REDUCING CARBON EMISSIONS IN A THIRD LEVEL EDUCATIONAL INSTITUTION IN SUB-SAHARA AFRICA

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Abstract

The effort to reduce carbon emissions as the arguably most prevalent cause of global warming has been a positive trend in most African countries. One of the most successful strategies towards reaching that goal is the shift from fossil fuel power generation to renewable sources of energy such as wind, hydro, geothermal and solar.

As Kenya sits on the equator it enjoys an all year round insolation between 5 to 6 kW/m2/day which is more than double of the average insulation in Germany, which is a country where solar energy is widely used. Taking advantage of a green line of financial support created by the French Government, Strathmore University embarked in a project to install a 600kW roof-top, grid connected solar PV system to cater for its electricity needs.

Having as a background of the newly instituted Feed-in-Tariff regulation, the system is designed to produce more than the required self-consumption such that the extra power can be sold to the utility via a PPA (power purchase agreement) and the revenue used to pay for the electricity used by the university at night.

This paper describes the whole process from the technical, regulatory, educational and financial aspect highlighting the positive and negative events along the path such that it can be useful for other private sector institutions interested in greening their sources of energy, invest in renewable and thus reduce their operation costs. The authors have written this work having in mind not only countries in Africa but all other countries which sit in the so called solar belt.

Introduction

The concentration of GHG emissions has been on the increase over the years in line with the temperature of the earth which was determined to have risen by 0.8 degrees between the year 1900 and 2005. Despite a rising awareness on greenhouse gas (GHG) emissions, Diabat et al. (2010) show that, over the last 150 years, the last decade was recorded as the hottest with the year 2005 being the hottest year. As a result, concerns over global warming have penetrated all parts of the society such as the corporate and industrial world and recently institutions of higher learning. Therefore, to motivate firms and institutions to green their energy sources and reduce emissions, a market pull was generated for them. The Kyoto protocol which is part of the United Nations Framework Convention on Climate Change was formed as part of a global effort to reduce GHG emissions. By reducing carbon emissions in their operations, companies and learning institutions optimize their internal and external operations and in the long-run minimize their operation costs.

Interventions by higher institutions of learning to reduce carbon emissions

In 2008, CO_2 emissions in Sub Sahara Africa (SSA) was reported at 0.84 metric tons per capita by the World Bank annual report on carbon emissions (World Bank, 2008). These carbon emissions were generated by burning of fossil fuels to generate electricity, drive the transport industry, and to run industrial processes such as cement manufacturing. According to Diabat et al. (2010), environmental awareness as well as legislation have forced companies and learning institutions to aim for greener sources of energy that would have less impact on the environment in all stages of their operations.

The current trend is that higher institutions of learning are taking a leadership role in driving sustainability initiatives. Thus, they are well placed in playing the role of fighting climate change since their focus is to educate future generations of leaders. This responsibility covers the institutions' carbon emission reduction, conservation of energy and water and other sustainability initiatives. Velazquez et al. (2006) define a sustainable university as a higher institution of learning that involves, addresses and promotes on a global and regional basis, the reduction of negative environmental, societal, economic, and health effects that result from the use of their given resources to meet their functions in outreach and partnership, teaching, research and stewardship to help the society achieve a transition to sustainable lifestyles.

In a quest to take a leadership role in Northern America, the American College and University President's Climate Commitment (ACUPCC) was formed. Its role was to challenge all universities to develop a comprehensive plan to achieve carbon neutrality, initiate practical ways of reducing carbon emissions and make their plan and progress available to the public. White (2009) argues that in order to maintain accountability, institutions of learning use an on-line tool of reporting to make their progress on greenhouse gas emissions visible to the general public. The data collected online by ACUPCC is from a large number of colleges and universities and represents carbon emissions from many areas of operations for instance, refrigeration and air conditioning, commuting and waste. Analysis of the above data provides an understanding into the factors influencing emissions from higher institutions of learning. Similarly, the metric used assesses the impact of a number of sustainable initiatives at operational level in academic institutions. As such, many campuses utilize the metric as an indicator to measure their progress towards a more sustainable system.

Lack of data concerning energy use and patterns has resulted in wastages (Eko et al, 2009). In essence if the correct data was made available, wastes in electricity would have been minimized regardless of the source of energy.

In Kenya, the Jomo Kenyatta University of Science and Technology (JKUAT) in collaboration with Pioneer Technologies Ltd are working jointly to produce polyethylene biogas digesters (PTDs). Pioneer Technologies Ltd provides the financial support while JKUAT carries out the investigations on arising issues from using the technology, with focus on how to improve the technology and make it more efficient. Schäfer (2011) argues that biogas projects are a crucial pre-condition in the long term sustainability of renewable energy use in learning institutions and residential houses. On the other hand, Paolo et al (2013) describe the technology to be dependent on training of technicians which is costly to an institution. Therefore, the technology requires some form of extension such as regular visits to the houses with installed the digesters for longevity and good use of the technology.

Sustainability initiatives at Strathmore University

Strathmore University (SU) is a higher learning institution which was established in 1961 as a college and has over the years grown into a renowned private university.

Strathmore University has actualized its commitment to sustainability in a number of ways such as management of social, environmental and governance issues. The University has an established policy of integrating business with environmental conservation which has been embraced by all employees towards environmental sustainability. With regards to its built environment, the University has adopted green buildings as a way of improving the benefits to students, staff, workers, the community, and a builder's bottom line.

The Student Centre (SC), Management Science Building (MSB) and the Strathmore Business School (SBS) which add up to 22,000 square meter of space were constructed using the LEED (Leadership in Energy and Environmental Design) standards. These green buildings consist of mainly offices, lecture halls, conference halls, recreational facilities and a cafeteria. Compared to conventional buildings, the energy consumption has been reduced by 40% (Da Silva, 2011). A Building Management System (BMS) is integrated into the buildings to control the resource utilization. The BMS used is based on SNAP PAC System Architecture with OPTO-SNAP controllers. User defined control-programming is used to define the functioning of the various components such as motion detectors, power cards and lighting control. The BMS uses room orientation and time-of-day to disable lighting fixtures that are close to the windows when sufficient natural lighting is available. It also disables all lighting in individual rooms when the BMS Motion Detectors indicate that the area has been vacated.

Figure 1: Management Science Building at Strathmore University

The buildings have in place a full-building voltage stabilizer to help protect all electronics, including the light ballasts from the recurrent voltage fluctuation on the National Grid. In addition, the buildings have incorporated water evaporation cooling system in addition to natural ventilation. Other sustainability initiatives in the University include:

- Landscaped flower beds with ornamental shrubs and trees to increase the aesthetic value of its landscape. It has also stabilized its ecosystem against fluctuations arising from climate, pests and diseases.
- On-site waste separation, processing and location of bins in strategic places around the University
- Common printing system aimed at reducing paper use in the university. A user password is utilized within the system to ensure wastage during printing is controlled.
- Water conservation through rain water harvesting from roof catchments through incorporation of pervious paving systems. Harvested rain water is utilized in irrigating flower gardens. Part of the rain water is pre-treated to be used for non-drinking purposes.
- Green roofs help reducing temperature in the buildings and a 10kW solar PV roof-mounted, grid-connected is installed in the Student Centre to help cater offset the base load.

University electrical load profile

The University spends approximately US$ 300,000 per annum on electricity costs. Major electrical loads mainly comprise of lighting, cooking, air ventilation, hot water heating, lifts, escalators and computers, and other appliances. During the week the demand increases from around 04:30Hrs and peaks at around 11:15Hrs and then drops at around 20:45Hrs. On weekends and holidays, the demand is low due to reduced number of activities.

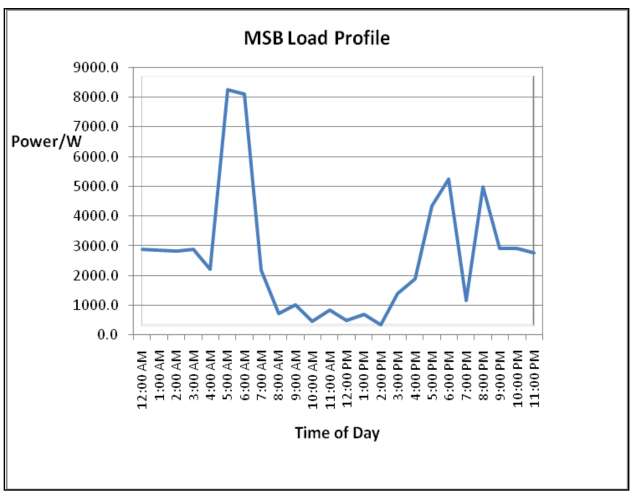

Figure 2: Daily load profile for the MSB building

Month-by-month consumption varies from lows of 80MWhrs to highs of 140MWhrs as shown in below:

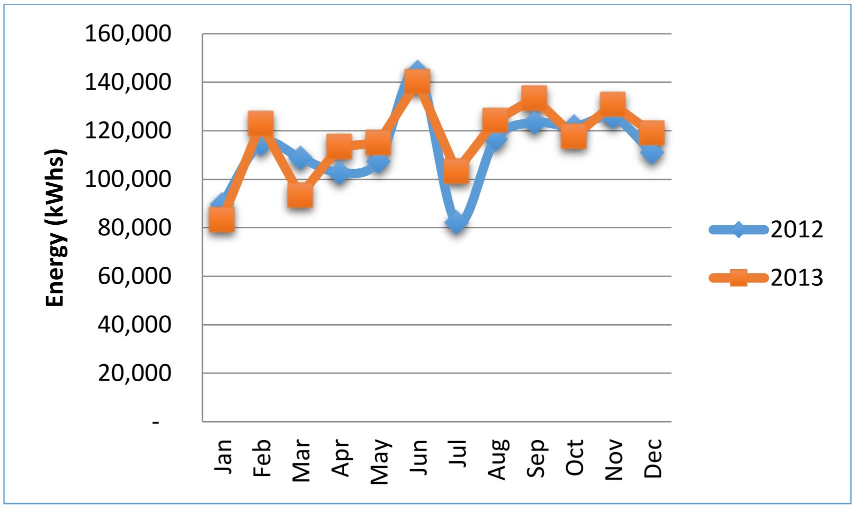

Figure 3: Monthly consumption for the entire university for 2012 and 2013

In order to reduce its operational costs, the University is constructing a grid-connected roof top solar-PV system designed for supplying Strathmore University's entire campus with electrical energy, for a period of no less than 20 years. In this regard, Strathmore University is set to be the first carbon neutral University in Sub Saharan Africa.

This paper serves to describe the process in which the University has followed from the technical, regulatory, and financial aspects highlighting the positive and negative events along the path such that it can be useful for other tertiary educational institutions interested in greening their sources of energy, invest in renewables and thus reduce their operation costs.

The Strathmore University solar PV project

In December 2012, Strathmore University approved the development of a roof-top grid-tied solar PV project as part of its sustainability initiative. A number of factors were important in the decision to invest in a solar PV power plant at the University:

- Awareness and knowledge of the University's senior management about solar PV technology, and its pioneering spirit.
- The University's location close to the equator giving it an advantage in tapping solar power due to the fact that it receives an average insolation of 4-6kWh/m2/day without the need for sun tracking.
- The existence of a green energy facility, set up by the French Development Agency, offering project financing at concessional rates.
- Additionally, the existing feed-in-tariff regime allowed the possibility of a grid-connected system without the need for storage which is always expensive and availing the possibility of selling to the utility excess power.

Regulatory processes

The concept behind the project was that the national utility, Kenya Power (KPLC), would accept to partner with the University in piloting an Electricity Banking Arrangement (EBA) which would have allowed the University to store excess energy in the grid. In the end, the discussions with KPLC on the EBA were not successful. Instead, KPLC referred Strathmore to the existing possibility of signing a Power Purchasing Agreement (PPA), under the feed-in-tariff regime, that would commit KPLC to purchase surplus solar power from Strathmore at $0.12/kWh.

The FiT route presented a number of challenges, namely:

- The PPA process is lengthy and costly as is best suited for large-scale projects aimed primarily at selling power to the grid. The processes consist of three major steps, all of which require substantial investment in funds and time.

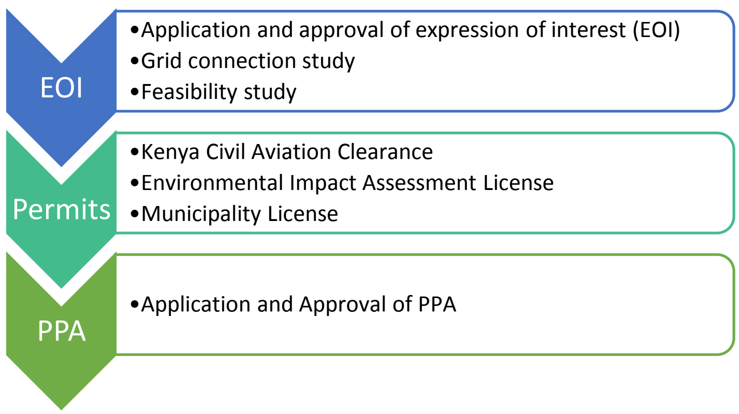

Figure 4: The PPA process in Kenya

- A number of procedures still need to be streamlined, using process tools to maximize efficiency of the FiT approval process. For example, guidelines on how project developers can access the required data to be used for grid connection from the utility within a reasonable period of time studies are required.
- While a standardized PPA exists for projects below 10MW, it is not suited for projects in which a large percentage of the energy generated is utilized for captive use on site. A number of clauses need to be amended and negotiated, which leads to delays.

Impact of the Value Added Tax (VAT) Bill, 2013

On September 2, 2013, the Kenya Government gazette the new VAT bill which introduced 16% VAT on hitherto exempted goods. Included in this category is specialized solar PV equipment and related products e.g. deep cycle batteries. The impact of this new regulation was to introduce an additional cost of 16% into the project (or approximately US$ 220,000). This development jeopardized the financial viability of the project. At the time of writing this paper, negotiations are on-going to obtain a VAT-exemption on the project.

Project sizing

The high costs of electricity in Kenya, averaging $0.225/kWh presents an opportunity for replacing electricity from the grid with “cheaper” solar PV electricity thus reducing operating costs. An optimal system size will maximize on-site consumption and minimize excess sales to the grid due to relatively low FiT of $0.12 per kWh

The minimum plant size eligible for the FiT regime in Kenya in 500kW, thus, this represented the smallest size that the University could consider. To arrive at an optimal plant size, modeling tools were applied to various plant sizes. The sizing analysis was undertaken through two models, namely;

- SAM (a renewable energy application designed by the National Renewable Energy Laboratory, an agency of the US Government); and
- A financial model in Excel that takes some of the results from the R model to calculate Net Present Value (NPV) of systems of various sizes.

Assuming a basic system cost of $2.40 per watt plus VAT, as well as current energy prices of $0.225 per kWh, and a feed-in tariff of $0.12 per kWh, the optimal size is 600kW as shown below:

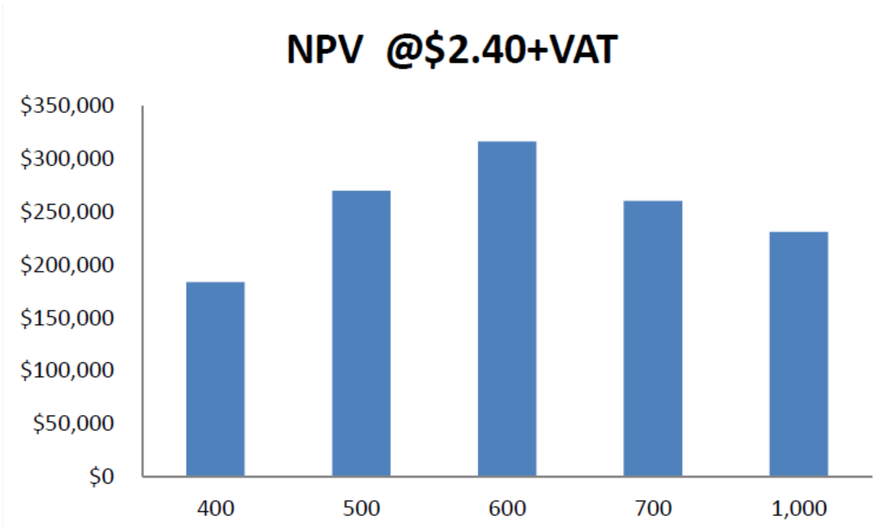

Figure 5: NPV of various solar PV project sizes considered.

Figure 5 above shows how the NPV varies as system size changes. Beyond 600kW the losses from energy exported to KPLC at a lower price than the Levelized Cost of Electricity (LCOE) begin eating into the savings achieved by Self Consumption (SC) of PV energy. A system that is too small will not reap all possible savings at $0.225. In addition, a system that is too large will export too much energy to KPLC at $0.12 per kWh.

The difference between the power produced by the solar system and that purchased from KPLC is the power saved and valued at $0.225 per kWh. At certain times, there would be excess power from the solar and it would be exported to KPLC (as shown below). Exported power is valued at $0.12 per kWh.

Project financing and economics

To finance the project, the University secured credit availed by a local bank, Co-operative Bank of Kenya, under a credit line provided by the AFD Green Line of Credit at 4.1% interest rate over a 10 year period, with one year moratorium. Prior to the project, the University monthly spending on electricity varied from KES 1.5 million (US$ 17,000) to KES 2.5 million (US$ 28,700) per month as shown below, and averaging an annual amount of KES 24 million (US$ 280,000).

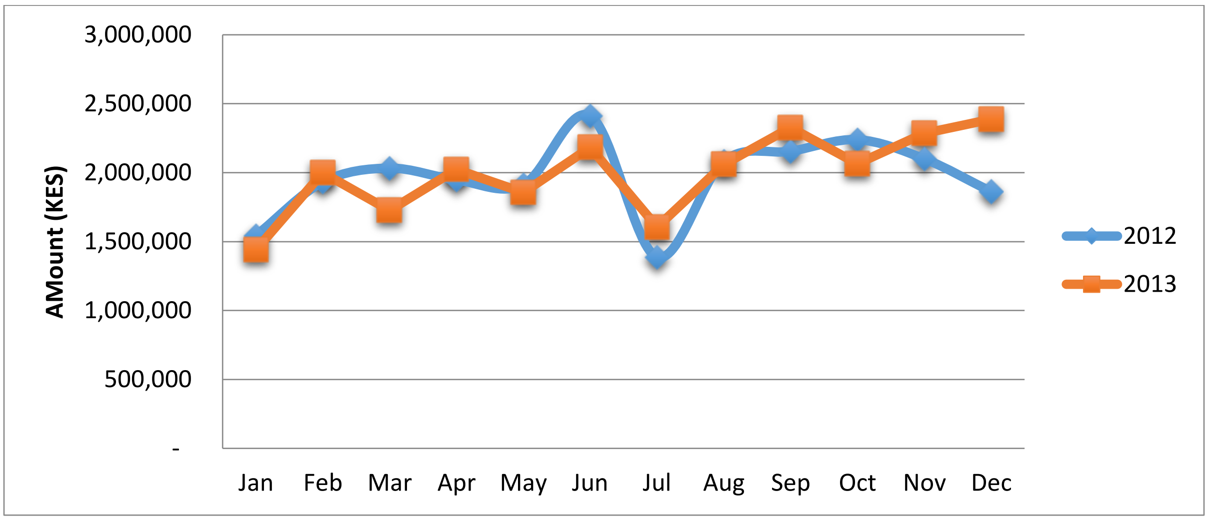

Figure 6: Monthly expenditure on electricity at Strathmore University for 2012 and 2013.

Assuming a basic system cost of $2.40 per watt plus VAT, as well as current energy prices of $0.225 per kWh, and a feed-in tariff of $0.12 per kWh, the ratio of captive use to export is 3:1, the expected financial returns from the project are as shown below:

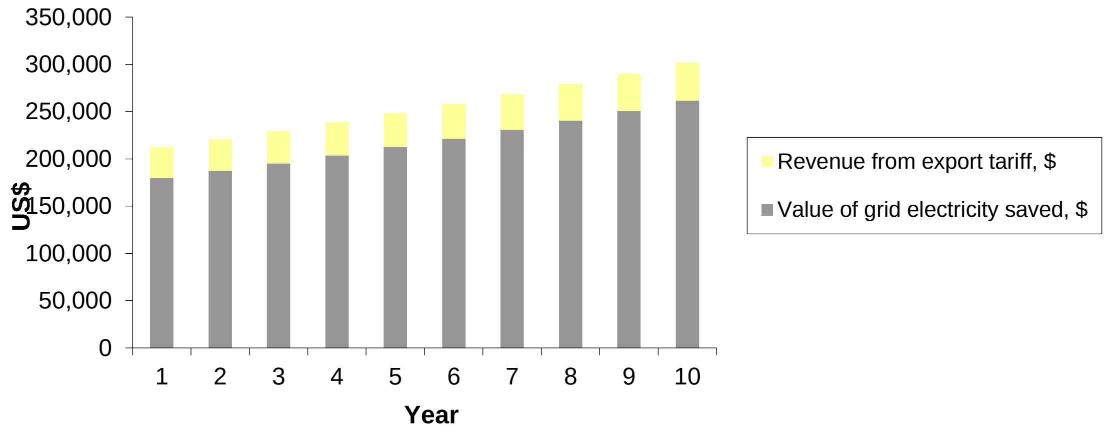

Figure 7: Projected combined revenue and savings (first 10 years of the Solar PV project)

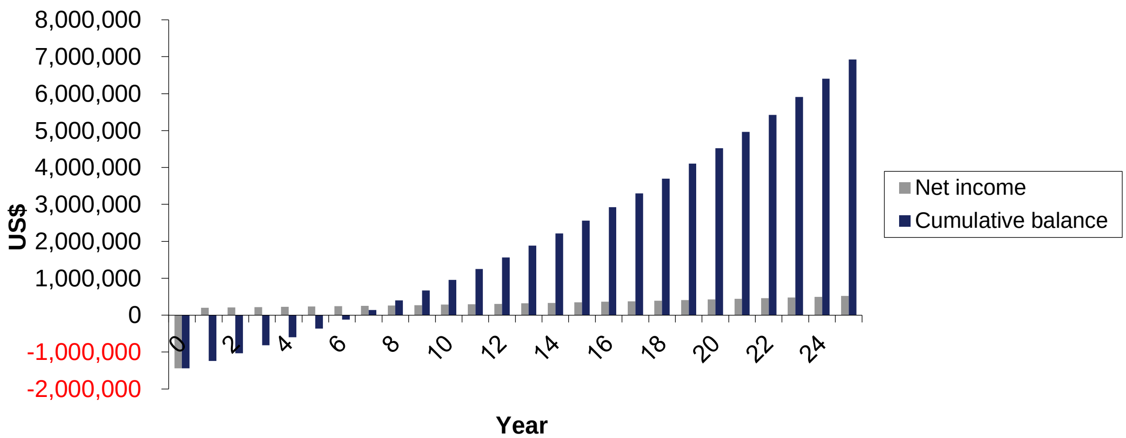

Figure 8: Cumulative project balance and net income for 25 years

The project is expected to turn to turn cash positive within the second year as savings from purchases from the grid and exports outweigh the cost of imports. Payback period is estimated at 7 years.

Discussions

Availability and accessibility to affordable financing schemes

The Weighted Average Cost of Capital (WACC) is as important a factor in determining the Levelized Cost of Electricity (LCOE) from Solar PV as solar radiation (Ondrazek et al, 2013).

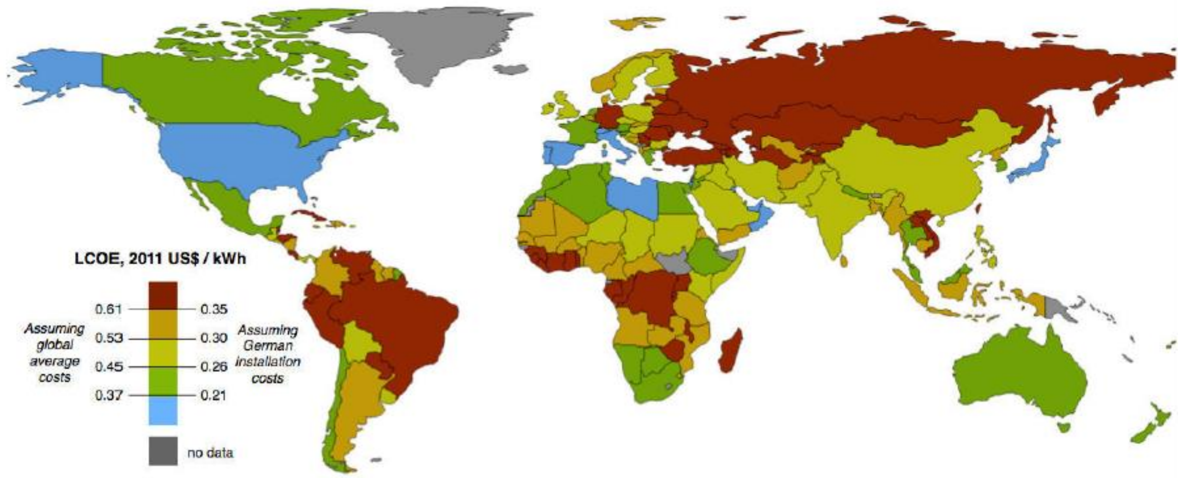

Figure 9: Global map of LCOE, based on weighted average national GHI nationally-specific WACC

The fact that Strathmore University could access relatively cheap financing at 4.1% interest rate compared to a market rates in Kenya in excess of 10%, made the project commercially viable without any subsidies. As a result, the sustainability initiative not only results in reduced carbon emission, but also lowers the cost of energy to the University (lower solar PV LCOE compared to costs of electricity).

Regulatory environment

Reducing carbon emissions at tertiary level institutions required an enabling policy environment. In the case of Strathmore University, the solar PV project has encountered numerous challenges that have delayed the implementation of the project. The cyclic annual nature of solar production, combined with University operating hours requires that the supply of excess electricity production be sent to the National Grid, for later use when the load exceeds the available generation capacity or the sun energy is not available. However, a net-metering policy is non-existent in Kenya at the moment while the existing FiT regime was not suitable to the University needs of using captive power on site. Further, changes to the VAT bill resulted in additional costs to the project which severely impacted its financial viability.

The University is working to ensure that a suitable policy environment exists which will make it easier for other institutions to adopt similar initiatives in their institutions.

Sustainability initiative as a change agent

Strathmore University has over 5,000 students on its campus. Through the project, the University aims to create awareness through its student population on incorporating sustainability initiatives into the built environment. Through the Strathmore Energy Research Centre, the University will conduct seminars to educate the students on the application of technologies such as solar PV. It is desired that these students will become agents of change in their homes or work places in the topic of sustainability. Further, senior management from other tertiary institutions will be invited to open days to interact with the people behind the 600kW project.

The project will also serve as a hands-on training for solar technicians. Grid-connected solar PV is a relatively new area in Kenya with a shortage of qualified technicians.

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