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PROJECT FINANCE MODEL

IN

RENEWABLE ENERGY PROJECTS

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Uusiutuvan energian resurssit ovat runsaat ja yhä useammat maat kehittävät politiikkaa, joka edistää sen käyttöä. Tästä huolimatta uusiutuvan energian kehitys on edelleen hidasta erityisesti kehitysmaissa. Tämä opinnäytetyö tutkii taloudellisia näkökulmia uusiutuvan energian hankkeiden kehittämisessä, ja työn päämääränä on tunnistaa ja analysoida erilaisia taloudellisia riskejä, jotka ovat uusiutuvien energiahankkeiden esteinä. Työssä tutkitaan erityisesti miten uusiutuvien energiahankkeiden riskejä ja esteitä voidaan vähäntää käyttämällä projektirahoitus- mallia. Tutkielma myös arvioi ja tutkii käytettävissä ja saatavissa olevien pääomarakenteiden käyttöä uusiutuvan energian hankkeisiin, erityisesti kehitysmaissa, ja yrittää määrittää optimaalisen ja toimiva mallin uusiutuvan energian hankkeisiin näissä maissa.

Projektirahoitus -malli pitkän aikavälin projektien tai infrastruktuurien rahoituksessa hyödyntää kassavirtaa suunnitellun hankkeen takaisinmaksuun liittyen. Yritysrahoituksessa, taas yritysten tai organisaatioiden omat resurssit ovat käytössä hankkeen rahoituksessa, joko suoraan niiden tase-omaisuutena tai ottamalla lainaa rahoituslaitoksesta käyttämällä "tase-omaisuutta" vakuutena.

Työn tavoitteen saavuttamiseksi käytettiin tutkimusta Nigerian uusiutuvan energianteknologian markkinoista, ja vertailtiin erilaisia globaalisti saatavilla olevia resursseja ja tekniikoita, samalla käyden läpi projekti rahoituksen osia ja tekijöitä, jotka vaikuttavat niihin. Empiirisen osaan hyödynnettiin Microsoft Exceliä ja energialiiketoiminnan laskinohjelmistosovellusta. Lisäksi haastateltiin uusiutuvan energian kehittämisen ja rahoituksen ammattilaisia.

Excel ja optimointi kaaviotosoittivat, että mitä pienempi pääoman osuus, sitä enemmän tuottoa ja nopeampi takaisinmaksuaika on investoinnilla. Se myös osoittaa aurinkosähköhankkeita kaikkein kannattavimmaksi kolmesta tutkitusta energiateknologiasta, koska Nigeriassa se antaa parhaat tuotot osakesijoittajille.

Haastatteluissa tunnistettiin toimintaan liittyviä riskejä, joista kehittäjät ja rahoittajat ovat enimmäkseen huolissaan tällä alalla sekä miten ratkaisut ovat toimineet heille. Tutkielma tukee myös erityisesti kehitysmaissa projektirahoituksen paremmuutta verrattuna yrityksen taserahoitukseen uusiutuvien energiateknologien hankkeissa.

Projekti Rahoitus, Uusiutuva Energia.

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ABSTRACT

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Renewable energy (RE) resources are abundant and more and more countries are developing policies that encourage its use. Yet its development has continued to be stunted especially in developing countries. This thesis work is aimed at researching the financial aspects of developing renewable energy projects with major focus on identifying and analyzing the various financial risks militating against the development of renewable energy projects and how this can be mitigated using the project finance model. It will also assess and analyze the available and obtainable capital structures in use for renewable energy projects, especially in developing countries, and try to determine the optimal and workable model of capital structure for RE projects in these countries.

Project finance as a model of financing long term projects or infrastructure utilizes the cash flow of the proposed project as the basis of repayment. While on the other hand in corporate finance, companies or organizations stake their resources in financing a project either directly by providing the funds from their ‘on-balance sheet’ assets or through acquisition of loans from financial institutions with their ‘on-balance sheet’ assets as collateral.

To achieve the aim of this thesis, a business case (feasibility) study of the Nigerian renewable energy technology market was used and this discussed the various resources and technologies available globally, while also covering the different components of project finance and factors that affect or influence them. For the empirical part the use of Microsoft excel spreadsheet and the energy business calculator software was deployed and finally structured interviews with professionals in areas of renewable energy development and financing.

Findings with use of excel spreadsheet and optimization graphs showed that the lower the equity contribution, the more the returns and faster the payback period of the investment. It also identified solar PV projects as the most viable of the three (3) technologies considered in Nigeria as it gives the best returns for investors.

The interviews identified the major risks that developers and financiers are mostly concerned about in this area and how the solutions have worked for them. It also corroborated the superiority of project finance over corporate/balance sheet finance in developing RE technology projects, especially in developing countries.

Project Finance, Renewable Energy

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1 INTRODUCTION

Project Finance according to different school of thoughts has been defined in different ways though there is a rallying point in all of the definitions.

The Export Import Bank of United States defines it as "the financing of projects that are dependent on project cash flows for repayment as defined by the contractual relationships within each project … the contractual relationships must be balanced with risk distributed to those parties best able to undertake them and should reflect a fair allocation of risk and reward."

Standards and Poor's an international credit rating agency defines PF as a 'non-recourse financing of a single asset or portfolio of assets where the lender can look only to those specific assets to generate the flow needed to service its fixed obligations – which includes interests and principal payments.'

The Basel committee on banking supervision states that PF is a 'method of funding in which the lender looks primarily to the revenues generated by a single project both as a source of repayment and as a security for the exposure… The repayment depends primarily on the project's cash flow and on the collateral value of the project's assets.'

The Organization for Economic Cooperation and Development (OECD) officially defines PF in the context of the Export Credit Consensus as 'financing for long term projects where the lender relies on the future cash flow projected to be generated by the project to pay their interest and fees and repay their debt.'

From the fore-going it is evident that project finance is a method of raising long-term financing for major projects or infrastructure, based on projected cash flow for the proposed project itself rather than the balance sheet of its sponsors. Its structure relies solely on a detailed evaluation of the construction, operating and income risk allocated between its sponsors through contractual or other techniques. Usually a project financing structure involves different parties who are equity investors known as the sponsors as well as a syndicate of banks or other lending institutions that provide the necessary loans for its operation.

1.1 Renewable Energy

Renewable energy sources have been touted as the best solution to the world's ever growing energy needs as a result of it sustainability and environmental advantages. With respect to sustainability which according to the world commission on environment and development (WCED, 1987) or the Brundtland Commission is defined as the 'development that meets the needs of the present without compromising the ability of the future generation to meet their own needs'. In the light of this definition for an energy source to be classified as sustainable it should be able to meet the current needs without compromising the ability of the future generation meeting theirs.

Non-renewable sources of energy has proved to be diminishing or depleting in their availability and this has also contributed to the present global warming and climate change situation which has had adverse effect on our environment and the lives of our present generation. Implementing RE and energy efficient methods are resulting in significant energy security, climate change mitigation and economic benefits (Energy Tech. perspective 2012). In international public opinion surveys there are strong support for promoting RE sources such as Solar and Wind (GTSEI, 2007) but on national level at least 30 nations around the world already have RE sources contributing more than 20% of their energy supply, and some 120 other countries have various policy targets for long term share of RE. Such policy targets such as in the EU with a target of RE representing 20% of all electricity generated by the 2020, with some other countries having a higher long term policy target of up to 100% renewable.

Outside Europe however, a diverse group of not less than 20 countries also target RE share in the range of 10-50% between 2020 and 2030 (RE future report 2013). Considering country specifics, Nigeria, which is a leading fossil fuel producer, according to the energy commission (RE master plan) has a target of 10% of all installed electricity capacity planned by the year 2025, while Ghana which is also a petroleum producing country also plans 10% of RE in the electricity generation by 2020.

1.2 Research Objectives

This thesis is aimed at researching the financial aspects of developing renewable energy projects with major focus on identifying and analyzing the various financial risks militating against the development of renewable energy projects and how this can be mitigated using the project finance model. It will also assess and analyze the available and obtainable capital structures in use for renewable energy projects especially in developing countries and try to determine the optimal and workable model of capital structure for RE projects in these countries which will not only encourage investing in RE but also make RE projects more lucrative and profitable for investors.

1.3 Research Problem and Questions

Insufficient or non-availability of sustainable energy production in many developing countries continue to stifle economic growth and though RE- resources are available in abundance they have not been fully harnessed.

In the course of this thesis work the following questions will be answered:

- What are the key financial risks in the development of RE projects such as solar, wind, and biomass energy sources in general but especially in developing countries?
- What are the benefits of the project finance model versus the balance sheet financing model?
- What is the most appropriate financial model in the development of RE projects in developing countries?

2 RENEWABLE ENERGY TECHNOLOGY AND SOURCES

This chapter will consider the different renewable energy sources available and briefly look into the various technologies implemented in renewable energy projects in developing countries. The three (3) major renewable energy sources are: Solar, Wind, and Biomass.

2.1 Solar Energy

Solar energy or sun energy is an inexhaustible source of energy as it is the radiant light and heat from the sun harnessed using a range of ever evolving technologies (I.E.A, 2011). The earth receives 174,000 terawatts (TW) an equivalent of 1,524million TWh or approximately 5.5million EJ/year of incoming solar radiation at the upper atmosphere (Smil, 1991: 240). About 30% of this is reflected back to the atmosphere while about 70% is absorbed by clouds, oceans, and land masses (I.P.C.C, 2001). The total energy absorbed by earth's atmosphere, oceans and land masses is about 3,850,000 Exajoules (EJ) per year (Smil, 2006). 'The solar radiation reaching the earth's surface in just one year, is an order of magnitude greater than all the estimated (discovered and undiscovered) non-renewable energy resources, including fossil fuels and nuclear'. (World Energy Council, 2013).

Most people around the world live in areas with solar radiation level of about 150-300 watts per square meter or 3.5-7.0 kWh/m² per day. The United Nations Development programme in its 2000 world energy assessment found the annual potential of solar to be 1575-49387 EJ which was way larger than 559.8EJ the total energy consumption by the world in the year 2012. The report also shows that Middle East and North Africa has the highest potential with minimum of 412.4EJ and maximum of 11060EJ, followed closely by sub-Saharan Africa with 371.9 and 9528EJ minimum and maximum respectively (W.E.A., 2000).

Solar Energy is utilized by converting sunlight into electricity directly using photovoltaic technology (PV) and indirectly using concentrated solar power technology (CSP).

2.1.1 Photovoltaic Technology

This technology makes use of photovoltaic cells, also known as solar cells and they convert light rays from the sun or photons into electricity through semiconductors such as silicon (Ndzibah, 2006; 2010; 2013). The process is both physical and chemical in nature, as the first step involves the photoelectric effect - a process where many metals emit electrons when light shines upon them. Electrons emitted in this manner can be called *photoelectrons*. This is commonly studied in electronic physics, as well as in quantum or electro-chemistry (Serway, 1990). The second step is an electrochemical process – a process where electrons are transferred to or from molecules or ions changing their oxidation state and this occurs through the application of an external voltage or through the release of chemical energy. This process involves crystallized atoms being ionized in a series, thereby generating an electric current. When rays from the sun or photons strike the surface of the silicon or other semiconductors used for photovoltaic cells, it is absorbed within the material so that its energy excites an electron to a voltage sufficient to produce a small electric current.

Figure 1 below illustrates the operation of a basic photovoltaic cell, where a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current or electricity. This electricity can then be used to power a load, such as a light or a tool.

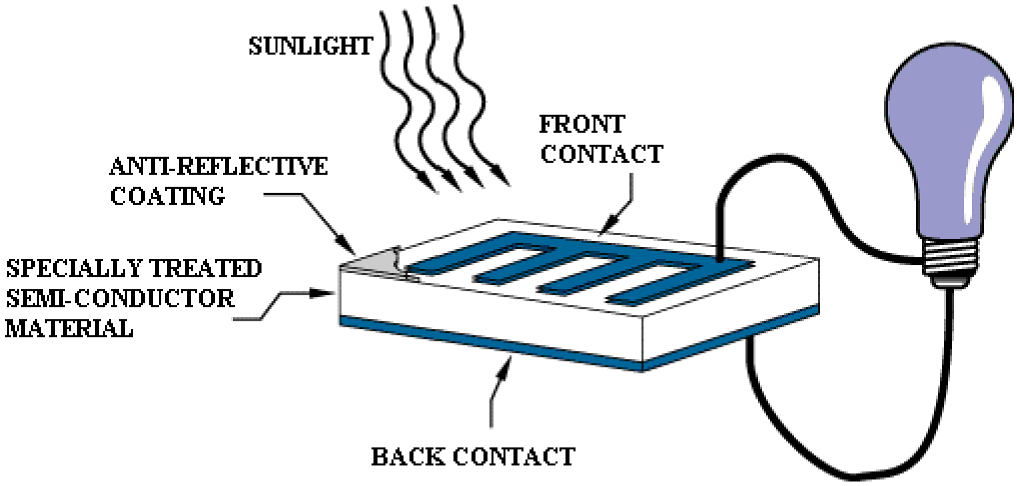


Figure 1: How the Photovoltaic works (NASA).

The more rays or photons absorbed by the semiconductor the more electrons are produced and the greater the current available.

Lots of improvements in the photovoltaic technology in recent times have led to better efficiency of generation. The Energy Department's National Renewable Energy Laboratory in the U.S. announced in December 2014 the demonstration of 45.7% conversion efficiency for a four-junction solar cell. This achievement represents one of the highest photovoltaic research cells efficiencies achieved across all types of solar cells. (News Release NREL Dec., 2014)

Figure 2 below shows a chart describing how the photovoltaic cells have evolved over the years as it presents the conversion efficiencies of Best Research solar cells worldwide for various photovoltaic technologies since 1976. These have efficiencies ranging from 9.9% through to the most recent technology with the highest efficiency placed at 45.7%.

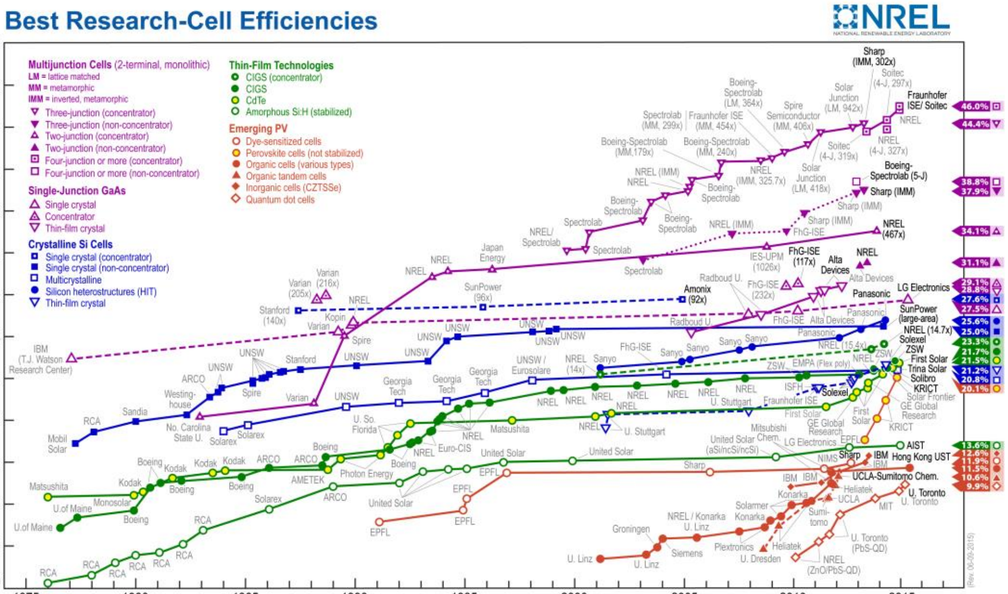


Figure 2: Best Research Cell Efficiencies. (NREL)

In 2008, as part of the ongoing improvements in the photovoltaic world, the ‘energy payback time’ which is the recovery time required for generating the energy equivalent of that spent in manufacturing a modern photovoltaic module was estimated to be from 1 to 4 years (PV FAQs 2008) depending on the module type and location. It is also estimated that a photovoltaic (PV) has a lifespan of between 20 to 30 years.

As at the end of the year 2014, total worldwide installed Photovoltaic capacity increased to at least 177 gigawatts (GW), with 23 members countries of the International Energy Agency - Photovoltaic Power Systems Programme (IEA PVPS) having a cumulative of 155 GW of PV installations together, mostly grid-connected. Additional countries that are not part of the PVPS programme totaled at least 22GW, mostly in Europe: with the UK having 5.1GW, the Czech Republic with 2.1GW (stable in 2014), Greece with 2.6GW (stable in 2014), Romania with 1.2GW, Bulgaria with 1GW (stable in 2014), and below the GW mark, Slovakia and Ukraine. Following these countries, India has installed more than 2.9GW and Taiwan more than 750MW. While other countries around the world have reached various PV installation levels, the total of these remains hard to quantify with certainty. At present, it appears that the 177GW represents the minimum total installed capacity at the end of 2014. Remaining installations account for some additional

GW installed in the rest of the world (non-reporting countries, off-grid installations, etc.) that could bring the total installed capacity to more than 177 GW in total. Germany still leads with (38.2GW), followed by China (28.2 GW), Japan (23.3 GW), Italy (18.5 GW) and the USA (18.3 GW) with all other countries far behind in terms of PV installations.

This total installed capacity at the end of 2014 is sufficient to supply 1 percent of global electricity demands. Figure 3 shows the exponential growth of photovoltaic installations worldwide as they are rapidly approaching the 200 GW mark – about 40 times the installed capacity of 2006.

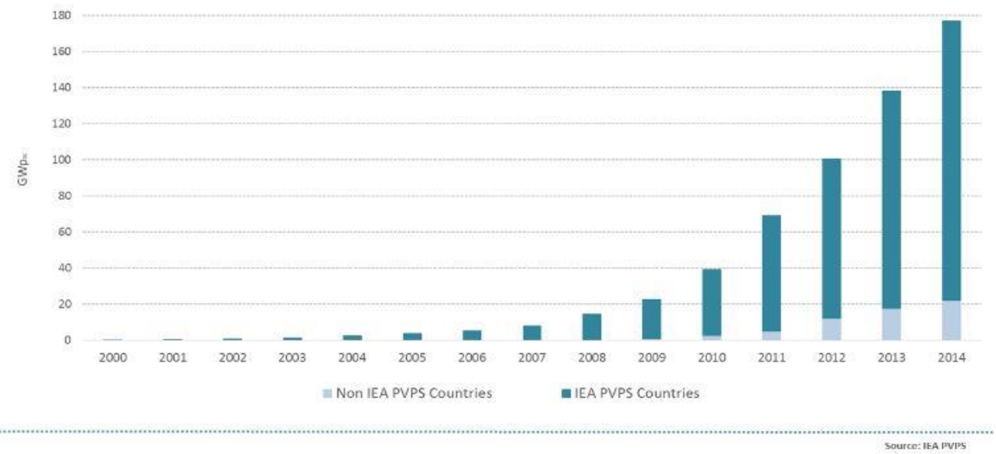


Figure 3: Evolution of Solar PV installations (GW). (IEA PVPS)

The total PV capacity installed in 2014 alone worldwide amounted to at least 38.7GW, if all reporting countries are taken into consideration, with PVPS countries having installed 34GW, and at least 4.7GW reported in non IEA PVPS countries. Figure 4 shows that China installed a capacity 10.95GW of PV in 2014 alone, followed closely by Japan with 9.7GW and the U.S.A with 6.2GW of PV a cumulative of 69.4% of the total reported installed capacity for that year.

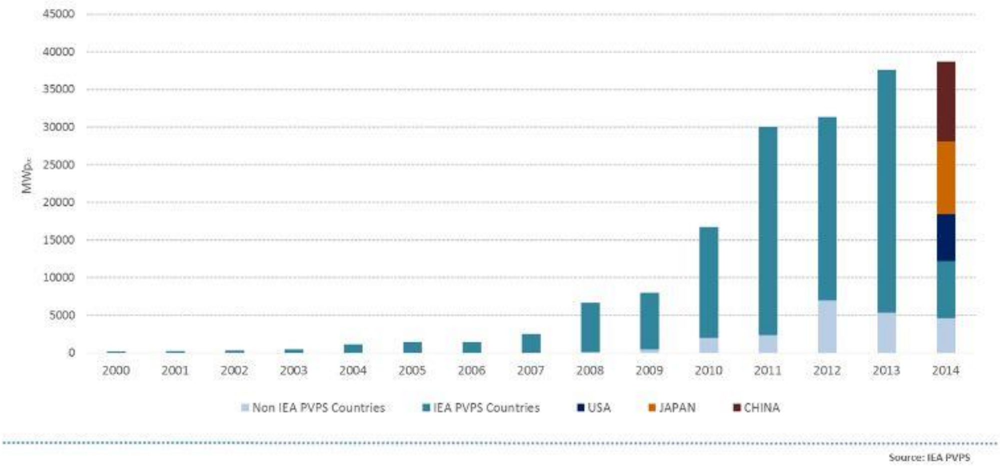


Figure 4: Evolution of Annual Solar PV installations (MW). (IEA PVPS)

All of these points to the fact that photovoltaic technology is seeing lots of development and patronage as we move towards a renewable energy dependent world.

2.1.2 Concentrated Solar Power (CSP) Technology

This technology also called **concentrating solar power**, **concentrated solar thermal**, and **CSP**) systems generate solar power by using mirrors or lenses to concentrate a large area of sunlight, or solar thermal energy, onto a small area or receivers that collect solar energy and convert it to heat. This thermal energy can then be used to produce electricity via a steam turbine or heat engine that drives a generator. There are different ways to collect solar energy that is then converted to heat. These are:

- Linear concentrator systems: A method that uses flat or U-shaped mirrors. The mirrors are lined up in a north-south direction and they follow the Sun as it moves from east to west. Instead of focusing light at a single point, the light is directed along a pipe containing the liquid to be heated. Figure 5 & 6 illustrates a linear concentrator system which reflects the sunlight through parabolic troughs as in the case of figure 5 and through flat or slightly curved mirrors a system also known as the linear Fresnel reflector system as in figure 6. The collected rays heats up the liquid along the receivers from where it is collected in a storage tank or fed directly to a turbine.

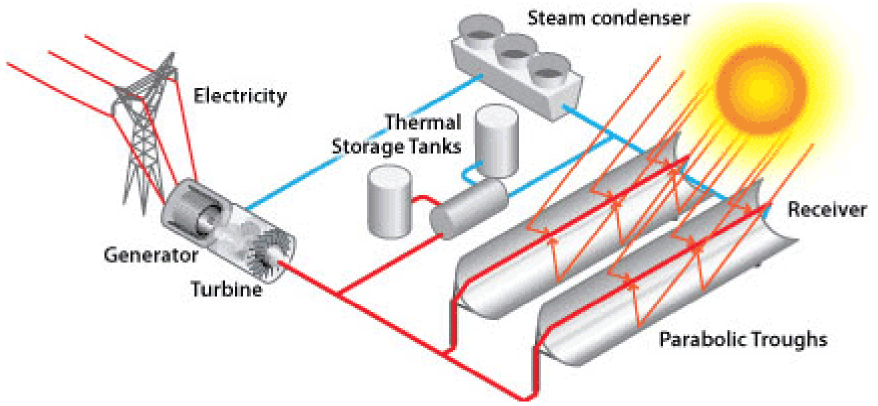


Figure 5: Linear U-shaped concentrator systems. (U.S. Department of Energy)

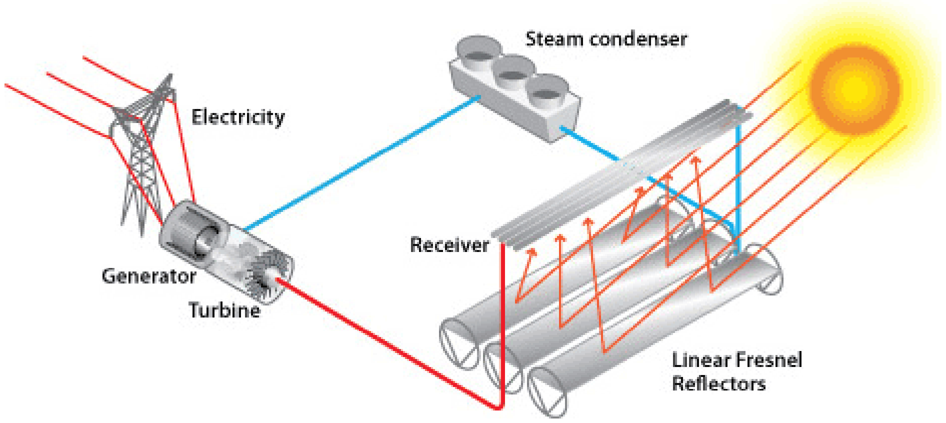


Figure 6: Linear flat shaped concentrator systems. (U.S. Department of Energy)

- Dish or engine systems: Dish/engine systems use a parabolic dish of mirrors to direct and concentrate sunlight onto a central engine that produces electricity. The solar concentrator, or dish, gathers the solar energy coming directly from the sun. The resulting beam of concentrated sunlight is reflected onto a thermal receiver that collects the solar heat. The dish is mounted on a structure that tracks the sun continuously throughout the day to reflect the highest percentage of sunlight possible onto the thermal receiver.

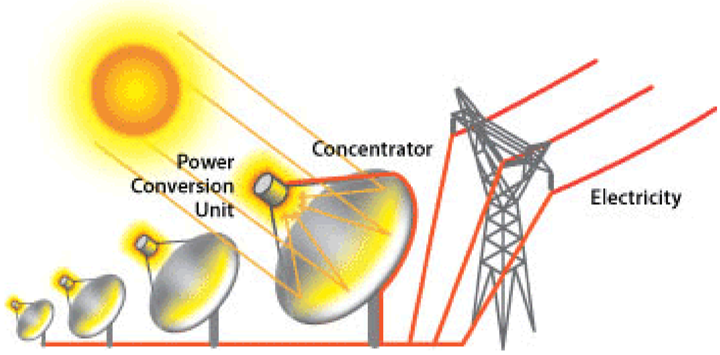


Figure 7: Dish/Engine Power plant. (U.S. Department of Energy)

- Power Tower systems: In power tower concentrating solar power systems, numerous large, flat, sun-tracking mirrors, known as *heliostats*, focus sunlight onto a receiver at the top of a tall tower. A heat-transfer fluid heated in the receiver is used to generate steam, which, in turn, is used in a conventional turbine generator to produce electricity. Some power towers use water/steam as the heat-transfer fluid. Figure 7.0 shows a typical illustration of a power tower plant.

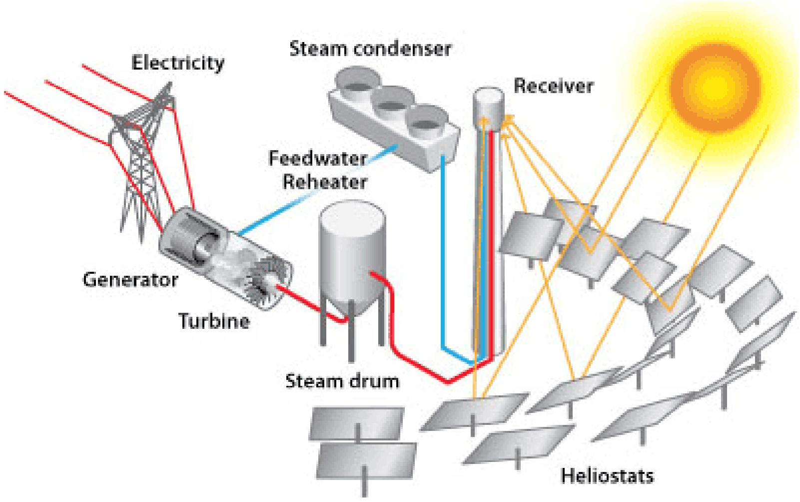


Figure 8: Power tower power plant. (U.S. Department of Energy)

Though the development of CSPs was suspended globally from 1991 to 2005, installed capacity has increased about ten (10) fold since 2004 and has continued to grow on average of 50% per year since then. In 2013, worldwide installed capacity increased by 36 percent or nearly 0.9 gigawatt (GW) to more than 3.4 GW (GSR 2014). Figure 8 below shows global capacity by country and region with the U.S. and Spain leading in capacity.

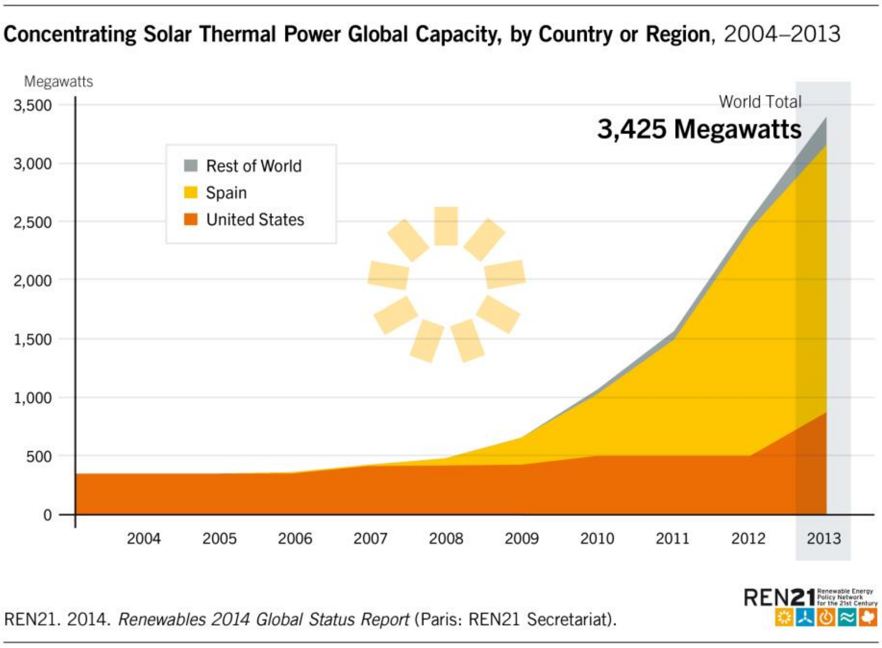


Figure 9: CSP global capacity. (GSR 2014)

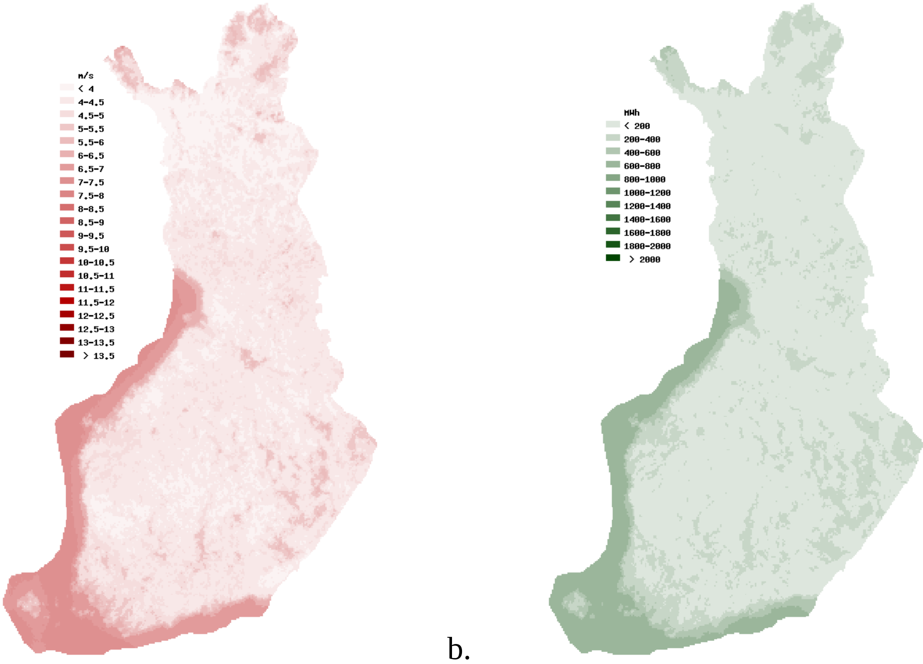
Growing evidence has emerged of the potential cost reductions of larger plants, relating directly to their ability to work at higher temperatures thereby achieving greater efficiencies. According to recent reports efficiencies for the Linear Concentrator System ranges from 14 to 17%, Solar/Power Tower system has about 29% while the Dish/Engine System has about 30% (IEA-ETSAP and IRENA, 2013). CSP costs also continue to be reduced through enhanced design and improved manufacturing and construction techniques. Materials cost through the adoption of new production technologies; the application of lightweight, high-strength materials and a proprietary structural stiffening technique; an automated manufacturing processes to create light and strong structures (GSR 2014). All this factors has increased interest and application of the CSP technologies.

2.2 Wind Energy Resources and Technology

This is the energy obtained through utilization and harnessing the wind to produce mechanical and electrical power. This is achieved with the use of windmills for mechanical purposes as in grain grinding, water pumping etc., and for electrical purposes as in wind turbines. This section will focus only on the conversion of wind energy for Electrical power.

Wind Resources varies by location and height, and a quantitative measure of the energy available at any location is called the Wind Power Density (WPD). It is a calculation of the mean annual power available per square meter of swept area of a turbine, and is tabulated for different heights above ground. Calculation of wind power density includes the effect of wind velocity and air density. Color-coded maps are prepared for a particular area described, for example, as "Mean Annual Power Density at 50 Metres". In the United States, the results of the above calculation are included in an index developed by the National Renewable Energy Laboratory and referred to as "NREL CLASS". The larger the WPD calculation, the higher it is rated by class. Classes range from Class 1 (200 watts per square meter or less at 50 m altitude) to Class 7 (800 to 2000 watts per square metres). Commercial wind farms generally are sited in Class 3 or higher areas, although isolated points in an otherwise Class 1 area may be practical to exploit.

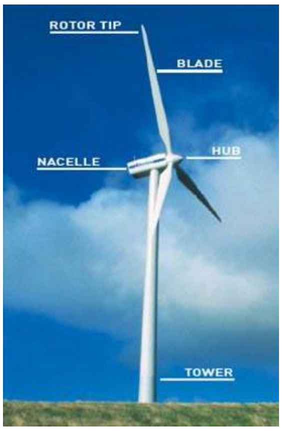
In Finland though, the wind speed is calculated arithmetically for each average month and average year from 3 hours to 6 hours forecasts produced by the numerical weather prediction model AROME and available online. The information is provided by the Finnish Ministry of Employment and the Economy (MEE) and data generated by the Finnish metrological institute with help from the Danish research institute Riso DTU. The Finnish wind atlas generates an average wind speed for different municipalities in three different altitudes 50, 100 and 200 metres above sea level calculated for each 2.5 x 2.5 km grid. The web calculator also provides data of the average wind power production in megawatts hour (MWh) on an atlas map interface for each month of the year at the three (3) different altitudes.



a. b.

Figure 10 a & b: Map of Average Finnish Wind Speed & Power Production for July. (TWA)

Turbines technology has been around for a while now and are in different types depending on their axis of rotation such as in Vertical or Horizontal with the horizontal type being the most common across the world, comprising of a blade turbine rotor mounted on an horizontal shaft. The shaft is connected through a gearbox to a generator, with the exception of the ‘direct drive’ which doesn’t use a gearbox, all of which (i.e. Rotor, Gearbox, Generator) are housed in a ‘nacelle’ and mounted on the top of a tower.



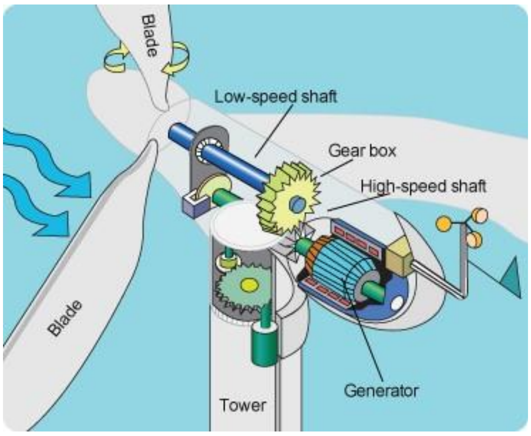


Figure 11a & b: Basic parts of a typical horizontal axis wind turbine. (Breanna B., 2013)

The development of wind turbines have resulted in major technology advancement, aimed at making wind power a better choice for power generation. A modern wind turbine has an average production-based availability around 98 percent (Power Engineering, 2014). It generates different outputs depending on the wind speed. Over the course of a year, it will typically generate 15-30% (or more) of the theoretical maximum output of the turbine. This is known as its capacity factor, and modern turbines are getting reasonably close to theoretical limit of power one can extract from a stream of moving air, hence they are very efficient. Statistics available from the Global Wind Energy Council shows that there has been a constant growth since 1997 and after a little slowdown in 2013, the wind industry set a new record for annual installations in 2014. Globally, 51,473 MW of new wind generating capacity was added in 2014 according to the global wind market statistics as shown in figure 12. The record-setting figure represents a 44% increase in the annual market, and is a solid sign of the recovery of the industry after a rough patch in the past few years. Total cumulative global installations stand at 369,597 MW at the end of 2014 as shown in figure 13. (GWEC, 2014)

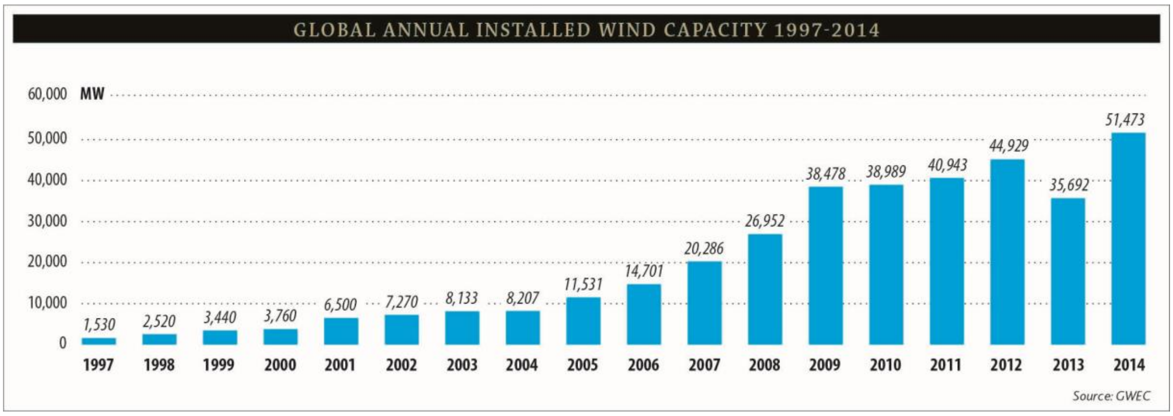


Figure 12: Annual installed wind capacity from 1997-2014 (GWEC, 2014)

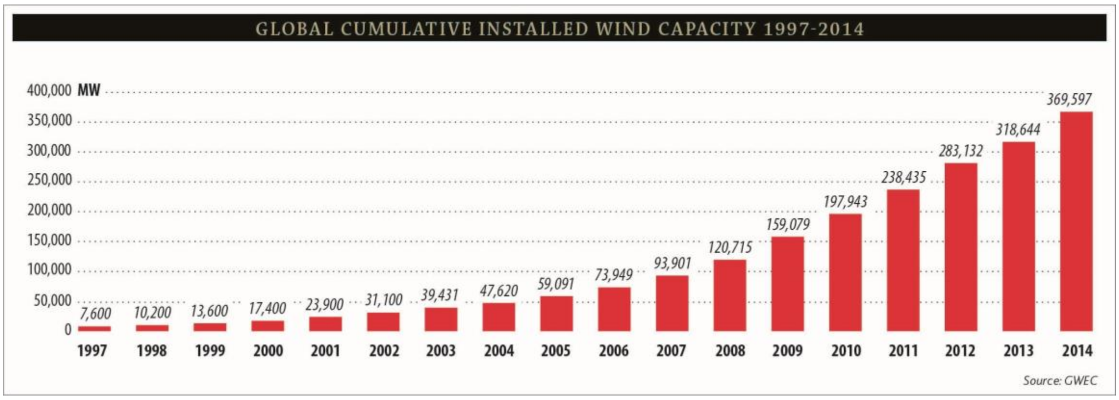


Figure 13: Global Statistics on installed capacity. (GWEC, 2014)

2.3 Bio-Energy Resources and Technology

This is a renewable form of energy obtained from 'Biomass' which is an organic material obtained from a diverse range of sources, the most important of which are energy crops, agricultural and forestry residues, wastes, and existing forestry. The chart below describes common sources of Biomass resources.

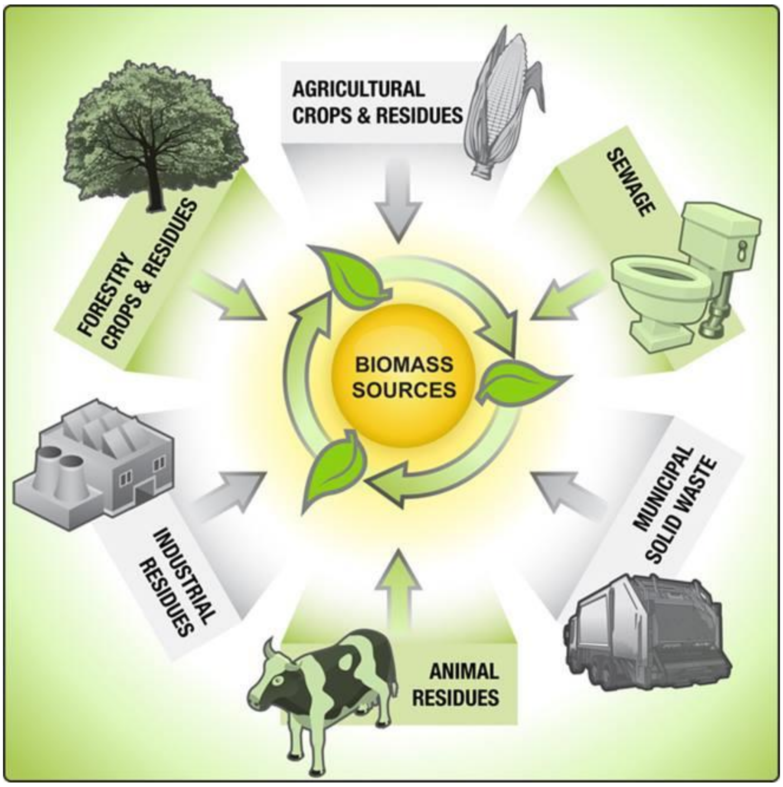


Figure 14: Common sources of Biomass resources

The widest range of potentials in Biomass relates to energy crops which are typically densely planted, high-yielding crop species where the energy crops will be burnt to generate power these includes among many others woody crops such as willow (Blas & Pär, 2008) or poplar and elephant grass, since estimates of their contribution can range from very small to beyond current global primary energy supply. The other categories of biomass (agricultural and forestry residues, wastes and existing forestry) are comparatively neglected in global studies but could make a contribution comparable in size to the existing use of biomass for energy (around 10% of global primary energy supply). Many of the most important factors affecting biomass potentials cannot be predicted with any certainty as a result all estimates must be viewed as 'what if' scenarios rather than predictions. The assumptions leading to the full range of global biomass potentials are found in figure 15 below.

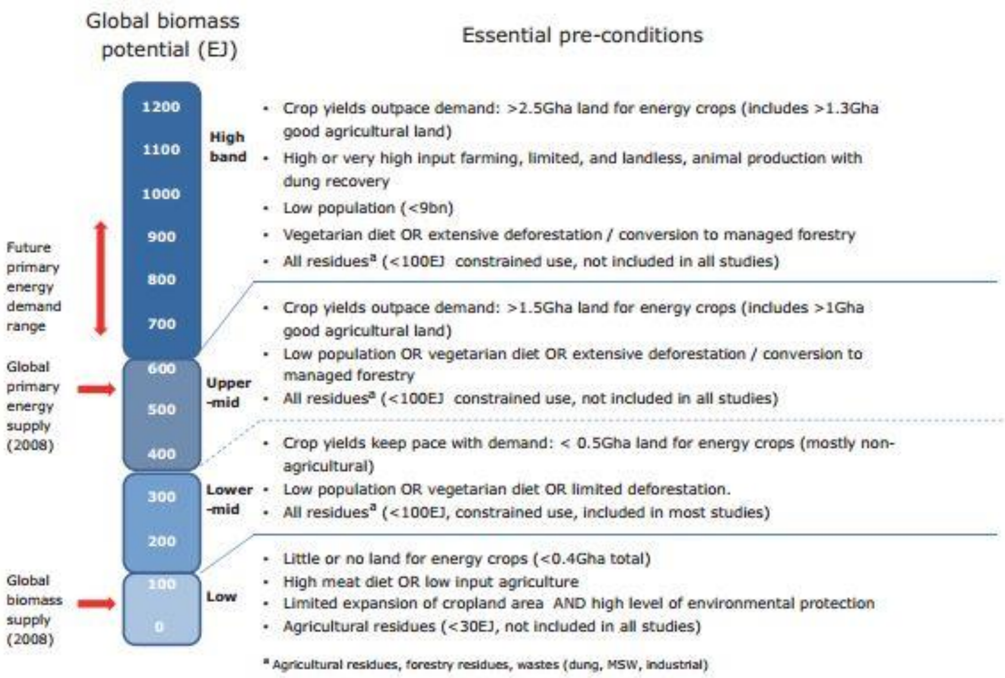


Figure 15: Common assumptions for high, medium and low biomass potential estimates.

The estimates show that at a low estimation there are approximately 100EJ (~1/5th of current global primary energy supply) assume that there is very limited land available for energy crops while under extreme estimation there could be potential in excess of 600EJ. Exploiting the potential in the low band of estimates could make an important contribution to future global primary energy supply through a combination of residues, wastes, and energy crops grown on different land types. Moving from the lower to the middle bands implies a dominant role for energy crops and requires increasingly ambitious assumptions about improvement in the agricultural system, and changes in diet.

Having considered the energy potentials of the Bio-energy resources we will then examine some of the available technologies adopted especially in electricity generation using Biomass resources. These can be categorized into 2 groups the ‘Direct use’ which includes Combined Heat and Power (CHP), Co-generation. Also the ‘Indirect use’ which includes Pyrolysis and Gasification.

2.3.1 Direct Combustion

This is a process where electricity is produced by direct combustion or incineration of biomass fuels using conventional boilers. These boilers primarily burn biomass fuels such as bark, wood chips, saw dust, peat, forest residues and municipal solid or other wastes. When burned, the biomass fuel produces steam, which spins a turbine. The spinning turbine then activates a generator that produces electricity. A typical biomass plant used in energy generation has three main sections as shown in figure 16.

Figure 16: Major sections of a Biomass Electricity plant.

The fuel feed system could be either stocker fuel feed system which is a mechanical system that feeds solid fuel as in this case biomass into the furnace of a steam boiler. The mechanical means used are, depending on design, combinations of the screw feed, the bio-grates and the bucket chain. The fuel feeder moves the fuel into the combustion chamber of the boiler and steam is produced which drives a turbine and the generator which eventually produces the electricity.

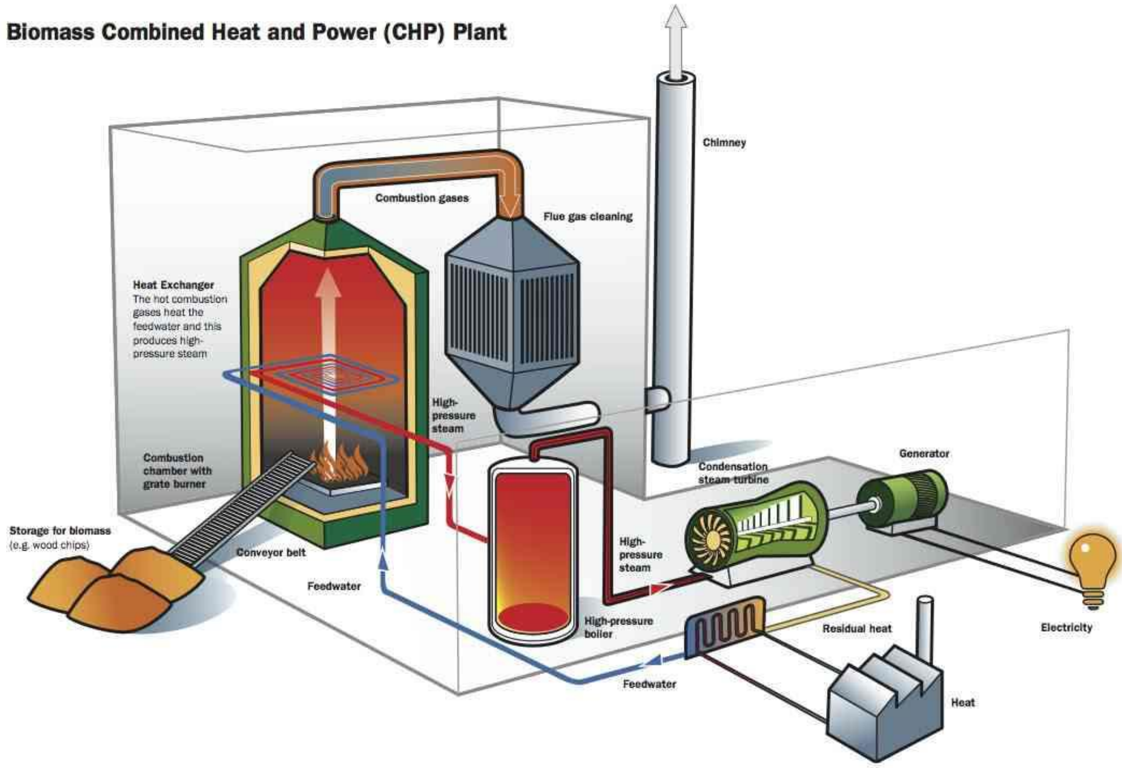


Figure 17: Typical diagram of a biomass plant.

The Bio-grate combustion technology has continued to see improvement in output thereby encouraging its application in energy production especially in electricity generation. The recent efficiencies in bio-grate solutions are up to 90% (Unicon Bio-grate).

2.3.2 Anaerobic Digestion

Anaerobic digestion, or methane recovery, is a common technology used to convert organic waste to produce a biogas, consisting of methane, carbon dioxide and traces of other ‘contaminant’ gases. In this digestion, organic matter is decomposed by bacteria in the absence of oxygen to produce methane and other byproducts that form a renewable natural gas. It also occurs naturally in some soils and in lake and oceanic basin sediments, where it is usually referred to as "anaerobic activity". This is the source of marsh gas methane as discovered by Volta in 1776. (Macgregor, A. N. and Keeney, D. R. 1973)

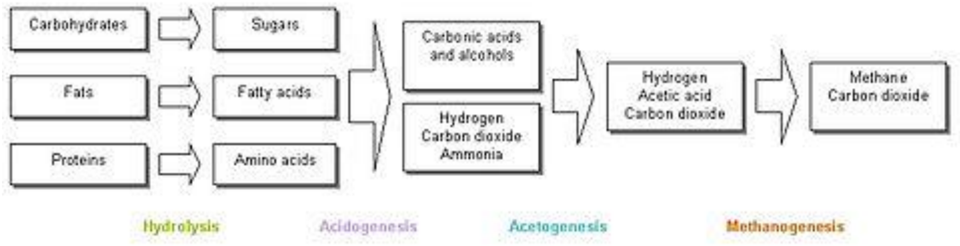


Figure 18: The key process stages of anaerobic digestion

There are 4 main processes in an anaerobic digestion and this includes as in figure 18.

- Hydrolysis where a compound is chemically decomposed thereby splitting into other compounds when reacting with water.
- Acidogenesis which is the second stage where further breakdown of the remaining components by acidogenic (fermentative) bacteria takes place to produce much simpler molecules.
- Acetogenesis is the third stage in anaerobic digestion where, simple molecules created through the acidogenesis phase are further digested by acetogens to produce largely acetic acid, as well as carbon dioxide and hydrogen.
- Methanogenesis which is the last stage is the stage where methanogens use the intermediate products of the preceding stages and convert them into methane, carbon dioxide, and water.

The digestion process begins with bacterial hydrolysis of the input materials. Insoluble organic polymers, such as carbohydrates, are broken down to soluble derivatives that become available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen ammonia, and organic acids. These bacteria convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Finally, methanogens convert these products to methane and carbon dioxide. The methane which is a biogas is then used directly as fuel, in combined heat and power gas engines or upgraded to natural gas-quality bio-methane. Figure 18 above shows the key major processes of an anaerobic digestion.

The methane is then dried of water to make it safe for use as fuel in combined heat and power engines.

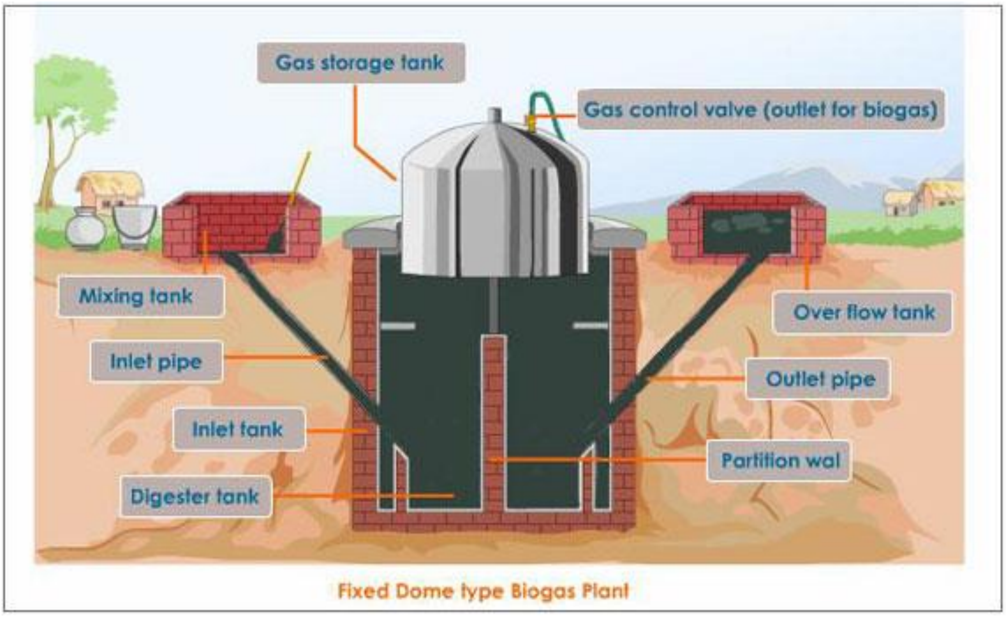


Figure 19: Fixed dome type biogas plant. (tutorvista.com)

Over the medium term, bioenergy generation and capacity are expected to scale up significantly. Global bioenergy production is expected to reach 560 TWh in 2018, up from 370 TWh in 2012 (+7% annually on average), driven by renewable energy targets in both OECD and non-OECD countries, as well as rapidly growing energy demand in a number of emerging economies with good biomass and renewable waste availability. The total of 370 TWh of bioenergy electricity produced in 2012 corresponds to 1.5% of world electricity generation.

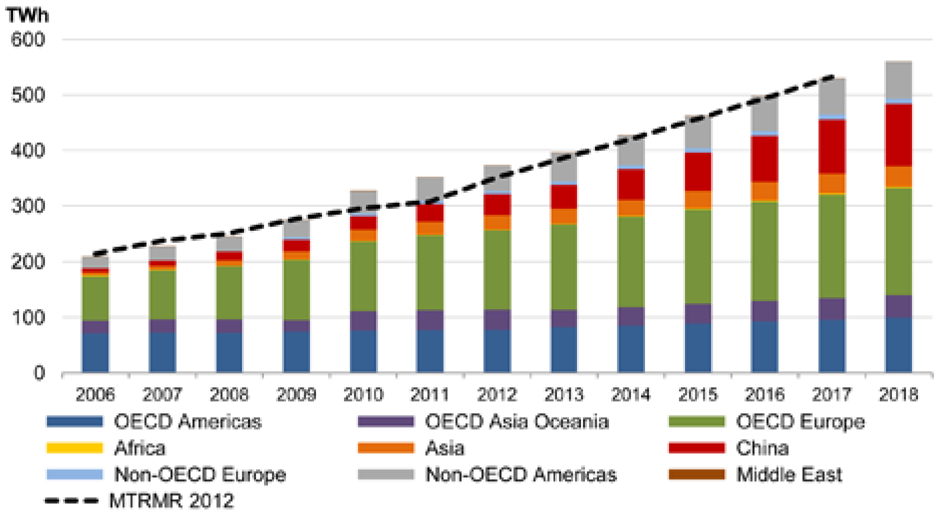


Figure 20: Medium-Term Renewable Energy Market Report (OECD/IEA, 2013).

Latest report states that the world's major bioenergy markets - namely the US, UK, Germany, Brazil, India and China - all witnessed growth over the last decade, except for the US, which saw a falling trend in annual capacity additions during 2007 to 2014. The annual installation of bioenergy capacity globally peaked in 2009 at 6.9 GW, due to increased installations in most key bioenergy countries during that year, with considerable installations in several other countries as well. This was followed by a slight decline in 2010, which can be attributed to the drop in capacity additions in the Americas and Europe as a result of the financial crisis. It is believed though that as more countries start adopting bioenergy - thanks to increased interest and state promotion - annual capacity additions will rise after 2015. However, it is suggested that annual installations worldwide will not return to 2009 levels until 2021. (GlobalData market report).

3 FINANCING OPTIONS AND FACTORS INFLUENCING THEM.

This chapter will review some of the major types of financing options available in financing renewable energy technology (RET) projects, it will also specify those options that are more compatible with the project finance model. These options are classified as direct or indirect financing options such that they address some barriers and define the level of risks involved and assumed by various players investing and financing renewable energy technology projects. It will further discuss other factors that are considered or that determine the choice of financing options that should be used.

3.1 Grants and Guarantees

These are basically 'non-repayable funds or products disbursed by one party (grant makers), often a government department, corporation, foundation or trust, to a recipient, often (but not always) a nonprofit entity, educational institution, business or an individual' with specific requirements or terms of use. These are generally allocated or approved to leverage the cost of operation or production of its recipients and are offered to promote environmental and developmental policies. Grants for financing renewable energy projects often originate from private foundations, but can sometimes be procured from international development organizations such as World Bank, the Global Environmental Fund (GEF), bilateral funding organizations or national renewable energy funding divisions as well.

Guarantees are contractual agreements or promissory notes from a financing or well capitalized organization to take responsibility for payment of a debt if the liable organization fails to do so, these are offered by multilateral development banks and national development bank. An example is the Multilateral Investment Guarantee Agency organized by the World Bank which provides investors and lenders coverage over political risk by insuring eligible projects against losses relating to currency transfer restrictions, breach of contracts, expropriation, wars and civil disturbances making developing countries attractive for investment opportunities.

There is no doubt that for Renewable Energy projects to be attractive and competitive the need of grants and guarantees cannot be overemphasized, knowing fully well that the initial investment or capital cost are usually very high compared to the conventional (fossil based) energy projects.

3.2 Debt Financing

This form of financing involves taking a loans or issuing bonds to provide capital and they both require repayment and most times with charged interests. Creditors who provide debt financing for projects are not interested in owning shares in the project but provide the funds for the purpose of earning interest. Creditors are very low risks takers as they have to be paid first though their returns may be limited to risk-adjusted market interest rates.

This is the most common type of project financing for developmental projects but they are granted on credibility basis both of the lender or credit taker and of the project it is meant for. Loans also comes with strict or specific schedules of payments and default may result in blacklisting the organization (credit taker) from assessing future facilities.

The major sources of debt financing are commercial banks both international and national. Banks can syndicate the debt financing of a major project among several other banks thereby sharing interest, but most importantly minimizing their risk exposure on that project.

Other sources for loans may include among many others multilateral development banks, international finance corporation, debt/equity investment funds, equipment suppliers, and private investors.

It should be noted though that international funds dedicated to developmental projects grant 'soft loans' that is loans with generous repayment terms as compared to commercial banks, they also provide this facility at a considerably low interest rates and a much more flexible repayment schedule.

There are two major types of debt financing available in renewable energy technology project and these are senior debt, and subordinated debt or mezzanine finance.

3.2.1 Senior debt

Senior debts are provided from public sources either in the form of project loans or credit line and they form the first among creditors to be repaid from a project. This loans are basically used to subsidize the cost of a project through provision of concessionary funds that may be blended with more expensive commercial debt, they also offer a longer-term payment period than may be available in local financial markets. These Long-term loans from public sources also help establish credibility among private financiers for longer-term lending to RET projects. A wide variety of debt amortization and repayment schedules can be used, allowing adaptation of debt service costs to project cash flows. An example is a lump sum payment of the principal amount paid at the maturity of the loan otherwise also known as bullet repayment which serves to reduce debt service costs in the initial years of the project.

There is also a major difference between direct loans to project companies and the provision of credit lines extended through commercial financing institutions (CFIs) or other intermediaries is that Credit lines can create incentives for intermediaries to extend their own loans to RET projects alongside that funded from the credit line as well as allowing blending of commercial and concessionary loans to reduce overall costs.

3.2.2 Subordinate Debt or Mezzanine Finance

Subordinated debt is debt which ranks after or are with lesser priority of payment than other debts if a company falls into liquidation or bankruptcy. This is synonymous with Mezzanine financing which basically is an interim debt, in which a borrower gets money for a project while looking for a better deal. Subordinate and/or Mezzanine debt are typically very expensive, as they carry higher risk that is generally compensated for by a higher returns than on senior debt.

Most professionals consider this as an interim measure - for use when they need money quickly - rather than as a long-term financing option. In renewable energy technology projects this is especially valuable as it allows project developers to reduce the risk to senior lenders by reducing the share of senior debt in total project financing, while still retaining control of the project. By doing so, it can make senior debt less costly or even make it available where it previously was not. It can also be used to extend the effective term of loans, thus helping project cash flows and viability.

3.3 Equity Financing

Equity financing provides capital in a project in return for a share of the equity of the project. This form of financing carries high risks as such expected returns is also considerably high, sometimes two or more times higher than that on debts and as such requires getting the right investor(s) who believes in the viability of the project and are ready and willing to buy a stake in it. It involves sharing ownership with other investment partners through ordinary or preferential shareholding, revenues after all other financial and tax obligations have been met. They also hold decision making rights in the project or company to protect their investments.

There are different channels of acquiring equity financing, common among which include project developers, venture capitalists, equity fund investors, equipment suppliers, multilateral development banks, insurance companies, cooperative societies/organizations and private individuals.

3.4 Corporate financing/Balance sheet Financing

This is a typical or traditional form of financing projects where a business organization either sole proprietorship, business partnership or corporation stake their resources in financing a project either directly by providing the funds from their 'on-balance sheet' assets or through acquisition of loans from financial institution with their 'on-balance sheet' assets as collateral (UNEP, 2004). In the situation debts or loans are granted and paid off based on an organization's balance sheet and not on the viability of the project. To qualify for the loan or debt financing in this case the organization or company has to be able to prove beyond reasonable doubt through their financial statements that they have the financial capability to offset the debt should the project fails. (Tony & Cyrus, 2002)

3.5 Factors affecting and/or influencing the various financing options

There are various and in fact an in-exhaustive list of factors that may influence or affect the financing of renewable energy projects but in this work, I will be limiting this to those that can directly impact on the choice of financing options chosen for a RET project.

3.5.1 Government Policy

Government policy is a statement of intent that describes the legal framework, prescribes acceptable methods or behaviors and is implemented as a procedure or protocol within a sector of the economy. Essentially, a policy is simply the way things are or to be done within the sector of the economy.

Essentially policies are made to serve as principles or guides for decision making and to achieve rational outcomes.

3.5.2 Status of Financial sector

The financial sector of a country or region is critical to its economic growth which is directly impacted by the sustainable development of the energy sector.

A substantial number of empirical researches directly link the impact of the operation of the financial system - either substantial or not, on the economic growth as microeconomic-based evidence is consistent with the theory that a better developed financial systems ease external financing constraints facing firms, which illuminates one mechanism through which financial development influences economic growth. (Levine, 2005).

3.5.3 Inflation

Inflation is a sustained increase in the general price level of goods and services in an economy over a period of time. (Blanchard, 2000). This implies that a given currency or medium of exchange in an economy loses its real value as its purchasing power is reduced as compared over a fixed period of time. There are two common measures of inflation and these are:

- Consumer Price Index: which is an annualized percentage change in a general price index numbers. This is based on a basket of goods and services and their percentage change in prices over a fixed time period.

  Mathematically CPI = $\frac{PIN_t - PIN_{t-1}}{PIN_{t-1}} \times 100\ \%$

  Where PIN_t is the price index number of the year to be measured, while PIN_{t-1} is the price index number for the previous year. (Dwiveli, 2010).

- Gross National Product (GNP) deflator: This is the ratio of a country's nominal gross national product to its real **gross national product**, expressed as a percentage. It measures the percentage increase or decrease in the price of products and services (inflation) by comparing the current **GNP** to a base period. This is more accurate as it incorporates all of the final goods produced by an economy.
  Mathematically GNP Deflator = $\frac{\text{Nominal GNP}}{\text{Real GNP}}$ X 100%

Economist believe a low rate of inflation is essential as it helps stabilize an economy allowing it to adjust more quickly to changes thereby preventing liquidity problems.

3.5.4 Credit Rating

This is a form of evaluation of the credit-worthiness of a debtor or a prospective debtor and predicting the debtor's ability to pay back the debt. The rating cut across individual corporations or firms and governments. In the case of government, a sovereign credit rating is applied and this indicates the level of risk of the investment environment for would-be foreign investors. These ratings are divided into different components such as political, economic risk and so on. These ratings are mostly complex processes due to the facts that it provides information about a prospective investment destination that is not readily available to the public. Kisgen credit rating - capital structure hypothesis also (Kisgen, 2006) argues that concerns about the impact credit rating changes directly affects the capital structure decision making. There are many credit rating agencies ranging from North Americas to far east Asia, but of this, there are 3 internationally acclaimed known as the ’big three’, these are: Moody’s, Standard & Poors and Fitch ratings.

3.5.5 Exchange Rate/Currency Volatility

This is the tendency for foreign currencies to appreciate or depreciate in value, thereby influencing the profitability or otherwise of foreign exchange trades or investments. As is obvious economies need foreign direct investments to achieve their potentials and thus implies that dealings would require the use of different currencies, this means that fluctuations in conversion rates especially when the margin is high over a period of time could greatly impact on overall financing of such FDIs. Studies have shown that real exchange rate volatility greatly impact on FDI negatively, thereby confirming other studies that real exchange rate volatility (risk) tends to reduce FDI inflows into any country (Anthony & Kwame, 2008).

4 RESEARCH METHODOLOGY

The methodology of a research is described as the 'overall approach to a problem which could be put into practice in a research process, from the theoretical underpinning to the collection and analysis of data' (Remenyi et al, 2003). Similarly methodology is also described as the 'overall approach to the entire process of a research study' (Collis and Hussey, 2009). With this in mind this chapter will consider the systematic approaches available for research work in the light of strategy, methods and data collection, it will then specify which of these various options will be employed in this thesis work.

4.1 Strategy

Saunders et al (2009, pp600) defined research strategy as 'the general plan of how the researcher will go about answering the research questions' as defined in the first chapter of this thesis work. On a similar note, Bryman (2008, pp698) identified research strategy as a 'general orientation to the conduct of research'. Research strategy, according to Remenyi et al (2003), provides the overall direction of the research including the process by which the research is conducted. Saunders et al (2009) mentioned that appropriate research strategy has to be selected based on research questions and objectives, the extent of existing knowledge on the subject area to be researched, the amount of time and resources available, and the philosophical underpinnings of the researcher. Yin (2003b) recommended that a particular research strategy has to be selected based on three (3) conditions; the type of research question, the extent of control an investigator has over actual behavioral events, and the degree of focus on contemporary or historical events.

4.2 Research Techniques

There are differing types or approaches to research, many of which are adopted depending on what data is available to work with and what is intended to be achieved. The various types of research types are; Qualitative, Quantitative, Correlation/Regression methods, Meta-analysis.

4.2.1 Qualitative Techniques

Qualitative research technique is a method designed to explore the human elements of a particular topic, where specific methods are used to examine how individuals see and experience the world (Lisa, 2008). This method is best for addressing many issues as it examines the *why* and *how* of the why questions that researchers have in mind when they develop their projects and not just the *what*, *where*, *when*, or *who*. They are also typically used to explore new phenomena and to capture individuals' thoughts, feelings, or interpretations of meaning and process. Data collection in this technique vary widely using either unstructured to semi-structured methods and this include group discussions, individual interviews, participation and observation.

In addition to these, official documents, articles, pictures which are referred to as secondary data can also be collected to support the primary data collected in exceptional cases (McDaniel, Roger, 2009), a case study (Stake, 1995;Yin, 1989) which examines in-depth "purposive samples" to better understand a phenomenon (Racino, 1999) is also used. Samples more often used in this methods are smaller but focused than large samples which may also be conducted by the same or related researchers or research centers (Braddock, et al., 1995).

4.2.2 Quantitative Techniques

Quantitative Research technique is a method used to quantify a problem or to test a hypothesis and measure the connection between empirical findings and the mathematical expression of a relationship which is then translated into useable statistics. In this method, research work starts with a statement of a problem theory/ies or mathematical models, from which a hypothesis is derived or designed (Isadore & Carolyn.1998). Data is generated and results generalized from a larger sample population as the main objective of this research method is not to get deeper knowledge and understanding of the phenomena but the Results and conclusion are based on the statistical analysis (McDaniel, Roger, 2009).

Commonly used in gathering materials or data for quantitative research techniques are surveys (online surveys, paper surveys, mobile surveys and kiosk surveys), face-to-face interviews, telephone interviews, longitudinal studies, website interceptors, online polls, and systematic observations.

4.3 Methodology of this research work

According to Yin (1994) the following main strategies of research are; surveys, experiments, histories, archival analysis, and case studies (real life or proposed). In addition the choice of the research strategy used is determined by such criteria as; the type of research question, the level of control the researcher on actual behavioral events, and the level of focus and attention placed on the contemporary as against historical events. In this thesis work the qualitative techniques approach have been adopted, using a 'Business case' study and interviews of selected professionals.

4.3.1 Business case study

A Business case is a well-structured document that presents a valid and substantiated argument for a project, policy, or program proposal requiring resource investment often including financial commitment (BCG, 2000). It is also a very viable management tool used in planning and decision making for a project as it provides an analysis of the cost, benefits and risk involved in a potential project. A compelling business case often captures both quantifiable and non-quantifiable characteristics of a proposed project and in some organizations it is referred to as a project feasibility study while some refer to it as concept study. For the purpose of this thesis work a 'Business case' is more or less referred to as a feasibility study (Simiao, 2012) for renewable energy projects. Figure 21 below shows the typical business case development process.

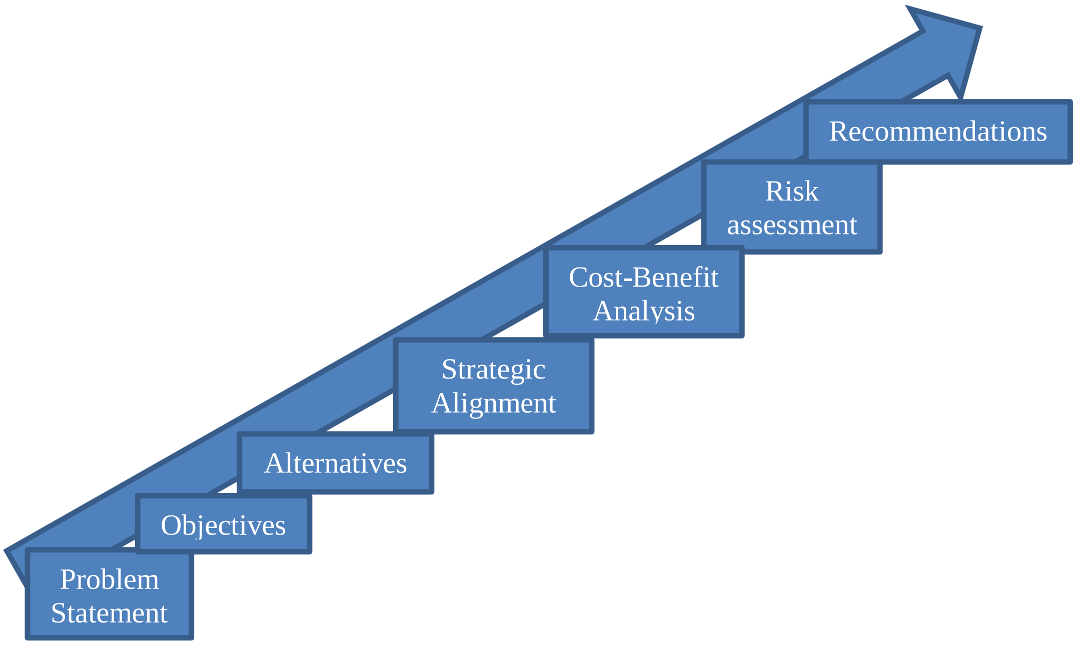


Figure 21: Business Case Development Process (Simiao, 2012).

4.3.2 Interviews

An interview is a one-on-one conversation where questions are asked and answers are provided. This can be structured or unstructured. A structured interview which is adopted for this thesis work is aimed at engaging the interviewees to respond to research questions prepared with specific wordings and sequence (Patton, 1991).

5 RESULTS

A business case as described earlier in this work is a feasibility study that is necessary, as a research work has it that only one in fifty business ideas are really commercially viable. As such the business case provides an in-depth study to help verify if a proposed idea or project is worth implementing. To implement this business case using the general business case development process I have readjusted the process for this work as shown in figure 22 below.

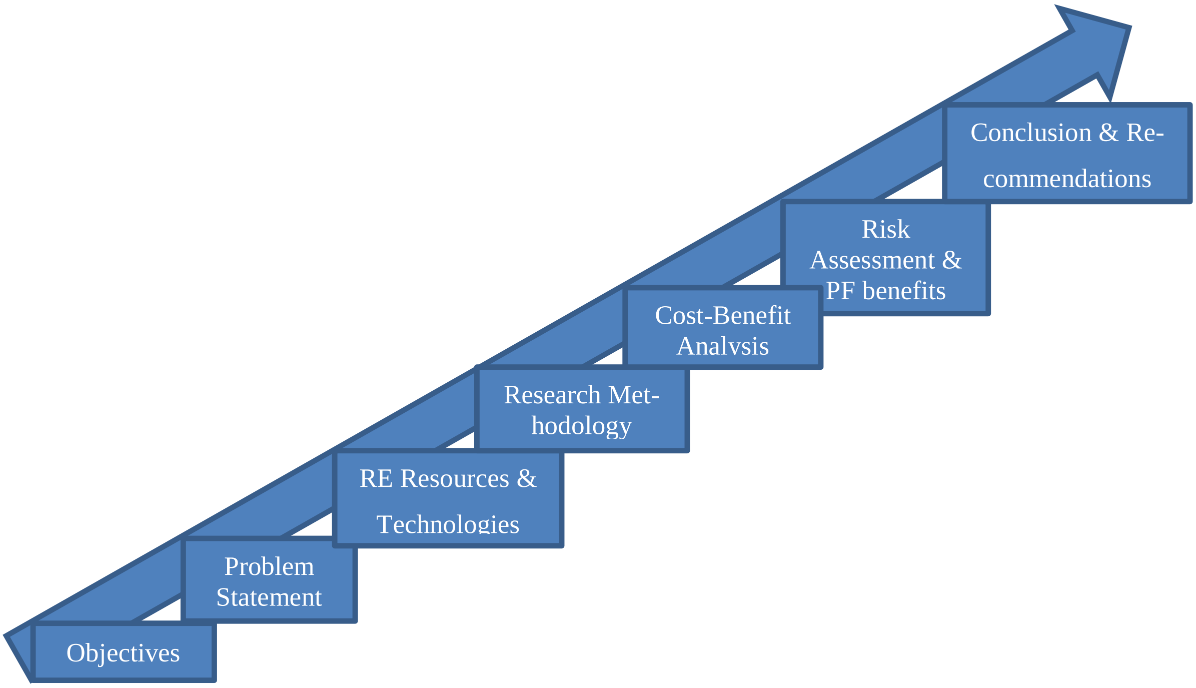


Figure 22: Business case development process for renewable energy technology projects.

The chart above clearly shows the various stages involved in the development process of an RE project and so far this thesis work has covered different stages of the process from chapters one through four. Therefore this chapter will focus on the cost-benefit analysis which will help to define an appropriate financial model in the development of RE projects in developing countries. It will also cover the risk assessment of renewable energy technology projects and recommend different ways to either reduce or avoid this risks.

5.1 Cost-Benefit Analysis

This analysis assesses the various cost involved in the development of the different renewable energy technology projects and the evaluation of these costs using the "Microsoft Excel" and "Energy Business Calculator" software which helps to determine the correlation of the various parameters to establish the relationship between this parameters.

5.2 Project Costing

There are different types of data estimations/assumptions needed in putting up a renewable energy project, these involves both fixed and variable cost and includes capital expense, operating expense, Annual Energy yield, Energy price, Financing assumptions and sensitivity analysis.

5.2.1 Capital Expense (CapEx)

This cost describes the total investment cost involved in the project and these includes cost of land, technology modules, mounting of structures, support infrastructure, grid infrastructure cost and start-up cost. The capital cost expenditure assumption is derived from the U.S. national renewable energy laboratory cost estimation.

5.2.2 Operating Expense (OpEx)

These are cost incurred in the day- to- day running of the plant after its commissioning, and this includes personnel cost and cost of replacement or repair of the various parts, it also includes the cost of obtaining the feedstock especially in the case of bioenergy technology and it is derived from the U.S. national renewable energy laboratory cost estimation.

5.2.3 Annual energy yield

This describes the total calculated energy capacity of the plant which takes into consideration the capacity factor or technology efficiency, availability factor, down-time or maintenance period, installed capacity and the module yield loss factor.

5.2.4 Energy Price

This is the agreed price/tariff stipulated in the power purchase agreement (PPA), as this is crucial to the economic viability of the project or not. There is no gain saying that renewable energy technology projects are projects with high capital cost as such the higher the negotiated tariffs the better. The tariffs and other financial incentives in Nigeria are fixed by the Nigerian Electricity Regulatory Commission (NERC) and the Energy Commission of Nigeria, and this is contained in the National Renewable Energy and Energy Efficiency Policy, the latest of which was drafted in March 2014. It is also notable to state that the tariffs defer from each other depending on the renewable energy technology been considered.

5.2.5 Financing Assumptions

Generally a financing structure is composed of Debt, Equity and most often than not grants or subsidies. Though other factors are considered still, banks are willing and able to give upwards of seventy percent (70%) as debt financing for viable projects, while the remaining part, especially equity takes a substantial part of the project finance.

5.2.6 Sensitivity Analysis

This analysis helps to observe how the different parameters affect or are affected by changes in each other, and how this can be explored in the decision making while considering the viability of a project. Parameters such as NPV, IRR, Pay-back-time, loan repayment period, equity ratio, FIT etc. all are connected to each other and with a little variation in any will affect the other.

5.3 Solar PV Power Plant

The following assumptions in Table 1 below, has been used in preparing the Business case analysis for a typical ten megawatt (10MW) solar PV project in Nigeria, some of which are stated in the national renewable energy and energy efficiency policy and other official documents of the federal republic of Nigeria.

Table 1: Parameters and Assumption for Solar PV power project in Nigeria.

Parameters	Assumptions for Solar PV	
Capital Expense CapEx KW ($ 1=€0.89)	$ 2,025	€ 1,792
Capacity Factor Solar PV / Efficiency (%)		21
Availability (%)		49.52
Max. Operating Expense OpEx ($/kW/Yr.)	$(16+9=25)	€22.25
Cost of loan (%)		6
Cost of Equity (%)		15
Profit tax % (50% of Normal)	Normal Profit Tax = 30%	15
Life span of Plant (Years)		20
Period of Loan (Years)	Loans are granted between 8-18	12
Feed in Tariff (FIT) KWh (₦1 =€ 0.00445)	₦ 92.19	€ 0.41

(Data from U.S. National Renewable Energy Laboratory & National Electricity Regulatory Commission Nigeria)

The above assumptions was applied to an excel spread sheet to derive the following results in Appendix 1 & 2.

Using the information from Appendix 1 & 2 on the Energy Business Calculator, an optimization graph is generated that clearly shows the correlation between the Internal Rate of Returns for the investment and the equity ratio of investment as shown in Figure 23 below.

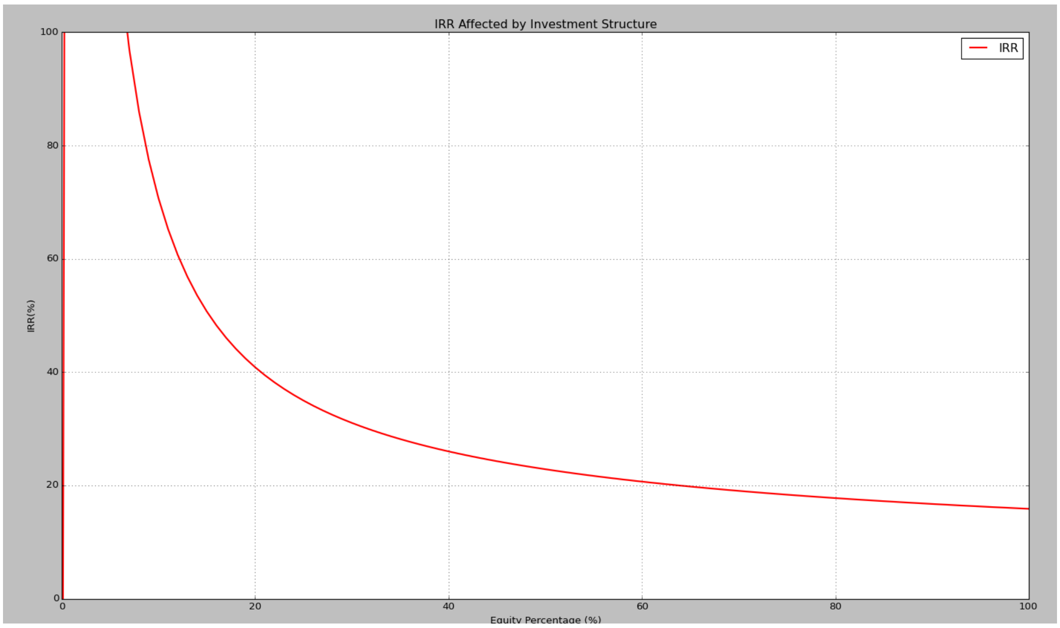


Figure 23: Optimization graph for Solar PV IRR-Equity percentage/Ratio

Figure 23 shows that the higher the equity contribution in a solar PV plant the lower the returns on the investment, this is obvious as cost of debt financing is way lower at 6% compared to the cost of equity financing which is always higher as equity investors want a way better returns for their investment. Therefore when the equity contribution of the solar PV plant is 30% the IRR on the investment is 29% but when the equity contribution of the investment cost of the solar PV plant is reduced to about 20% the IRR rises to approximately 38%, while the payback period of the equity investment reduces drastically from 3.5 to 2.7 years. Appendix 1 & 2 also provides other data such as the debt service cover ratio (DSCR) which is at 2.32 and 2.03 respectively showing the capacity of the project to settle its obligations. All of this points to the importance of grants, guarantees and possibly soft loans in renewable energy investment cost as it tends to cushion the initial investment cost thereby making investing in solar PV plants very viable and lucrative for potential investors.

5.4 Wind Power Plant

The following assumptions in Table 2 below, has been used in preparing the Business case analysis for a typical ten megawatt (10MW) on-shore Wind power plant project in Nigeria, some of which are stated in the national renewable energy and energy efficiency policy and other official documents of the federal republic of Nigeria.

Table 2: Parameters and Assumption for on-shore Wind power project in Nigeria.

Parameters	Assumptions for Wind	
Capital Expense CapEx (KW) ($1=€0.89)	$ 2,346	€ 2,087.94
Capacity Factor / Efficiency (%)		30
Availability (%)		91.78
Max. Operating Expense OpEx ($/KW/Yr.)	$ (33+17=50)	€44.50
Cost of loan (%)		6
Cost of Equity (%)		15
Profit tax % (50% of Normal)	Normal Profit Tax = 30%	15
Life span of Plant (Years)		20
Period of Loan (Years)	Loans are granted between 8-18	12
Feed in Tariff (FIT) KWh (₦1=€ 0.00445)	₦ 33.433	€ 0.149

(Data from U.S. National Renewable Energy Laboratory & National Electricity Regulatory Commission Nigeria)

The above assumptions was applied to an excel spread sheet to derive the following results in Appendix 3 & 4.

Using the information from Appendix 3 & 4 on the Energy Business Calculator, an optimization graph is generated that shows the correlation between the Internal Rate of Returns for the investment and the equity ratio of investment as shown in Figure 24 below.

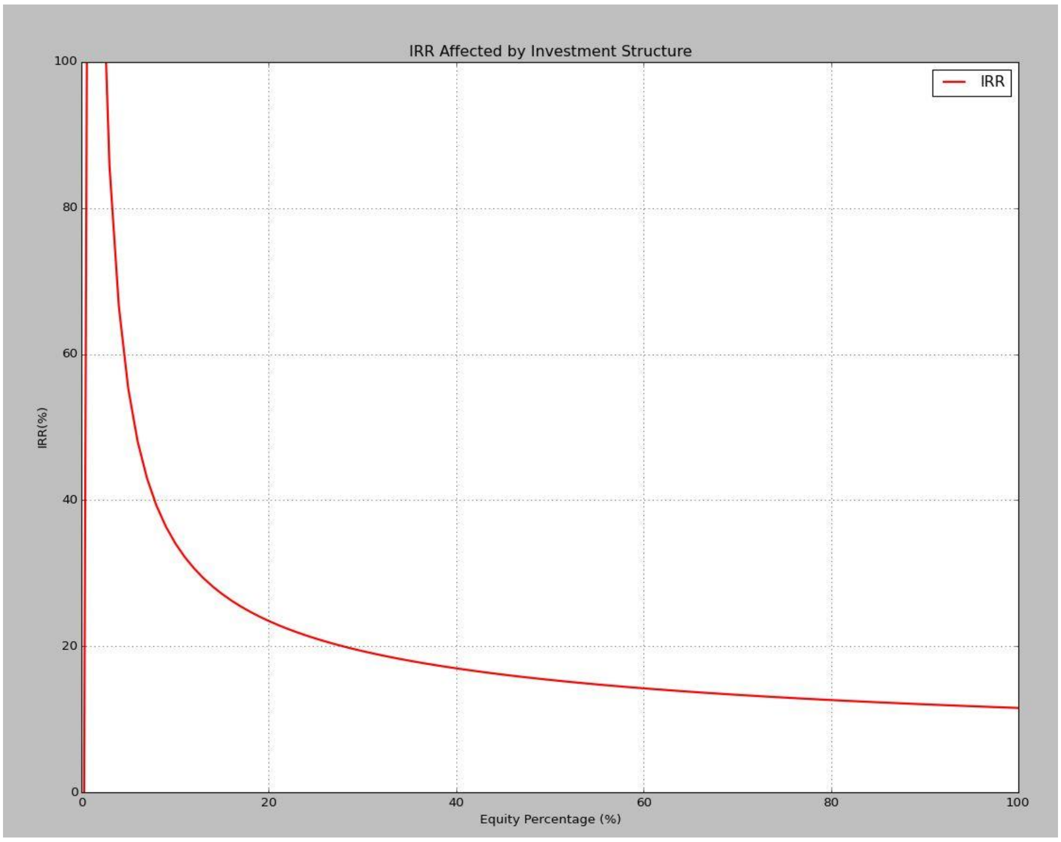


Figure 24: Optimization graph for Wind IRR-Equity percentage/Ratio

The optimization graph in figure 24 above shows that the higher the equity contribution for a Wind power plant the lower the internal rate of returns on the investment. In this case when the equity contribution is held at 30% the IRR stands at 18% as compared to when the contribution is 20% where the IRR increases to 22%. The payback period for the investment reduces from 5.9 to 4.8 years, and as shown in appendix 3 & 4 the debt service cover ratio reduces from 1.79 to 1.57. An overall assessment of the calculated data and the graph shows that wind energy investment in Nigeria can yield more returns upon reduction of the equity contribution with some grants.

5.5 Bio-Energy Power Plant

The assumptions in Table 3 below, was applied in preparing the Business case analysis for a typical ten megawatt (10MW) bio-energy power plant project in Nigeria. The data was pulled from the U.S. National Renewable Energy Laboratory (NREL) record, the Nigerian national renewable energy and energy efficiency policy, and other official documents of the federal republic of Nigeria.

Table 3: Parameters and Assumption for Bio-Energy power project in Nigeria.

Parameters	Assumptions for Bio-Energy	
Capital Expense CapEx / KW ($1=€0.89)	$5,792	€5,154.88
Capacity Factor / Efficiency (%)		85
Availability (%)		83.56
Max. Operating Expense OpEx ($/KW/Yr.)	$(98+29+0.04+0.02+0.04=127.1)	€113.12
Cost of loan (%)		6
Cost of Equity (%)		15
Profit tax % (50% of Normal)	Normal Profit Tax = 30%	15
Life span of Plant (Years)		20
Period of Loan (Years)	Loans are granted between 8-18	12
Feed in Tariff (FIT) KWh (₦1=€ 0.00445)	₦ 37.357	€ 0.166

(Data from U.S. National Renewable Energy Laboratory & National Electricity Regulatory Commission Nigeria)

The above assumptions was applied to an excel spread sheet to derive the following results in Appendix 5 & 6.

Using the information from Appendix 5 & 6 on the Energy Business Calculator, an optimization graph is generated that shows the correlation between the Internal Rate of Returns for the investment and the equity ratio of investment as shown in Figure 25 below.

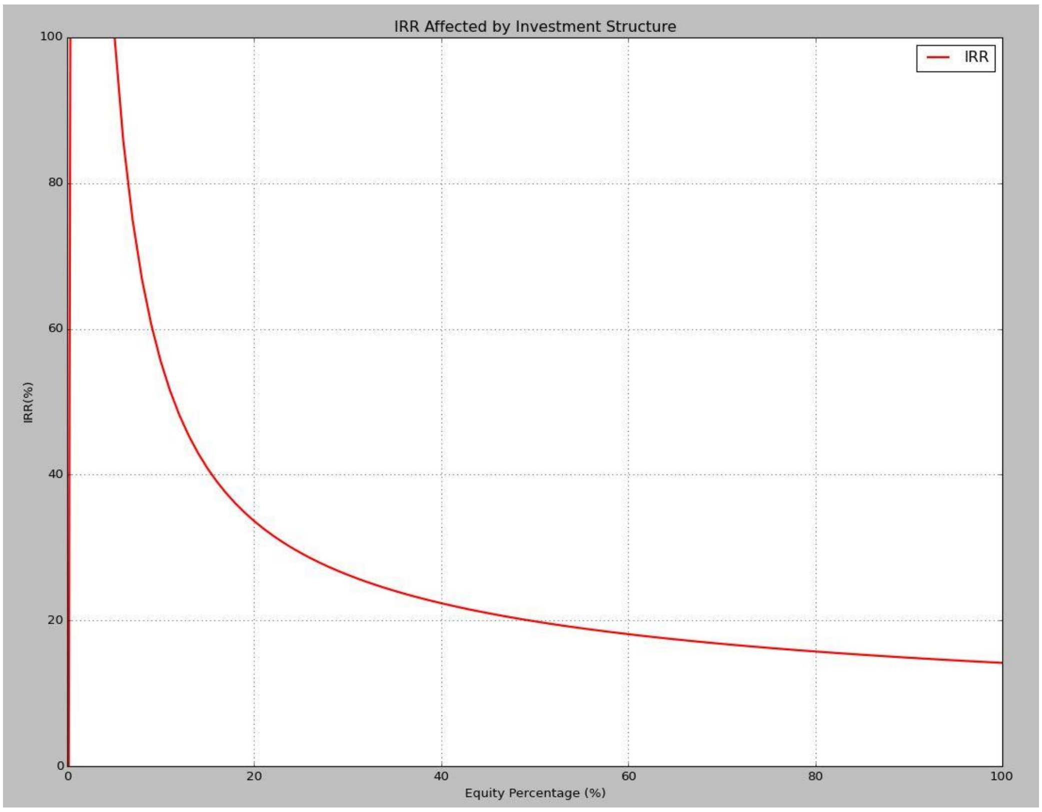


Figure 25: Optimization graph for Bio-Energy plant IRR-Equity percentage/Ratio

As in the case of the other renewable energy power plant projects the optimization graph in figure 25 above also shows that the higher the equity contribution for a Bio-Energy power plant the lower the internal rate of returns on the investment. In this case when the equity contribution is held at 30% the IRR stands at 25% as compared to when the contribution is 20% where the IRR increases to 32%. The payback period for the investment reduces from 4.1 to 3.2 years, and as shown in appendix 5 & 6 the debt service cover ratio reduces from 2.13 to 1.86. With the foregoing calculated data and the graph shows Bio-Energy power plant investment in Nigeria can yield more returns upon reduction of the equity contribution with some grants.

5.6 Field Study

As mentioned earlier in chapter 4.3.2, a structured interview was conducted with 3 different industry professionals using the research questions with the particular sequence found in Appendix 7.

Interviewee 1, who is a project developer and consultant has operated in 78 countries around the globe, 12 of which are located in North, Central and West Africa. He also has experience his major experience in 2 areas of renewable energy technology projects namely: Wind and Biomass.

Interviewee 2, a project officer for Ecowas center for renewable energy and energy efficiency (ECREEE), operates mainly in the 15 West African countries that constitute the economic community of West Africa states (ECOWAS). And he has had experience in the 3 major renewable energy technology discussed in this work.

Interviewee 3, who is a project developer and teacher has mainly operated in 3 developing countries, he has teaching experience in all types of renewable energy technology but with specific project development, consultancy and management experience in Solar.

5.7 Process of Project Financing

Questions 1, 2, 6 & 13 was designed to get a broader view of the interviewees background and experience in project development and financing, and consultancy and this produced the information found in section 5.6 above.

Questions 3 & 5 focused on the key factors and challenges considered when evaluating a project for financing and their responses were that:

- Interviewee 1: "…Stakeholder communication and management and Counterpart risks are the key challenges. I mean if the profitability is good and these challenges can be managed then you have an excellent project".
- Interviewee 2: ... "we have considered issues such as the nature of licenses and acceptability of the technology by the locals. And especially for on-grid projects, grid capacity and stability are very important. With inadequate grid infrastructure the project success would be hindered".
- Interviewee 3: '… debt financiers are worried about political stability, because even if all other factors are in order when there is crisis they don't get paid'.

Question 10 dealt with the risks associated with project financing in developing countries and the responses were:

- Interviewee 1 - Policy change, counterpart risk, stakeholder communication and management.
- Interviewee 2 - Bureaucracy (for licenses and permits), grid stability and stability, political stability, policy implementation.
- Interviewee 3 - '… political stability and the difficulty to get a power purchase agreement (PPA)'.

Question 11 was asked to determine the methods used by these professionals that have worked in mitigating the various risks and challenges faced in project finance in developing countries.

- Interviewee 1: Sovereign and other guarantees, …'utilities are forced to take domestic counterpart risks'…, 'use of bonds and securities'.
- Interviewee 2: … 'make sure the grid can handle the addition you intend to feed in or maybe you build your own mini-grid and service smaller communities', get Financial Insurances, power purchase agreement (PPA), Investment bank guarantee for capital investment.
- Interviewee 3: Export credit agency (ECA) agreement, completion guarantees, political risk insurance, 'local partner or equity contributor to obtain the PPA'.

5.8 Risk Assessment

With reference to the research question in section 1.3, "what are the key financial risks in the development of RE projects in general but especially in developing countries?"

The various risks associated with renewable energy technology projects in developing countries, Nigeria inclusive are numerous but this work through the conducted interviews focused on the financial risks or risk that could adversely affect the financial status of an RE project and how to mitigate them. In project financing and indeed other forms of financing of project, stakeholders and financiers are interested in the risks involved prior to staking their funds or investment, as such financial risk assessment and management is crucial to attracting financing both debt (from Banks) and equity.

Table 4 below shows major financial risks for RE projects in developing countries with Nigeria inclusive and the results of interviews conducted with industry professional as to how to mitigate them.

Table 4: List of risks and how to mitigate them.

Risks	Risks Addressed	Research Interview
Political/Policies	• MYTO (PPA), • Sovereign and other Guarantees • ECA insurance • Political Risk insurance	• Sovereign guarantees • Political risk insurance • ECA insurance
Cost Risks	• Fixed EPC price contract • Full Maintenance contracts • Insurance coverage • Warranties	This was not a major risk factor to them.
Exchange Rate/currency fluctuation	• Futures • fixed interest rate agreement • Export credit agency.	This was not a major risk factor to them.
Stakeholder Management	• Creditworthy off-taker agreement. • EPC contracts and completion guarantees	• Binding contracts and agreements • Completion guarantees
Counterpart Risk	• Use of security as guarantees • Fall back mechanism • Predetermines arbitration procedure	• Use of securities as guarantees • Utility companies and Generating companies as equity contributors.

The responses of all the interviewees to questions 3, 5 & 10 about factors, challenges and risk associated with project finance in developing countries as shown in section 5.7, all point to 3 major risks with RE project financing. They are Political, Stakeholder communication and Management and Counterpart risks.

To mitigate these risks their answers to the interview question 11 as shown in table 5 suggested the use of tested and trusted instruments:

- For Political Risks
  - Sovereign guarantees (which is becoming almost impossible to get).
  - Political risk insurance.
  - Export Credit Agency (ECA) insurance.

- Stakeholders Management
  - Well-structured contracts and agreements that are binding on parties.
  - Completion guarantees from EPC contractors.
- For Counterpart Risk
  - Use of securities such as bonds as guarantees for equity contributors
  - In Nigeria because of its Electricity industry structure, it is therefore important involving utility companies and licensed generating companies as equity contributors.

With this it is believed that project financiers, developers and coordinators can mitigate these risks.

5.9 Advantages of Project finance over corporate finance

A second research question was to compare the project finance model with the corporate/balance sheet finance model. Earlier in this thesis work the project finance and corporate finance method was explained but for proper differentiation and comparison, this section pitches them side-by-side to show the major differences and especially the benefits of project financing method over corporate finance in developing countries as shown in table 5 below.

Table 5: Major difference between project finance and corporate finance.

Project finance	Corporate finance
Fixed time period (not more than project life).	Indefinite time period.
Fixed dividend policy.	Dependent on corporate management.
Highly transparent capital investment decisions.	Investment decisions are shrouded in secrecy.
Credit evaluation is based solely on the project and its deliverables.	Credit evaluation based on the financial health of the company (balance sheet and cash flow)
Reinvestment not allowed, limiting exposure to initial investment.	Reinvestment allowed and financial exposure may be limitless.
Bank finances the project.	Bank finances the company/corporate entity
Predictability of future cash flow.	Not necessarily
Longer debt tenure but always lesser than lifespan of project.	Short debt tenure.
Only validity and coverage of contracts and licenses are needed.	Rigorous due diligence carried out on the organization financial history.
Easier to achieve project objective because financing is project focused.	Finance can be diverted depending on the pressing needs of the company.

Responses from the Interviews conducted revealed that the corporate governance structure available in most developing countries are not able to address challenges that are specifically unique to renewable energy technology projects. As such the project finance which employs the use of special purpose vehicle (SPV) will better address this challenge as the SPV can design a new corporate governance structure suitable to its success. It will also save organizations the time and effort required to go through rigorous due diligence on their financial history as credit evaluation in project finance is based solely on the projects ability to generate cash flow to fulfill its debt obligations and provide satisfying returns for the equity investors.

Interviewee 2, in his response to Questions 4 & 5 further revealed that reservations and in extreme cases non-acceptability of the renewable energy technology in terms of efficiency and reliability in comparison to traditional forms of energy generation makes corporate financing almost impossible, as organizations with the stature and capacity to do so are unwilling to take such presumed high risks which might heavily impact on the company's other activities.

6 CONCLUSION

This chapter gives a brief summary of the thesis and highlights the major findings and results. It also gives recommendations as to what areas further research needs to be carried out as this will contribute immensely to the overall success of implementing project finance in renewable energy projects in developing countries.

6.1 Summary

This research work has delved into the various renewable energy resources and technologies available and in abundance in most developing countries and the gains this can have by driving sustainability and closing the huge gap that exists between supply and energy needs which eventually will drive economic development.

Project finance was also discussed at length with its various components, such as debt financing, equity financing, grants and guarantees. This work also used a business case (Feasibility) study of the Nigerian renewable energy technology market data and other international information applied to micro-soft excel spreadsheet and the business energy calculator software with several interviews of renewable energy developers, financiers and managers arrived at the following conclusions:

- The lower the equity contribution of renewable energy projects and the availability of grants will go a long way in adding to the viability or profitability of renewable energy projects.
- The optimization graphs also shows that the solar PV technology has much more viable potential in the Nigerian market as the 3 renewable energy technologies considered it produced the highest IRR with the shortest payback period. This definitely would be of special interest to project developers and equity investors and will help in selection of technologies to developer invest in.
- Of all risks associated with project financing in developing countries, 3 stand out and they are political, stakeholder management and counterpart risks. This work also established how these stakeholders have and are mitigating this risk to achieve their goals in this challenging terrain.

- That project financing better suits developing countries due to some of the advantages it has over corporate financing.

6.2 Recommendation

This research work has highlighted several issues so that further research could be conducted in most developing countries and especially in Nigeria. As Nigeria's renewable energy policy master plan is being implemented it would be of great interest to know to what extent it has been achieved and how much has been achieved as to installation capacity of the various RE technologies in the country.

With regards to grants which can serve as a major buffer in making renewable energy technology projects more profitable, further work can be done to determine the different grants available to potential developers and prospectors of renewable energy projects in Nigeria and how they can assess them.

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APPENDICES

Appendix 1: Spreadsheet for 10MW Solar plant with 30% equity contribution.

10MW Solar PV Power Plant

Service Period (~ 7 days = 84 hours)	84	Government Grant 0%	0.00 €	Corporate Income Taxes	15%
Project Capacity(KW)	10000	Loan 70%	12,615,750.00 €	Life Span of Solar PV Plant (years)	20
TIME(YR) (hours)	8760	Equity 30%	6,075,000.00 €	Salvage Value of Plant & other items	0.00 €
Time (Sun shines in year) @ 12 Hrs/day	4380	Cost of Loan	6.00%	Total Salvage Value	0.00 €
Operating Capacity/ Efficiency	21.00%	Cost of Equity	15.00%		
Availability	49.52%	Cost of Grant	0.00%		
Energy Produced kwh/yr	9,109,800	Weight of Loan	70.00%	Ammortization=Investment Cost / Relevant Factor	1,504,741.17 €
PPA Rate(₦/MWh)	₦ 92,192.00	Weight of Equity	30.00%		
PPA Rate(€/KWh) ₦1 = €0.00445	0.410 €	Weight of Grant	0.00%		
CapEx @ $2025/KW	$ 20,250,000.00	Relevant Factor (6% @ 12yrs)	8.384		
CapEx in € @ 1$ = 0,89€	18,022,500.00 €	WACC	8.70%		
OpEx @ $25/kW @ 1$= 0,89€	22.25 €				

Financial yr		1	2	3	4	19	20
Annual Pay		1,504,741.17 €	1,504,741.17 €	1,504,741.17 €	1,504,741.17 €		
Prin. Pay		747,796.17 €	792,663.94 €	840,223.78 €	890,637.21 €		
Interest Pay		756,945.00 €	712,077.23 €	664,517.39 €	614,103.97 €		
Unpaid Principal.	12,615,750.00 €	11,867,953.83 €	11,075,289.88 €	10,235,066.10 €	9,344,428.89 €		
	Straight line Depreciation	901,125.00 €	901,125.00 €	901,125.00 €	901,125.00 €	901,125.00 €	901,125.00 €
Loss of Module Yield (KWh) @ 0.5%	0.50%	9,064,251	9,018,930	8,973,835	8,928,966	8,282,232	8,240,821
Revenue		3,718,648.86 €	3,700,055.61 €	3,681,555.33 €	3,663,147.56 €	3,397,822.00 €	3,380,832.89 €
Expenses		222,500.00 €	222,500.00 €	222,500.00 €	222,500.00 €	222,500.00 €	222,500.00 €
	EBITDA/Net Op. Income	3,496,148.86 €	3,477,555.61 €	3,459,055.33 €	3,440,647.56 €	3,175,322.00 €	3,158,332.89 €
	Total Op. Expenses	1,123,625.00 €	1,123,625.00 €	1,123,625.00 €	1,123,625.00 €	1,123,625.00 €	1,123,625.00 €
	EBIT/Tot Op. Income	2,595,023.86 €	2,595,023.86 €	2,595,023.86 €	2,595,023.86 €	2,595,023.86 €	2,595,023.86 €
	EBT	1,838,078.86 €	1,882,946.63 €	1,930,506.46 €	1,980,919.89 €	2,595,023.86 €	2,595,023.86 €
	TAXES	275,711.83 €	282,441.99 €	289,575.97 €	297,137.98 €	389,253.58 €	389,253.58 €
	NET INCOME	1,562,367.03 €	1,600,504.63 €	1,640,930.49 €	1,683,781.91 €	2,205,770.28 €	2,205,770.28 €
	NET CASH FLOW	2,463,492.03 €	2,501,629.63 €	2,542,055.49 €	2,584,906.91 €	3,106,895.28 €	3,106,895.28 €
	CFBD&DP	3,220,437.03 €	3,213,706.86 €	3,206,572.89 €	3,199,010.87 €	3,106,895.28 €	3,106,895.28 €
	Free Cash Flow	1,715,695.85 €	1,708,965.69 €	1,701,831.71 €	1,694,269.70 €	3,106,895.28 €	3,106,895.28 €
	Payback Per.	3.5					
	NPV	12,522,090.06					
	IRR	29%					
	DSCR	2.32					
For Calculating IRR	-6,075,000.00 €	1,715,695.85 €	1,708,965.69 €	1,701,831.71 €	1,694,269.70 €	3,106,895.28 €	3,106,895.28 €

Appendix 2: Spreadsheet for 10MW solar plant with 20% equity contribution.

10MW Solar PV Power Plant

Service Period (~ 7 days = 84 hours)	84	**Government Grant 0%**	**0.00 €**	**Corporate Income Taxes**	**15%**
Project Capacity(KW)	**10000**	**Loan 80%**	**14,418,000.00 €**	**Life Span of Solar PV Plant (years)**	**20**
TIME(YR) (hours)	8760	**Equity 20%**	**4,050,000.00 €**	Salvage Value of Plant & other items	0.00 €
Time (Sun shines in year) @ 12 Hrs/day	4380	Cost of Loan	6.00%	**Total Salvage Value**	**0.00 €**
Operating Capacity/ Efficiency	21.00%	Cost of Equity	15.00%		
Availability	49.52%	Cost of Grant	0.00%		
Energy Produced kwh/yr	9,109,800	Weight of Loan	80.00%	Ammortization=Investment Cost / Relevant Factor	1,719,704.20 €
PPA Rate(₦/MWh)	₦ 92,192.00	Weight of Equity	20.00%		
PPA Rate(€/KWh) ₦1 = €0.00445	0.410 €	Weight of Grant	0.00%		
CapEx @ $2025/KW	$ 20,250,000.00	Relevant Factor (6% @ 12yrs)	8.384		
CapEx in € @ 1$ = 0,89€	**18,022,500.00 €**	WACC	7.80%		
OpEx @ $25/kW @ 1$= 0,89€	**22.25 €**				

Financial yr		1	2	3	4	19	20
Annual Pay		1,719,704.20 €	1,719,704.20 €	1,719,704.20 €	1,719,704.20 €		
Prin. Pay		854,624.20 €	905,901.65 €	960,255.75 €	1,017,871.09 €		
Interest Pay		865,080.00 €	813,802.55 €	759,448.45 €	701,833.10 €		
Unpaid Principal.	14,418,000.00 €	13,563,375.80 €	12,657,474.15 €	11,697,218.40 €	10,679,347.31 €		
	Straight line Depreciation	901,125.00 €	901,125.00 €	901,125.00 €	901,125.00 €	901,125.00 €	901,125.00 €
Loss of Module Yield (KWh) @ 0.5%	0.50%	9,064,251	9,018,930	8,973,835	8,928,966	8,282,232	8,240,821
Revenue		3,718,648.86 €	3,700,055.61 €	3,681,555.33 €	3,663,147.56 €	3,397,822.00 €	3,380,832.89 €
Expenses		222,500.00 €	222,500.00 €	222,500.00 €	222,500.00 €	222,500.00 €	222,500.00 €
	EBITDA/Net Op. Income	3,496,148.86 €	3,477,555.61 €	3,459,055.33 €	3,440,647.56 €	3,175,322.00 €	3,158,332.89 €
	Total Op. Expenses	1,123,625.00 €	1,123,625.00 €	1,123,625.00 €	1,123,625.00 €	1,123,625.00 €	1,123,625.00 €
	EBIT/Tot Op. Income	2,595,023.86 €	2,595,023.86 €	2,595,023.86 €	2,595,023.86 €	2,595,023.86 €	2,595,023.86 €
	EBT	1,729,943.86 €	1,781,221.31 €	1,835,575.41 €	1,893,190.75 €	2,595,023.86 €	2,595,023.86 €
	TAXES	259,491.58 €	267,183.20 €	275,336.31 €	283,978.61 €	389,253.58 €	389,253.58 €
	NET INCOME	1,470,452.28 €	1,514,038.11 €	1,560,239.10 €	1,609,212.14 €	2,205,770.28 €	2,205,770.28 €
	NET CASH FLOW	2,371,577.28 €	2,415,163.11 €	2,461,364.10 €	2,510,337.14 €	3,106,895.28 €	3,106,895.28 €
	CFBD&DP	3,236,657.28 €	3,228,965.66 €	3,220,812.54 €	3,212,170.24 €	3,106,895.28 €	3,106,895.28 €
	Free Cash Flow	1,516,953.08 €	1,509,261.46 €	1,501,108.35 €	1,492,466.04 €	3,106,895.28 €	3,106,895.28 €
	Payback Per.	**2.7**					
	NPV	**14,479,442.40**					
	IRR	**38%**					
	DSCR	**2.03**					
For Calculating IRR	-4,050,000.00 €	1,516,953.08 €	1,509,261.46 €	1,501,108.35 €	1,492,466.04 €	3,106,895.28 €	3,106,895.28 €

Appendix 3: Spreadsheet for 10MW on-shore Wind plant with 30% equity contribution.

10MW Wind Power Plant

Service Period (~ 30 days = 720 hours)	720	**Government Grant 0%**	0.00 €	**Corporate Income Taxes**	15%
Project Capacity(KW)	10000	**Loan 70%**	14,615,580.00 €	**Life Span of Wind plant (years)**	20
TIME(YR) (hours)	8760	**Equity 30%**	7,038,000.00 €	Salvage Value of Plant & other items	0.00 €
		Cost of Loan	6.00%	**Total Salvage Value**	0.00 €
Operating Capacity/ Efficiency	30.00%	Cost of Equity	15.00%		
Availability	91.78%	Cost of Grant	0.00%		
Energy Produced kwh/yr	24,120,000	Weight of Loan	70.00%	Ammortization=Investment Cost / Relevant Factor	1,743,270.52 €
PPA Rate(₦/MWh)	₦ 33,433.00	Weight of Equity	30.00%		
PPA Rate(€/KWh) ₦1 = €0.00445	0.149 €	Weight of Grant	0.00%		
CapEx @ $2346/KW	$ 23,460,000.00	Relevant Factor (6% @ 12yrs)	8.384		
CapEx @ 1$ = 0,89€ (€/KW)	**20,879,400.00 €**	WACC	8.70%		
OpEx Estimated Max. for 1 - 10 MW ($)	$ 50.00				
Estimated OpEx in € @ 1$= 0,89€	**44.50 €**				

Financial yr		1	2	3	4	19	20
Annual Pay		1,743,270.52 €	1,743,270.52 €	1,743,270.52 €	1,743,270.52 €		
Prin. Pay		866,335.72 €	918,315.86 €	973,414.81 €	1,031,819.70 €		
Interest Pay		876,934.80 €	824,954.66 €	769,855.71 €	711,450.82 €		
Unpaid Principal.	14,615,580.00 €	13,749,244.28 €	12,830,928.43 €	11,857,513.62 €	10,825,693.92 €		
	Straight line Depreciatio	1,043,970.00 €	1,043,970.00 €	1,043,970.00 €	1,043,970.00 €	1,043,970.00 €	1,043,970.00 €
Loss of Module Yield (KWh) @ 0.5%	0.50%	23,999,400	23,879,403	23,760,006	23,641,206	21,928,849	21,819,205
Revenue		3,570,555.13 €	3,552,702.36 €	3,534,938.85 €	3,517,264.15 €	3,262,505.08 €	3,246,192.56 €
Expenses		445,000.00 €	445,000.00 €	445,000.00 €	445,000.00 €	445,000.00 €	445,000.00 €
	EBITDA	3,125,555.13 €	3,107,702.36 €	3,089,938.85 €	3,072,264.15 €	2,817,505.08 €	2,801,192.56 €
	Total Op. Expenses	1,488,970.00 €	1,488,970.00 €	1,488,970.00 €	1,488,970.00 €	1,488,970.00 €	1,488,970.00 €
	EBIT/Tot Op. Income	2,081,585.13 €	2,081,585.13 €	2,081,585.13 €	2,081,585.13 €	2,081,585.13 €	2,081,585.13 €
	EBT	1,204,650.33 €	1,256,630.48 €	1,311,729.43 €	1,370,134.32 €	2,081,585.13 €	2,081,585.13 €
	TAXES	180,697.55 €	188,494.57 €	196,759.41 €	205,520.15 €	312,237.77 €	312,237.77 €
	NET INCOME	1,023,952.78 €	1,068,135.91 €	1,114,970.01 €	1,164,614.17 €	1,769,347.36 €	1,769,347.36 €
	NET CASH FLOW	2,067,922.78 €	2,112,105.91 €	2,158,940.01 €	2,208,584.17 €	2,813,317.36 €	2,813,317.36 €
	CFBD&DP	2,944,857.58 €	2,937,060.56 €	2,928,795.72 €	2,920,034.99 €	2,813,317.36 €	2,813,317.36 €
	Free Cash Flow	1,201,587.07 €	1,193,790.05 €	1,185,525.20 €	1,176,764.47 €	2,813,317.36 €	2,813,317.36 €
	Payback Per.	**5.9**					
	NPV	**7,175,243**					
	IRR	**18%**					
	DSCR	**1.79**					
For Calculating IRR	-7,038,000.00 €	1,201,587.07 €	1,193,790.05 €	1,185,525.20 €	1,176,764.47 €	2,813,317.36 €	2,813,317.36 €

Appendix 4: Spreadsheet for 10MW on-shore Wind plant with 20% equity contribution.

10MW Wind Power Plant

Service Period (~ 30 days = 720 hours)	720	**Government Grant 0%**	**0.00 €**	**Corporate Income Taxes**	**15%**
Project Capacity(KW)	**10000**	**Loan 80%**	**16,703,520.00 €**	**Life Span of Wind plant (years)**	**20**
TIME(YR) (hours)	8760	**Equity 20%**	**4,692,000.00 €**	Salvage Value of Plant & other items	0.00 €
		Cost of Loan	6.00%	**Total Salvage Value**	**0.00 €**
Operating Capacity/ Efficiency	30.00%	Cost of Equity	15.00%		
Availability	91.78%	Cost of Grant	0.00%		
Energy Produced kwh/yr	24,120,000	Weight of Loan	80.00%	Ammortization=Investment Cost / Relevant Factor	1,992,309.16 €
PPA Rate(₦/MWh)	₦ 33,433.00	Weight of Equity	20.00%		
PPA Rate(€/KWh) ₦1 = €0.00445	0.149 €	Weight of Grant	0.00%		
CapEx @ $2346/KW	$ 23,460,000.00	Relevant Factor (6% @ 12yrs)	8.384		
CapEx @ 1$ = 0,89€ (€/KW)	**20,879,400.00 €**	WACC	7.80%		
OpEx Estimated Max. for 1 - 10 MW ($)	$ 50.00				
Estimated OpEx in € @ 1$= 0,89€	**44.50 €**				

Financial yr		1	2	3	4	19	20
Annual Pay		1,992,309.16 €	1,992,309.16 €	1,992,309.16 €	1,992,309.16 €		
Prin. Pay		990,097.96 €	1,049,503.84 €	1,112,474.07 €	1,179,222.51 €		
Interest Pay		1,002,211.20 €	942,805.32 €	879,835.09 €	813,086.65 €		
Unpaid Principal.	16,703,520.00 €	15,713,422.04 €	14,663,918.20 €	13,551,444.13 €	12,372,221.62 €		
	Straight line Depreciatio	1,043,970.00 €	1,043,970.00 €	1,043,970.00 €	1,043,970.00 €	1,043,970.00 €	1,043,970.00 €
Loss of Module Yield (KWh) @ 0.5%	0.50%	23,999,400	23,879,403	23,760,006	23,641,206	21,928,849	21,819,205
Revenue		3,570,555.13 €	3,552,702.36 €	3,534,938.85 €	3,517,264.15 €	3,262,505.08 €	3,246,192.56 €
Expenses		445,000.00 €	445,000.00 €	445,000.00 €	445,000.00 €	445,000.00 €	445,000.00 €
	EBITDA	3,125,555.13 €	3,107,702.36 €	3,089,938.85 €	3,072,264.15 €	2,817,505.08 €	2,801,192.56 €
	Total Op. Expenses	1,488,970.00 €	1,488,970.00 €	1,488,970.00 €	1,488,970.00 €	1,488,970.00 €	1,488,970.00 €
	EBIT/Tot Op. Income	2,081,585.13 €	2,081,585.13 €	2,081,585.13 €	2,081,585.13 €	2,081,585.13 €	2,081,585.13 €
	EBT	1,079,373.93 €	1,138,779.81 €	1,201,750.04 €	1,268,498.49 €	2,081,585.13 €	2,081,585.13 €
	TAXES	161,906.09 €	170,816.97 €	180,262.51 €	190,274.77 €	312,237.77 €	312,237.77 €
	NET INCOME	917,467.84 €	967,962.84 €	1,021,487.54 €	1,078,223.71 €	1,769,347.36 €	1,769,347.36 €
	NET CASH FLOW	1,961,437.84 €	2,011,932.84 €	2,065,457.54 €	2,122,193.71 €	2,813,317.36 €	2,813,317.36 €
	CFBD&DP	2,963,649.04 €	2,954,738.16 €	2,945,292.63 €	2,935,280.36 €	2,813,317.36 €	2,813,317.36 €
	Free Cash Flow	971,339.88 €	962,429.00 €	952,983.47 €	942,971.20 €	2,813,317.36 €	2,813,317.36 €
	Payback Per.	**4.8**					
	NPV	**8,940,636**					
	IRR	**22%**					
	DSCR	**1.57**					
For Calculating IRR	-4,692,000.00 €	971,339.88 €	962,429.00 €	952,983.47 €	942,971.20 €	2,813,317.36 €	2,813,317.36 €

Appendix 5: Spreadsheet for 10MW Bio-Energy plant with 30% equity contribution.

10MW Bio-Energy Power Plant

Service Period (~ 60 days = 1440 hours)	1440	**Government Grant 0%**	0.00 €	**Corporate Income Taxes**	15%
Project Capacity(KW)	10000	**Loan 70%**	36,084,160.00 €	**LifeSpan of Bio-Energy plant (yrs)**	20
TIME(YR) (hours)	8760	**Equity 30%**	17,376,000.00 €	Salvage Value of Plant & other items	0.00 €
		Cost of Loan	6.00%	**Total Salvage Value**	0.00 €
Operating Capacity/ Efficiency	85.00%	Cost of Equity	15.00%		
Availability	83.56%	Cost of Grant	0.00%		
Energy Produced kwh/yr	62,220,000	Weight of Loan	70.00%	Ammortization=Investment Cost / Relevant Factor	4,303,931.30 €
PPA Rate(₦/MWh)	₦ 37,357.00	Weight of Equity	30.00%		
PPA Rate(€/KWh) ₦1 = €0.00445	0.166 €	Weight of Grant	0.00%		
CapEx @ $5792/KW	$ 57,920,000.00	Relevant Factor (6% @ 12yrs)	8.384		
CapEx @ 1$ = 0,89€ (€/KW)	**51,548,800.00 €**	WACC	8.70%		
OpEx Estimated Max. for 1 - 10 MW ($)	$ 127.10				
Estimated OpEx in € @ 1$= 0,89€	**113.12 €**				

Financial yr		1	2	3	4	19	20
Annual Pay		4,303,931.30 €	4,303,931.30 €	4,303,931.30 €	4,303,931.30 €		
Prin. Pay		2,138,881.70 €	2,267,214.60 €	2,403,247.48 €	2,547,442.32 €		
Interest Pay		2,165,049.60 €	2,036,716.70 €	1,900,683.82 €	1,756,488.97 €		
Unpaid Principal.	36,084,160.00 €	33,945,278.30 €	31,678,063.70 €	29,274,816.23 €	26,727,373.90 €		
	Straight line Depreciatio	2,577,440.00 €	2,577,440.00 €	2,577,440.00 €	2,577,440.00 €	2,577,440.00 €	2,577,440.00 €
Loss of Module Yield (KWh) @ 0.5%	0.50%	61,908,900	61,599,356	61,291,359	60,984,902	56,567,703	56,284,864
Revenue		10,291,651.96 €	10,240,193.70 €	10,188,992.73 €	10,138,047.77 €	9,403,738.51 €	9,356,719.82 €
Expenses		1,131,190.00 €	1,131,190.00 €	1,131,190.00 €	1,131,190.00 €	1,131,190.00 €	1,131,190.00 €
	EBITDA	9,160,461.96 €	9,109,003.70 €	9,057,802.73 €	9,006,857.77 €	8,272,548.51 €	8,225,529.82 €
	Total Op. Expenses	3,708,630.00 €	3,708,630.00 €	3,708,630.00 €	3,708,630.00 €	3,708,630.00 €	3,708,630.00 €
	EBIT/Tot Op. Income	6,583,021.96 €	6,583,021.96 €	6,583,021.96 €	6,583,021.96 €	6,583,021.96 €	6,583,021.96 €
	EBT	4,417,972.36 €	4,546,305.26 €	4,682,338.14 €	4,826,532.99 €	6,583,021.96 €	6,583,021.96 €
	TAXES	662,695.85 €	681,945.79 €	702,350.72 €	723,979.95 €	987,453.29 €	987,453.29 €
	NET INCOME	3,755,276.51 €	3,864,359.47 €	3,979,987.42 €	4,102,553.04 €	5,595,568.67 €	5,595,568.67 €
	NET CASH FLOW	6,332,716.51 €	6,441,799.47 €	6,557,427.42 €	6,679,993.04 €	8,173,008.67 €	8,173,008.67 €
	CFBD&DP	8,497,766.11 €	8,478,516.17 €	8,458,111.24 €	8,436,482.01 €	8,173,008.67 €	8,173,008.67 €
	Free Cash Flow	4,193,834.81 €	4,174,584.87 €	4,154,179.94 €	4,132,550.71 €	8,173,008.67 €	8,173,008.67 €
	Payback Per.	**4.1**					
	NPV	**29,161,581**					
	IRR	**25%**					
	DSCR	**2.13**					
For Calculating IRR	-17,376,000.00 €	4,193,834.81 €	4,174,584.87 €	4,154,179.94 €	4,132,550.71 €	8,173,008.67 €	8,173,008.67 €

Appendix 6: Spreadsheet for 10MW Bio-Energy plant with 20% equity contribution.

10MW Bio-Energy Power Plant

Service Period (~ 60 days = 1440 hours)	1440	**Government Grant 0%**	0.00 €	**Corporate Income Taxes**	15%
Project Capacity(KW)	10000	**Loan 70%**	36,084,160.00 €	**LifeSpan of Bio-Energy plant (yrs)**	20
TIME(YR) (hours)	8760	**Equity 30%**	17,376,000.00 €	Salvage Value of Plant & other items	0.00 €
		Cost of Loan	6.00%	**Total Salvage Value**	0.00 €
Operating Capacity/ Efficiency	85.00%	Cost of Equity	15.00%		
Availability	83.56%	Cost of Grant	0.00%		
Energy Produced kwh/yr	62,220,000	Weight of Loan	70.00%	Ammortization=Investment Cost / Relevant Factor	4,303,931.30 €
PPA Rate(₦/MWh)	₦ 37,357.00	Weight of Equity	30.00%		
PPA Rate(€/KWh) ₦1 = €0.00445	0.166 €	Weight of Grant	0.00%		
CapEx @ $5792/KW	$ 57,920,000.00	Relevant Factor (6% @ 12yrs)	8.384		
CapEx @ 1$ = 0,89€ (€/KW)	**51,548,800.00 €**	WACC	8.70%		
OpEx Estimated Max. for 1 - 10 MW ($)	$ 127.10				
Estimated OpEx in € @ 1$= 0,89€	**113.12 €**				

Financial yr		1	2	3	4	19	20
Annual Pay		4,303,931.30 €	4,303,931.30 €	4,303,931.30 €	4,303,931.30 €		
Prin. Pay		2,138,881.70 €	2,267,214.60 €	2,403,247.48 €	2,547,442.32 €		
Interest Pay		2,165,049.60 €	2,036,716.70 €	1,900,683.82 €	1,756,488.97 €		
Unpaid Principal	36,084,160.00 €	33,945,278.30 €	31,678,063.70 €	29,274,816.23 €	26,727,373.90 €		
	Straight line Depreciatio	2,577,440.00 €	2,577,440.00 €	2,577,440.00 €	2,577,440.00 €	2,577,440.00 €	2,577,440.00 €
Loss of Module Yield (KWh) @ 0.5%	0.50%	61,908,900	61,599,356	61,291,359	60,984,902	56,567,703	56,284,864
Revenue		10,291,651.96 €	10,240,193.70 €	10,188,992.73 €	10,138,047.77 €	9,403,738.51 €	9,356,719.82 €
Expenses		1,131,190.00 €	1,131,190.00 €	1,131,190.00 €	1,131,190.00 €	1,131,190.00 €	1,131,190.00 €
	EBITDA	9,160,461.96 €	9,109,003.70 €	9,057,802.73 €	9,006,857.77 €	8,272,548.51 €	8,225,529.82 €
	Total Op. Expenses	3,708,630.00 €	3,708,630.00 €	3,708,630.00 €	3,708,630.00 €	3,708,630.00 €	3,708,630.00 €
	EBIT/Tot Op. Income	6,583,021.96 €	6,583,021.96 €	6,583,021.96 €	6,583,021.96 €	6,583,021.96 €	6,583,021.96 €
	EBT	4,417,972.36 €	4,546,305.26 €	4,682,338.14 €	4,826,532.99 €	6,583,021.96 €	6,583,021.96 €
	TAXES	662,695.85 €	681,945.79 €	702,350.72 €	723,979.95 €	987,453.29 €	987,453.29 €
	NET INCOME	3,755,276.51 €	3,864,359.47 €	3,979,987.42 €	4,102,553.04 €	5,595,568.67 €	5,595,568.67 €
	NET CASH FLOW	6,332,716.51 €	6,441,799.47 €	6,557,427.42 €	6,679,993.04 €	8,173,008.67 €	8,173,008.67 €
	CFBD&DP	8,497,766.11 €	8,478,516.17 €	8,458,111.24 €	8,436,482.01 €	8,173,008.67 €	8,173,008.67 €
	Free Cash Flow	4,193,834.81 €	4,174,584.87 €	4,154,179.94 €	4,132,550.71 €	8,173,008.67 €	8,173,008.67 €
	Payback Per.	**4.1**					
	NPV	**29,161,581**					
	IRR	**25%**					
	DSCR	**2.13**					
For Calculating IRR	-17,376,000.00 €	4,193,834.81 €	4,174,584.87 €	4,154,179.94 €	4,132,550.71 €	8,173,008.67 €	8,173,008.67 €

Appendix 7: Interview Questions

<u>Question 1</u>
What kind of renewable energy projects are you familiar with?

a. Wind
b. Solar
c. Bioenergy
d. Others

<u>Question 2</u>
What kind of financing model do you usually adopt for financing projects?

a. Project financing
b. Corporate financing

<u>Question 3</u>
What key *factors* do you consider when evaluating a project for financing, especially in developing countries?

<u>Question 4</u>
What are the key challenges in corporate financing in developing countries?

<u>Question 5</u>
What are the key challenges in project financing in developing countries?

<u>Question 6</u>
Which countries do you operate in?

<u>Question 7</u>
Do you finance projects which have no equity?

<u>Question 8</u>
What types of financial instruments do you use to finance projects procured by project finance?

A. Long term loan from banks
B. Short term loan
C. Zero interest loan from government
D. Government grants
E. Bonds
F. Others (Specify)

<u>Question 9</u>
The financial packages (debt/equity) ratio of the projects you handled is normally decided by:

A. Risk analysis
B. Availability of possible financial instruments

C. Legal requirement
D. Established by usage
E. the company's capital capability
F. Others (specify)

Question 10
What are the major risks associated with project financing in developing countries?

Question 11
How do you mitigate these risks?

Question 12
Have you ever used any refinancing methods in the project you have been involved in? In the following refinancing/restructuring methods, please tick the ones which you know have been used in the operation stage in developing countries: (leave blank if none of them applies)
A. Debt refinancing (debt to debt)
B. Government support
C. Standby loan
D Tax holiday
E. Soft loan
F. Grace period
G. Interest rate & margin agreement
H. Equity for debt
I. Equity-bond swap
J. Maturity extension
K. Leasing
L. Sale and lease back
M. Renegotiation on related agreements and contracts
N. Equity buy back

Question 13
Please name major developing countries that you gain your project financing and refinancing experience from?