking) and the syngas for the production of electricity and industrial heat. We plan a system delivering 6.5 MW and 5.5 MW of power available. Counting 1 MW for the internal needs of the Central, we plan a system delivering 7.5 MW and 6.5 MW of power available. - Drinking water production by four drillings, treatment of dirty water from households and universities residences and recycling for household purposes. - Use of part of 1 MW for sweet potatoes and yam flour production. This entails sweet potatoes drying process and transformation into flour. - Enhancement of local bakery industry from sweet potatoes and yam flour using 1 MW (dedicated to internal needs of the Central) for sweet potatoes flour manufacturing. It includes sweet potatoes and yam drying process (with electricity produced by the Central) and transformation into flour. Sweet potatoes and yam will be bought from farmers who have difficulties to sell their products. The flour production will alleviate traditional bakeries burdens. Project cost: The total project cost net of taxes and custom duties, is estimated at 40 million dollars. Donors: The potential donors are the African Development Bank (AFDB), Central African States 'Bank BDEAC
The sponsors	The potential donors are the African Development Bank (AFDB), Central African States 'Bank BDEAC
Market analysis and strategy	Beneficiaries: They entail the local population and communities, farmers and businesses (restaurants, photocopiers and printers' owners, bakeries owners). The public, the private health and the educational institutions in Bini will also benefit Strategy: Organic waste will be collected from universities residences and households (40%). Students will work as temporary staff for waste collection during their spare time. The other 60% of organic and solid waste will be collected from the hygiene and healthiness company of that locality.
Project scope	The expertise of TRANSA Company based in France experimented in similar projects will be required especially for methanization and gasification technologies. TANTY company's expertise based in Cameroon, will bring his expertise in sweet potatoes and yam flour. Generators from PERKINS ENGINES will be used.
Regulation and environmental information	Regulation information: The law governing power in Cameroon of November 2011 authorizes and establishes the procedures for private power generation Project sustainability: ➢ Environmental impact - Methane emission reduction (solid and liquid waste treatment for biogas and syngas production to transform them into energy). - Possibility to prevent gas leaks with a poultry farm. - preventing pollution of the water rejected by the treatment plant by implementing a wild-game farm of goliath frogs. This will also help to preserve this protected species. - using the Goliath frogs as bio-indicator of water quality will allow at the same time to sustainably manage this protected species whose flesh is highly prized. - Four drilling supplying the OLEMBE city, recycled treated water will be used to manage groundwater in good father family. - The gas supplied to households is an alternative energy to firewood. Thereby preserving the surrounding forest. ➢ Social and development impact - Hygiene and cleanliness - Job creation: Direct jobs (engineers, technicians, managers, maneuvers…) Indirect jobs (creation of poultry farm and pigsty) - Implementation of a wild-game farm of goliath frogs - People's access to domestic energy at lower cost - Acquisition of innovative eco-technologies by people. - Free access to recycled water for household use and fire (public fountains and hydrants) - Acquisition of environmentally inert building materials at lower cost (flag). - Improve food security (availability of sweet potatoes and yam flour which mixture has a high nutrient value especially for kids)
Project costs	It is estimated to be US$ 40 million.
Financial projections	In consideration of tariffs applicable in Cameroon and full operation of the station: - Electricity: 57 GWh/year × 151 815 USD = 8,653,465 USD - Gas: 110 GWh-th/year × 32 000 USD = 3,250,000 USD - Inorganic residues: 4320 tons/year × 80 USD = 345 600 USD - sweet potatoes and yam flour: 4000 tons/year × 80 = 320 000 USD Gradual production in 3 years: First year 50% of the production gives 6,419,530 USD Second year 75% of the production gives 9,629,300 USD Third year 100% of the production gives 12,839,065 USD For a total of 28,887,895 USD the first three years.
Business model	The IRR is 17.8% and the NPV, 0.41 million assuming the −6.5 MW power generated by the central, and the average economic life of the project is 50 years after construction. As the project deal with gas, syngas generation, water drilling, the outputs which are: electricity, waste from methanization, inorganic products from gasification and water will generate our incomes. Electricity produced from syngas will be sold to ENEO, the national electricity utility. Water will be stored and sold in the locality. Waste from methanization process will be sold as fertilizers to farmers in the locality. Furthermore, it is possible to obtain and sell gasification products which are gasoline, Diesel, Plastics and Polymer, Wax, Oil and lubricant as well as residues (slag) sold as raw materials for construction of buildings
Project innovativeness	This project is innovative in the fact that simultaneously, it: - Makes the city clean; - Enhances energy access to people and economic development of that locality; - Boosts local sweet potatoes industry through its transformation into flour for bakery and socio-economic development.
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Table A14
Investment plan for the project: "A 458KWel Biogas Combined Heat and Power plant (CHP) from Municipal Solid Waste (MSW) treatment plant".

Items	Comments and justifications
Project synopsis	The proposed project is a A 458KW_{el} Biogas Combined Heat and Power plant (CHP) from Municipal Solid Waste (MSW) treatment plant. The selected case study is Arua Municipality in Uganda. Currently in Arua municipality, waste is collected under the local municipal authority, sorted and composted with different landfill cells without electricity generation. The whole process costs a lot to the authority in charge amounting to Ugandan Shillings 100 million (USD $30120) per year [41]. My proposed project is meant to generate electricity to be fed into the existing grid under Renewable Energy Feed-in Tariff (REFIT) and Gobal Energy Transfer Feed-in Tariff (GETFiT) programs in Uganda. In addition, thermal heat and digestate as manure will be produced and can be used in profitable agricultural activities liking food drying and fertilizer application. The technology considered is Anaerobic Digestion Combined Heat and Power (AD-CHP) due to its maturity and economic viability for biogas production [14]. In Arua Municipality 50tons of solid waste is generated per day; hence 18250tons per year, and 70% of the waste is organic matter [41] which is suitable for the proposed technology of AD-CHP. The probable major partners for this project could include the private power producer, the local municipal authority, government environment ministry, the ministry of energy, and the regional and international bodies like African Development Bank (AfDB) and World Bank. Given the waste potential for this case study considered, and the electrical and thermal efficiency of AD-CHP technology; the investment cost is estimated to be about £0.837 M for an estimated capacity of 11MWh_{el} (458KW_{el}) and 12.6MWh_{th} in a day.
The sponsors	The major prospective stakeholders include the private power producer company, Uganda government, the African development bank, and the World Bank. The private power producer can provide 30% of the cost as equity and source out 50% as loan from the regional development bank (AfDB) and the probably get grant to cover the remaining 20% of the cost from the government through international donor agencies.
Market analysis and strategy	This project is beneficial to the community, the government and the whole world as it does not only help to protect the environment and climate but also helps to improve the socio-economic level of the community. This is because the project will provide job opportunity, and electricity for the community, manure and thermal heat for drying of agricultural products of the farmers. The government of Uganda has a program of REFIT. And electricity from Biomass (MSW) is among the technologies considered with a REFIT of US $0.103/KWh [42] paid for a period of 20 years. In addition, Uganda in 2013 introduced GETFiT program to top up the REFIT by giving a front loaded premium payment. Front loaded payment results from discounting the GETFiT premium for the whole project period of 20 years and disbursing that amount in the first five years of operation. GETFiT pays its 50% discounted premium on commercial operation date and the remaining 50% completed over the first five years of operation. GETFiT for Biomass is US $0.01/KWh [43]. This provides a good and stable market for the electricity generated from the biogas plant. Another very viable market opportunity lies in the sale of dried foods and fruits using thermal heat from the plant. The main market competition comes from power production from other technologies like solar and hydro energy.
Project scope	The project team can mainly come from the private power producer with excellent qualification and high level of experience in waste to energy technologies. The project is implemented and managed in partnership with the local authority. As already in the status quo, the local authority can be involved in the collection of the waste from different collection points within and outside the municipality, weighing and sorting. The private power producer then manages the biogas plant including the thermal heat use.
Regulation and environmental information	The project will be implemented within the environmental laws and policies of the Uganda. The supervision can be done by the government ministry of energy. The environmental impact as well can be assessed by the National Environmental Authority of Uganda (NEMA). This project is sustainable because it ensures clean and productive management of municipal solid waste, reduction of GHG emissions, generation of electricity, thermal heat use and job opportunity for both women and men.
Project costs	The Estimated cost of the project in terms of CAPEX and OPEX are £0.837 M and £54270 (annually) respectively. OPEX is mainly due the waste collection, vehicle maintenance and labor. While the CAPEX is from the cost of the biogas storage digester, CHP unit, biogas cleaning, installations, getting permissions, transport and other contingencies.
Financial projections	The cash flows will be recorded on daily bases taking into account the incomes and expenditures. The major income is from the sale of electricity to the grid, under REFIT of US $0.103/KWh for biomass (MSW) and GETFiT of US $0.01/KWh. While the expenditures will be due to salary of the workers, vehicle maintenance and other equipment breakdowns. Considering only revenue from the REFIT, the proposed project could break even in the fifth year, with a discounted net present value of £0.786 and internal rate of return of 36.4% at discount rate of 18% by the end of 20year project period. With inclusion of GETFiT, the project is even more viable to undertake. The balance sheet will be balanced at the end of every year showing clearly the assets, liabilities and the equity. The annual loan repayment will also be clearly indicated in the books of accounts.
Business model	The business model of the project lies mainly on the sale of electricity to the grid and then to a lesser extent on the sale of dried agricultural products from use of thermal heat for food and fruit drying purposes. The project expects to get income from the power purchasers in accordance to the feed in tariff (REFIT) and the GETFiT programs which are so stable over the project life span. More revenue is expected from sale of packaged and branded dried food products to supermarkets, shops and open markets. Due to the sale of more than one product from the proposed project, it earns much more revenue compared to the current system of only composting hence its competitive advantage. This project can also be scaled up or upgraded by use of mixture of substrate (feedstock) that may include use of agricultural waste and municipal solid waste.
Project innovativeness	In Uganda, there is only one biomass based electricity generation plant, the plant uses bagasse burnt in a boiler to form steam that runs a steam turbine. Within the programs of REFIT and GETFiT, no biomass project based on MSW has been registered [43], one would wonder why it's so. With implementation of such a viable project as a pilot many more biomass MSW based projects would be registered in Uganda. In the case study of Arua Municipality considered here, waste management involves collection, sorting and compost in a landfill resulting into manure to be sold to farmers, without utilizing the energy potential in the municipal solid waste. Hence the proposed project innovativeness is situated in the generation of electricity from the waste as well the use of the thermal heat produced. The electricity that will be generated may be sold to the grid and the thermal heat used for drying of agricultural products for better storage and value addition. This projects also creates more job opportunities beside tackling environmental and climate change concerns. Hence this project ensures more self-sustainability of MSW treatment plant which makes it worth funding.
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Table A15
Investment plan for the project: "Reduction of roughly 30 tonnes of food wastage per year and agricultural value addition through post-harvest drying using solar dryers in Uganda". For this we cannot calculate average price in dollars per KW.

Items	Comments and justifications
Project synopsis	Africa, Uganda in particular largely depends on agriculture as her economic activity. However, during the peak season of most of the agricultural products, farmers face a problem of low prices. Post-harvest handling is thus more important as this can reduce wastage and as well help farmers sell off their products during periods of scarcity. Top amongst the priorities of helping farmers in their post-harvest handling is preservation and storage techniques. The best preservation techniques of agricultural produce are through drying and conditioned storage. Utilization of solar dryers and cold rooms are perfect matches and can be saviors for all the above. Unfortunately, these technologies have not yet been adopted in Uganda due to lack of knowledge about them. This project seeks to introduce the solar dyer technology to the farmers. The government of Uganda is committed to improving agriculture. To achieve that, it needs to partners with people with different ideas in line with its mission in order to make agriculture a successful story in the country. Against the above, the project developers will seek support (grant) from ministry of Agriculture. Also intended is to seek support from international bodies or any willing investor/business partner in this project. Successful implementation of this project in one region will motivate us expand it to other areas/regions of the country. Investment into this project is presumed 150,000 USD for the start. This will see the project owners set everything in place in addition to manufacturing roughly 137 units for the start and selling them to farmers at a reduced profit. Each solar dryer unit is estimated to cost 140 USD for construction.
The sponsors	As the project owners' options are that we can get a commercial loan of 150000 USD to help us in the preliminary studies of the right locations for our project within the target districts of Uganda. Obtaining permit/license for our project. In addition, we need to do farmers' sensitization and training about the units since they are our target customers. This initial capital will again help us purchase land and as well setup a workplace workshop. Lastly construction of the a few units to start with will be inclusive on this money A grant or money from a business partner/investor will be added advantage to help in further construction of the solar dryers and expansion of the business to other areas
Market analysis and strategy	The local farmers need this project more. Those producing fruits and vegetables like mangos, tomatoes need the project to reduce their wastage and as well add value to their produce. Those producing cash crops like coffee need the project for quality production which will increase their returns. With this project, farmers will be able to preserve and store their products for future sale or when there is scarcity. The project will allow farmers to order for the size of a unit they can afford or the one that corresponds to their production capacity. To attract more customers, MB intends to invest a lot in sensitization programs for the farmers in order to sell its idea and innovation to them helping farmers look for the market of their dried products will be a second initiative for MB. The project being Renewable utilizing sunlight, it has no harm to the environment and the life span of one unit is worthy the initial cost thus a higher expectation for the market penetration.
Project scope	MB investments will be manufacturing these solar dryers and selling them to farmers. Apart from cleaning the dyer, no major maintenance is required. MB investments with its expert team intends to train farmers on what should be done to maintain these dryers fully operational within their life spans.
Regulation and environmental information	There is no serious environmental issue associated with the project as such apart from setting up the workshop. The project is sustainable because sunlight will never get exhausted and in addition, the solar dryer can be constructed using local materials hence affordable. We shall only need to register the business with Uganda Investment Authority and as well obtain a working license from the local council where our business is established.
Project costs	150000 USD
Financial projections	Initial costs Land $30000 Permit $305 Preliminary Survey $500 Construction of the workshop $90000 Farmer sensitization $10000 Construction material/dryer $100 (137 units for the start) Labor costs/unit $40 Total initial costs $150,000 Debt payments/month (for 5 years) $3727.89 Income (cost/unit) $ 200 Note: 1. Target units to be sold per month are 100 units 2. Unit price changes with size ordered 3. Price per unit reliable to changes with changes in the real prices of the construction material or the dryers 4. The interest rate used here is the current commercial interest rate of Uganda (according to central bank) and it's 17%
Business model	MB Investment will be selling the manufactured solar dryers to the farmers at reduced prices (retail model) and installing them for free. Installing for free will be our customer care services. The business will be successful because our dryers will be so efficient. Our business success will solely depend on the sensitization done
Project innovativeness	It will be one of its kind in Uganda and it will help reduce wastage of agricultural produce and as well help farmers control their agricultural products' prices since they can preserve and store their commodities when the prices are not competitive. In addition, their products can never sell less since a value would have been added to them. The project on its own is applicable almost in the whole country since agriculture is currently the major source of income for many Ugandans.
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Table A16
Investment plan for the project: "Smart village mini hydro power with 200 KW capacity in Rwanda".

Items	Comments and justifications
Project synopsis	Rwanda is one of African countries located in east Africa below equator with a population around 12 million. Like many other African countries, Rwanda has a high population with no access to electricity, only 23% population has access with installation capacity of 160 MW [44]. Rwanda has potential resources such as hydro with 313 MW and more than 75% of this potential still unexploited [45]. The Smart Village mini hydro project of 200 KW will be developed to contribute on existing capacity, the purpose of project will be to provide energy which is affordable, accessible and sustainable to the rural area. The project is meant to extend electricity access to the rural population households and bring cost savings of up to $81 per year by spending less on lighting and phone charging. This project is also expected to bring significant benefits to the economy, health, education and social services.
The sponsors	Smart village mini hydro will involve different partners whom will help in successful implementation of project. The governments will be involved in providing advice and support such as subsidies of 14% per KWh, the community will be our focal point who will buy our product, Rwanda Development Board (RDB) will help the project for field analysis and in registration of our company, Rwanda Environment Management (REM) will help in advice about environment impact and the way of minimizing negative environmental impact and GIZ as major sponsor of the project who will give 60% of investment after plant installation, the bank will give us the loan for 70% of initial cost and 30% will be equity.
Market analysis and strategy	As mentioned above the community need accessible, affordable, reliable and sustainable electricity to fulfil their daily needs. The project will provide 200Kw which will meet the demand of project location and project will intend to increase the supply according to the community growth and needs. The project will also help the government to meet the Economic Development and Poverty Reduction Strategy (EDPRSII) goal and achieve vision 2020.
Project scope	The company itself will produce and sell electricity to the people in the community. The operation and maintenance will be controlled by skilled labors hired by the company and any assistance will be provided by any time to attract our customers. The project will provide the training to them and improve more research for the purpose of innovative. The motivation fees and salary will be provided on time and cooperation will be our priority in proving good service to our customers and partners. Monthly report will be provided to our sponsors showing the use of budget and money collection from selling electricity.
Regulation and environmental information	According to the national energy policy which aims to ensure better use of energy resources with promotion of socio-economic development and environmental protection. We shall make sure that from exploitation, generation, transmission and distribution environmental assessment impact will be conducted and provide mitigation to negative environmental impact. Working closely with both RDB&REMA by ensuring that environmental will be protected. This project is aimed at replacement of kerosene lamps with modern sources of energy offering valuable savings to poor households, provision of brighter light for various sorts of tasks and reduction of harmful indoor air pollution that could risk causing respiratory and eye problems to the population. There is also control of greenhouse gas emissions.
Project costs	The project will require USD 686,750 for starting operation. This budget includes: electromechanical system (turbine, generator, cables) USD 103,527, civil works USD 394,429, distribution system USD109,638, office equipment USD 3,413, starting and other project costs USD75,743.
Financial projections	(i) The project will spend every year the amount of USD 30932 for operation and will have annually income of USD 31000 from selling electricity. The project will get grant from GIZ 60% of the investment cost which is USD 412050 after completion of plant. There will be annually loan repayment of USD111809. The annually cash flow will be $(30932 + 111809) - (412050 + 31000) = \text{USD}300309$. (ii) The balance sheet of this project at the end of the first year of operation. Firstly, this will include the assets costs such as the value of the whole plant with depreciation of 2%, income from selling electricity and the grant from GIZ of 60% of total investment. Secondly, it will include liabilities costs such O&M, personnel, insurance, electricity and water bill, consumables, transport, local tax and environmental management. The difference between assets costs and liabilities costs is the net tangible assets. (iii) Income statement, the income revenue and expenditures will be evaluated at the of quarter period of first year of plant operation.
Business model	The project will target the people of rural in north province of the country where this plant will be built. It will serve at least 70000 households and It will use grants 30% and loan of 70% of the total investment cost and it will produce 200 KW. The people in that region have low access of electricity therefore the project will solve the lack of electricity. The project is better because it will not need high cost for electricity transmission. Due to grant and feed in tariff the unit cost will be less which will make the project to be attractive and profitable. The project will get profit from sell electricity to the people, the subsidies from government and also the grant from GIZ will help the project to run very well.
Project innovativeness	This project will use Francis turbine technology which has more efficiency compare to other type of turbine. The mini isolated hydro is new in country it does not cost a lot of money compare to centralized hydro because the transmission will be locally which make it cheaper. We will provide internship to university students and technical school which will help local citizens in maintenance of the project. Local entrepreneurs may find this as a profitable business opportunity through training. The economy of Rwanda will thus benefit from the strengthened private sector and rural retail structures. This project aims at provision of research and development to encourage innovations by this project. The project implementers are to work closely with the Rwandan government in especially policy and regulations development for long term benefits.
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Table A17
Investment plan for the project: "5 MW solar farm for the Gold mining region, Mubende district (Uganda)".

Items	Comments and justifications
Project synopsis	Uganda has so many minerals spread all over the country exploitation of which is a big challenge mainly because of lack of electrical power. Mubende district, located in the central region of Uganda, is one of the areas rich in Gold mineral resource but there is no energy access because the national grid does not reach this area. The current source of energy in the gold area are few privately owned diesel generators (with capacity less than 5 kW) that sell electricity at very high prices. The few miners travel long distances to access services in the small Mubende district town due to poor infrastructures throughout the district. The mined gold is transported and processed in Kampala. Big investors are discouraged from doing business in this area. There is therefore a lot of illegal mining by the poor inhabitants who sell their gold to illegal sources that pay them much less than the actual gold worth. The local population are majorly subsistence farmers who also lack access to electricity. Agriculture is their major economic activity. This project aims to install a 5 MW solar farm in Mubende district to provide electricity especially for Gold mining activities and also provide alternative electricity to support economic and social development.
The sponsors	The capital will be from both Equity and debt financial sources. The Project owners and venture capitalists will fund 30% of the budget. 70% will be financed by a loan from a developmental bank or Renewable energy support organization. The Government of Uganda through Uganda Electricity Distribution Company Limited (UEDCL) will incur the costs involved in the grid extension to the region.
Market analysis and strategy	Mubende district has a total land area of 4646 square kilometers. The district was projected to have a population of 633,400 persons in 2013. 75.1% of the population is literate. 89.7% of total households use firewood as a source of cooking fuel, 8.6% use charcoal and less than 1.7% use either electricity, gas, paraffin or cow dung. For lighting, 93.3% use paraffin in form of local wick tin (tadooba) and lanterns while 3.4 use electricity and 3.3% use other means [46]. Currently, the national grid reaches the small-town area of the district. The condition of the majority of health, academic and other social infrastructures in this district is poor. Poor energy access is one of the contribution factors. The project will assure energy access throughout the district. This will attract investment in the mining sector and other economic activities such as commercial farming. The project scope along with availability of power access will allow development of infrastructure in the area. This will lead to overall development of the district and power access by most inhabitants. The project is expected to last 25years. At the end of which, there is expected to be enough capital to re-run the project.
Project scope	The solar energy generation farm will be owned by the private investors, the board of directors who will employ a managing director to run the farm. The project will employ Ugandans skilled in Solar energy and other employees from Mubende district. With support by the Uganda government, the energy produced, will be sold to the Uganda Electricity Distribution Company Limited (UEDCL) at 145USD/MWH. This company will have to extend their grid system to the solar farm and also make available electricity access throughout Mubende district.
Regulation and environmental information	Being a clean energy source, this project has no negative effects on the environment. 16% of the total land area is covered by wetlands, while 79% is under forest cover. The district has wild mammals, reptiles and birds spread within the forest covers. The district has a Department of Natural Resources responsible for "sustainable and productive utilization of natural resources for poverty reduction, enhanced economic growth and improved livelihoods" [46]. Liaising with this department before and within project enforcement is mandatory. Mubende district has a lot of economically un productive land covered with vegetation. Installing the solar project in a small area of this district will have insignificant negative effect on land use and wildlife. Instead, there will be economic utilization of land that will create overall sustainable economic growth of the district and its inhabitants. The Key regulations and policies that will affect the project are the Uganda Import and Export Regulation which requires Pre-shipment inspection of the solar equipment through the Pre-Export Verification of Conformity (PVoC) program. The National Energy Policy 2002 and the Renewable Energy Policy 2007 affect implementation procedures, the tariffs and costs of energy production and distribution [47]. Mubende has a tropical climate. The average annual solar insolation averages at 5.15 kWh/m^2/d. The solar energy resource is very rich in this region. It allows yearly energy production. The National Energy Policy 2002 and the Renewable Energy policy 2007 have high support for Renewable energy projects development [47].
Project costs	The estimated initial cost of implementation is USD 5,046,482, the annual costs and debt payment are USD 83,752, and periodic costs of USD 8000.
Financial projections	Simple payback time of 7.1 years, Equity payback time of 5.6 years. Annual life cycle savings of about $ 684,993 Levelized cost of production of 62.24 $/MWh. Net Present Value of $7,312,142. Pre-tax Internal Rate of Return – equity 26.4% Pre-tax Internal Rate of Return – assets 12.5%
Business model	The project is to generate electricity which is to sell to the Uganda Electricity Distribution Company Limited (UEDCL). UEDCL is responsible for grid extension within Mubende district and will distribute power throughout the energy starved district. The power is to be sold to the Electricity Distribution company at a cost of 145USD/MWh which is less than the selling price of energy to household consumers in Uganda (150USD/MWh) and also less than the feed in tariffs for solar PV (362USD/MWh). This assures market for the generated power. As the demand for energy grows within the district, the Energy Distribution Company can meanwhile sell the electricity to other neighboring districts.
Project innovativeness	This project is in line with the Sustainable Development Goals; the 2030 agenda for sustainable Development. This project is meant to realize immediate economic growth of the whole district by assured power access throughout the region, thereby increasing opportunities for viable economic activities, infrastructural development and improved livelihoods on the inhabitants. Mubende district being a rich Gold mineral resource area but currently whose mining activities are being hindered by lack of energy access (as one of the key factors), this project would have a direct and immediate positive impact on the economic development of this district. The project location is also perfect due to high solar insolation throughout the year. There is availability of land for the solar project. All the current policies in place by the government of Uganda encourage and support investment in solar energy. The project has a high positive Net Present Value of approximately USD 7,312,142 and is therefore very financially viable. The payback time is less than 8 years out of the 25 years of project life. This type of project is also replicable to other districts.
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Table A18
Investment plan for the project: "3.2 kW photovoltaic project in Lafia, Nasarawa (Nigeria)".

Items	Comments and justifications
Project synopsis	The project is 3.2Kw photovoltaic project to serve a small community in Lafia, Nasarawa, Nigeria. The project is aimed at improvement of access to sustainable energy while utilizing the abundant solar resource. The site has a daily DNI as high as 6.15 KWh/m^2/d which makes it a good location for installation photovoltaics. The improved access to electricity will stimulate and attract small business growth thereby improving the economic standard in the location. The project is more of a developmental project and other support systems like feed in tariff could play a great role in improving its sustainability.
The sponsors	The developmental partner on this project will provide a grant of $10,000 as part of its energy support program in Nigeria. The other 60% of the initial cost will be sourced from National bank (United Bank for Africa). Other stakeholders involved in the project are the National Electricity Regulatory Commission and they are responsible for energy policy enforcement, also the government of Nasarawa state.
Market analysis and strategy	The people living in Lafia, Nasarawa state in Nigeria. The area is plagued with low electrification rates and poor quality power supply. In the GIZ report 2015, It is stated that only 33.2% have access to electricity. The project meets current needs however for future needs, the project feasibility has to be re-evaluated [48]. This is due to the long payback time of 16 years for a project whose lifetime is 25years. Also, the electricity generation using photovoltaics is expected to drop as production cost for PV systems is relatively high.
Project scope	The cell to be used is a monocrystalline silicon solar cell of 12.9% efficiency, from Shell and the model is mono-Si - SM55. The choice of mono-si is as a result of its high efficiency. The maintenance will be carried out by GIZ technical personnel seeing as the project is implemented in partnership with them. It will be managed by the project initiator Nwadiaru Vivian.
Regulation and environmental information	The overall goal of the project is to promote low carbon energy provision to poor and isolated communities. Improved provision of energy services will in turn stimulate development of the local economy through generation of new opportunities for small and medium enterprises in agriculture, small scale manufacturing, trade and local services such as lighting for kiosks, and hairdressing salons. Sustainable and affordable energy services provision will enhance social, educational, and health prospects for the local population. National Renewable Energy and Energy Efficiency through its energy efficiency campaign will promote the use of efficient lighting and electrical appliances, making it easier to reach more people.
Project costs	The initial Implementation cost is $29.468 and the components of this cost are; PV system accounts for 17.3% of the capital cost, the Balance of system accounts for 46.4 and the remainder was used in project development and feasibility studies.
Financial projections	The Payback time of the project is estimated at 17.4 years. The cumulative cash flow at the end of the project life time is $26,144 while the net present value is $2177. The total annual income is $1314 and the lifecycle savings is $187/year.
Business model	The basic model is to feed electricity into an isolated grid and it is sold to the government at the indicated rate which in turn is retailed to the people by the distribution company.
Project innovativeness	It is exceptional because it targets people who are cut-off from the main national grid and require access to electricity. This utilizes the high amount of Direct Normal Irradiation reaching the location.
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Table A19
Investment plan for the project: "Use of solar maize dryer for 45 tons to improve agriculture sector in Rwanda".

Items	Comments and justifications
Project synopsis	The proposed project will use solar energy for drying harvest such as maize. This consist of use of air-heating solar energy collector and drying chamber. The collector is for collecting solar energy to heat air which goes to the drying chamber where it will exchange heat with maize and dry them. The major partners involved in this projects are the farmers who are currently grouped in the cooperatives and project developer. The important sponsors will be the Workforce Development Authority (WDA) and Rwanda Ministry of Agriculture. The investment cost will be mains based on the quantity of production from the cooperative. This will give us the size of the solar dry we have to build and the cost will be measured depending to the materials used. Taking an example of one with production of 45 tons of maize per year. The total investment on this is about $ 34469.1. This technology will help in time saving. Normally ordinary method takes about one month to dry maize which harvested with 20%–25% moisture. But this technology only takes 3 days to dry maize with the same moisture content. And the time save will be used for other activity. The direct exposition to the solar radiation (Ultraviolet) could otherwise have caused reduction in nutrients level such as vitamin [49]. Drying maize reduces the risk of mold and aflatoxins and helps farmers to achieve good market prices. This technology will help to keep the maize contents level of vitamins as well as the quality of product.
The sponsors	The major stakeholder in financial success of project are Workforce Development Authority (WDA) and Ministry of Agriculture. Currently, government is encouraging people to come up with innovative projects in Rwanda to get more facilities and easy the loan process. It will help us to get loan easily for implementation of the project. In supporting and encouraging innovation in Rwanda this will be more interesting. The amount of loan will depend to the production of the cooperative we will sell to our project. If we start targeting one producer of 45 tons/year where we need about US$ 34469.1. The ministry of agriculture will help us to meet the cooperative in place which grow maize.
Market analysis and strategy	This project is mainly needed by the Farmers to save their time and increase the quality of the maize, and avoid the possible damage. The ordinary drying method has the following risks which can be mitigated by our project: (i) spoilage of the maize due to rainfalls, (ii) animals can access it, eat it, defecate on it and reduce its quality, (iii) ordinary drying involves high labor costs: somebody has to be around throughout the drying process and keep watch of the maize. The ministry of agriculture needs this project also to help the farmers to produce the good quality of maize. Currently the are no competitors only the competitors can be the farmers who want to still using the ordinary method for drying. However, the ministry of agriculture through Rwanda Cooperative Agency (RCA) will be involved in training and disseminations. The project will be appreciated, it meets the current demand because now the farmers are using the ordinary method for drying the maize which related to the mentioned risk above and the future will be reached also by using this technology as it will remain in place and always needed for the reasons we said.
Project scope	The project developer is the vendor. Operational and maintenance will be provided by project developer and trained technicians. The skilled staff and maintenance will be available also for maintaining the functionality of the project and controlling the temperature in the drying chamber.
Regulation and environmental information	Currently, there is no environmental issues related to this project as it will be using green energy. No harm for environment. The project is sustainable as it will meet the currents demand (use) and the future demand (use). The farmer will never stop growing the maize and need the quality of the maize. This make the project to be sustainable. The regulation and requirement to be filled by this project include: (i) contract negotiations, (ii) permits and approvals, (iii) land rights, and (iv) registration.
Project costs	As we have said the cost of the project depend to the size of production but in our case, we estimated the cost to be US $34469 which is supposed to cover the following items: (i) land cost & preparation, (ii) constructions (store, office, drying chamber and maize bed), (iii) Buying solar energy collector & installation, (iv) others (office material, man power, etc.).

Table A19 (*continued*)

Items	Comments and justifications
Financial projections	Based on the quantity we suggested of 45 tons of maize/year and the facility available in Rwanda. The following key points been used to analyze the proposed project: - Installed cost: $ 34469.1 - Rebates/Incentives: $ 14256.3 - Annual maize quantity output: 45000 Kg - Annual O&M: $ 827 - Useful life: 10 years - Drying maize price/kg: $ 0.076 - Discount rate:1.15% Net Maize Savings ($/year) = [45000 × 0.076] − 827 = $2593 Payback (year) = $\frac{\$34469.1-\$14256.3}{2593(\$/year)} = 7.7$ years PVAF for a 1.5% discount rate over 10 years is 9.22. Discounted Net Annual Savings ($) = 2593 × 9.22 = $23907.46 NPV ($) = $23907 - $20212.8 = $ 3694.66 LCOE ($/kg) = $\frac{\$20212.8+[827*9.22]}{45000*9.22} = \$0.067/kg$ The simple payback period for proposed project is 7.7 years shorter than the useful life (10 years). This suggests the solar maize dryer will pay for itself before it stops working. The NPV is positive meaning that, accounting for the time value of money, we will gain money on this project. The LCOE implies that the solar maize dryer will work over the next 10 years at a cost of $0.067 per kg. This is less than the current utility rate of $0.076.
Business model	This business will be mainly between the farmers and project developer. The famers will bring the maize to be dried with the solar maize dryer and pay according to the quantity. Drying will cost about $0.067 per kg and this can change according the market situation. This cost will not highly affect the market. The model will be successful as the government is going to be interested in the innovation comes in agricultural sector. This will ease the implementation of the project, as the service and other facilities will be provided for promoting innovation. We expect that the farmer will be happy for the project as it will help them for time saving, keeping maize quality, and hygienic of products which will improve the market. This will motivate these mentioned above to be committed in the project and make it successful. One of the main reason, is that the proposed project brings innovation of Rwandese agricultural sector. And this have also interest on both side, famers and government (time saving & improving maize production quality). The project will be interesting as the government is now promoting innovation in all sectors.
Project innovativeness	The proposed project is innovative as it will be new technology introduced in Rwandese agriculture sector. Currently no such technology exists in Rwanda. It is an exceptional project as it will help the farmer to dry maize in short period of time (three days!) Instead of using one month using ordinary method. This project is innovative, will help to boost economy, as it will help the farmers to get time for other economic activities. The project is sustainable, as it will meet the current use and future use. This need to be done to help farmers to reduce the risk due to the ordinary drying method and help famers to achieve production of good quality of maize product whereby it will market as well as economic of country.
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Table A20
Investment plan for the project: "15 MW wind farm, Saint Louis (Senegal)".

Items	Comments and justifications
Project synopsis	The project is a 15 MW wind farm. The important wind energy potential of the Senegalese coast will be used in the St. Louis area. The implementation of a wind farm in this area is important because of the good wind speeds that can reach 7 m/s at just 10 m high. The produced energy will be injected into the national grid and purchased by the National Electricity Company.
The sponsors	Developers including: C3E companies (Senegal) and Cegelec (France). The Regional Council of St. Louis is a licensing authority. Project is supported by the Department of Energy, with financial aid from the Midi-Pyrénées Region and AFD. SENELEC will ensure connection to the national grid.
Market analysis and strategy	All the Energy Produced will be used by SENELEC to provide enough Energy to the population an average price of 0.16USD/kWh (excluding fees and taxes). This Price is less than the Price of the Electricity Produced by fossil Energies. The location is out of the capital city; this will help to emphasis the Energy decentralization.
Project scope	CEGELEC will study wind potential, sitting/micro siting (preparing the land to implement the turbines), environmental impacts. The capacity will 15 MW. Wind turbines will be delivered by Vestas, unit power 600 kW, rotor diameter (60 m), 25 turbines are planned. The O&M will be leaded by C3E.
Regulation and environmental information	Its benefits globally (fight against global warming) and locally (support and diversification electricity production, reducing the fuel bill) and its innovative character, the project will be entitled to preferential conditions for its financing and operation. Ultimately, the project is eligible for the CDM mechanism and as such may obtain green certificates that could be sold on the market. Today this project would save between 20,000 and 25,000 tons of CO_2 each year.
Project costs	The estimate cost is 20,640,000.00 USD
Financial projections	Production capacity is 27,336 MWh. An average price of 0.16USD/kWh (excluding fees and taxes). Saving = 76 368.00 USD/year. Given that the capital rises to 25% of 20,640,000.00 USD = 5,160,000.00 USD equity provided by the manufacturer: 10% of capital = 516 000.00 USD. Payback time through savings on energy bills = 6.8 years.
Business model	The project will be based on a project company, which has the status of a limited company. The project company will benefit from a transfer from C3E, Cegelec and Council Regional St. Louis, authorizations and achievements: (i) land law, in terms of the Concession owned by C3E for the exploitation of wind energy. Complementing the Company project will make the Application Declaration of Public Utility to dispose of securities land plots required for the installation of wind power (ii) the shares of this company will be distributed among different industrial present Senegal and consumers of electricity (that is to say connected to 30 kV and with higher annual requirements to 2000 MWh) (iii) shareholders have the status of self-producer vis-à-vis the SENELEC, (iv) the profitability of the project is provided by the difference between the price of electricity Senegal, which is very high (the General Price Medium Voltage option gives a price per kWh delivered by SENELEC around 0.16USDHT) and the price returns of the wind kWh (less than0.09 USD)
Project innovativeness	Being the first wind farm that will be established in Senegal, this project is a great step towards the energetics mix. Similarly, it will be the first renewable energy on grid, so that we have the support of local authorities. At the same time having SENELEC as buyer of all the energy produced guarantee the success of the project.
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