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Cost benefit analysis of energy development aid: case study of Ghana

Diploma Thesis

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Declaration

I declare that I elaborated this diploma thesis on the topic Cost-benefit analysis of energy development aid: Case study Ghana under the guidance of doc.Ing.Petr Blizkovsky, Ph.D. All literature and other source of information used are mentioned in the References chapter.

In Brno, May 21, 2015

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Tomáš Stankovič

Abstract

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1. Target of thesis is to analyze economic and social potential of investments into energy sector particularly renewable energy source such as photovoltaics. Is estimated that increasing consumption and its constantly increasing price will result into even more blackout and electricity shortages. Energy security and its access are vital assets in development and key source for economic and human development. Without access to this asset the development is less likely to occur in Ghana.
2. Willingness of foreign investors to invest in middle and long term horizons in territory of Africa is low due to economic crises and political instability. To increase potential to invest in energy sector in Africa and particularly Ghana it is necessary to start with development aid into sector to convince potential investors in capability and rational retail ability of such investment. Development of such projects can have positive effects on both Ghana and EU in social and economic aspects.
3. By processing this thesis by doing cost benefit analysis of aid into photovoltaic power plant as form of development aid provided by EU and contributed by Ghana. Analyze influences of incurred expenditures on economic development in economic accountable equations.
4. In analytical part of thesis use cost benefit analysis and SWOT analysis based on historical-comparative method. Sum up the results of cost benefit analysis in SWOT analysis to interpret results of this diploma thesis

Key words

Development aid, cost benefit analysis, inflation, net present value, cash flow profitability index, rate of return, EU, EDF, Ghana, discount rate, photovoltaic, renewable energy

Abstrakt

Stankovič, T. Analýza nákladů a přínosů energetické rozvojové pomoci: Případová studie Ghany. Diplomová Práce, Brno, 2015

1. Cílem této práce je analyzovat ekonomický a sociální potenciál investic do energetického sektoru, speciálně do obnovitelných zdrojů, jako je například fotovoltaika. Předpokládá se, že díky vzrůstající spotřebě a její neustále rostoucí ceně, může tato skutečnost vyústit v ještě častější výpadky proudu a nedostupnost elektřiny. Energetická bezpečnost a její dostupnost jsou klíčové aspekty pro ekonomický a sociální rozvoj. Bez přístupu k tomuto zdroji je jakýkoliv rozvoj v Ghaně velmi nepravděpodobný.
2. Ochota zahraničních investorů investovat ve středním až dlouhém horizontu v Africe je nízká kvůli hluboké ekonomické krizi a politické nestabilitě. Je proto nezbytné zvýšit potenciál investování do energetického sektoru v Africe, a to specialně v Ghaně. Rozvojová pomoc do tohoto sektoru by měla přesvědčit potencionální investory o schopnosti a návratnosti jejich investice. Vývoj takovýchto projektů by mohl mýt pozitivní dopad na sociální a ekonomické aspekty Ghany i Evropské Unie.
3. Při zpracování této práce bude použita analýza nákladů a přínosů rozvojové pomoci do fotovoltaické elektrárny jako forma rozvojové pomoci poskytnuté z fondů Evrpské Unie za spoluúčasti Ghany. Dále bude analyzován vliv vynaložených výdajů na ekonomický rozvoj v ekonomicky zodpovědných rovnicích.
4. V analnytické části práce bude použita analýza nákladů a benefitů a dále SWOT analýza s použitím historicko-srovnávací metody a shrnutí výsledků analýzy nakladů a zisků v SWOT analýze s interpretací výsledků diplomové práce.

Klíčová slova:

Rozvojová pomoc, analýza návratů a vynosů, inflace, čistá současná hodnota, tok peněz, index ziskovosti, míra návratnosti, EU, EDF, Ghana, diskontní sazba, fotovoltaika, obnovitelné zdroje

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Introduction

Energy, its consumption and availability were to determine technological and economic progress since the beginning of industrial revolution. It was the first steam engines that sparked the dawn of old and rise of new age. Mass production, industrialization, transportation all aspects of modern day life are closely connected with energy and its distribution as it was proven over two centuries ago and it is even more valid today than ever before. Entering new digital age of globalized world and economy the energy and its availability becomes more than just driving force of economic development, it becomes life necessity. As energy flows through the globe and lights pierces through the night sky human activity can be observed from the space all around the world. Old cities of Europe, economic centers of America and booming megalopolises of Asia are shining through darkness that would normally cover entire planet. Symbols of economic prosperity and development. Despite all the progress all over the world one continent remains desperately covered in darkness. Africa, the birth place of human race is still in many regions and counties kept in darkness as it was centuries ago. However economic progress and development is reaching shores of Africa as well. In new emerging world of global economy Africa will slowly and surely engage in global competition and for that it is necessary to build proper infrastructure and make sure that basic needs for population are addressed or progress and integration into world economy will be slowed down to benefit of none, nor the world nor the African countries.

Ghana has emerged as one of the stable countries in African region with relatively good economic and social progress and status. Since its independence in 1960s country went through some turbulent years but was able to emerge from them successfully and it is now one of the few stable democracies with good human rights records and no major internal problems or regional disputes. As country Ghana can be classified as low-income country emerging from least developed countries and making economic progress in last two decades helped significantly reduce poverty and addressed some major problems that country was

facing after British colonial masters left. With several development programs and reforms with combination from foreign aid Ghana established itself relatively good compare to other north or West African neighbors. However it is still developing country and many issues need to be addressed to help Ghana develop and increases it chances to succeed in globalized world of economic interdependencies and complicated foreign and domestic relationships addressing issues such as lacking infrastructure, electrification and access to main grid are necessities common in developed world in which Ghana is lacking at the moment.

On international stage Ghana was able to make some wise choices regarding foreign affairs becoming full UN member, entering African Union and making bilateral and multilateral agreements with United States and European Union. With them Ghana shares common goals in foreign policy seeking cooperation, peace, security prosperity and addressing climate change. Especially on the last topic Ghana and EU are strongly devoted into climate change and investments and promotion of renewable energy and sustainable development. Adapting several treaties in recent years Ghana went to strengthening its ties with EU particular in several topics such as climate change, human rights improvement and civil society promotion. The common topic between two partners is sustainable development, climate change and overall social and economic progress in which both entities promote usage of renewable energy sources and technologies to achieve this goals. Cooperation between Ghana and EU with regards to other issues is likely to further increase and develop.

Geographical position of Ghana on coast of West Africa and in subtropical climate on equator makes Ghana ideal for wider usage of various renewable sources. On coast wind turbines and further inland geography favors solar and photovoltaic power plants. With electrification and access to main grid widening from region to region reaching up to almost 100% in capital city Accra to only just above 40% in northern regions as the electricity distribution and its infrastructure possess a great challenge for further development. Renewable energy can provide necessary infrastructure and improvement on all economic and social aspects with respect to environment and achieving all three goals that are correspondent with sustainable development of Ghana and its proclamation to international

partners in EU. Renewable energy might be the right way in politic aspects of decision making, but how it can stand on economic terms for low income country such as Ghana. Investments in technology and infrastructure is necessary, but can this expensive technology be an option for developing country? If the political and international community is willing to participate on sustainable development and live improvement in Ghana and helping it achieve its goal then economic analysis of pros and cons of such decision is necessary. This will be the main topic of this thesis to find answers to those complicated questions

Ghana as a low-income developing country is economically growing but it is lacking in electrification and overall access to main grid. Blackouts and electricity shortages are common in country and are causing severe economic backlash slowing its economic growth and ability to compete on world markets. Availability of electricity and access to main grid is also increasing regional differences in regions within Ghana thus again slowing economic and social progress. Ghana have addressed this by creating National Development Plan: Ghana 2020 vision in which infrastructure and electrification plays a key role for its further development.

Ghana internationally promotes its role to address climate change and actively participates on this topic on international stage with EU and other Western countries. It is one of official statements of Ghana that is also included in Ghana National Development Plan to achieve 100% electrification and diversify its energy sources from which 10% should come from renewable energy (hydropower not included) that needs to be adopted by government.

Access to electricity is playing a vital role in addressing income inequality and poverty in Ghana as access to this commodity is not distributed fairly among regions in country thus creating social tensions between regions.

As a low income country Ghana needs cheap and cost-effective solution for its shortage of electricity production and overall infrastructure regarding access to main grid.

The solution must be also sustainable from primary economic reason but never the less also from social and environmental aspect.

The economic solution will be focusing on primary aspects of renewable energy sources particularly photovoltaic installations and its effective constellation settings based on cost-benefit analysis. The fact of this approach is the expensiveness of technology and its installation in remote parts of country and later interconnection with old infrastructure. Challenge will be to create constellation that will support this new energy infrastructure, question however is if it is in economic reach of low-income country such as Ghana.

There are two hypothesis of this work. Firs is if the economic benefit of photovoltaic power plant on local and regional level able to reach of to low-income country. Second can developing nation use scares resources that it is lacking to adopt high-value added expensive energy production to address its social and economic problems proclaimed by politicians in promoting renewable energy. If both hypothesis are answer what should proposed constellation include that would make this project successful, by those two hypothesis the research question is proposed what should be the new installation?

The main goal of this thesis is to provide answer to research if installation of renewable energy sources particularly photovoltaic energy source is economically and socially beneficial for the country in Africa which will be examine on Ghana. If the investment is reasonable from economic standpoint based on cost benefit analysis. If the cost benefit analysis will provide positive outcome the work will suggest a new constellation for development of Ghana's energy sector with further involvement of EU in the process. This cost benefit analysis will be focusing primarily on three actors in constellation thus being EU as coordinator and major financial contributor, Ghana's government will be operator and financial contributor as well in the constellation and finally actor will be local population which will be the major benefiter of the project proposal.

Cost benefit analysis will be key aspect of this work, therefore data requirement will be key aspect of this thesis. This work will also include data research in topic of energy

benefits for economic development and its wider contribution to potential development from socio-economic aspect. The analysis will be made focusing on leas developed regions on northern part of Ghana where electrification is only around 40% depending on region.

Based on geographical and political aspects of possible contribution of socio-economic development of renewable energy this thesis will be then establishing the framework and possible logical matrix for project of renewable energy constellation pilot project if the calculations will show that economic benefits of renewable energy are affordable for Ghanaian government and if it is rentable or possible to run those installations with economic benefit or long sustainability.

With conclusion of the research done by this thesis the work will provide solution for the current situation in Ghana and conclude if the renewable energy option is vital for further development and more investment in future or should be left in preparation stage when economic situation in Ghana will improve to at least middle income country status.

Chapter 2: Situation overview

Historical and social aspects of Ghana

Ghana as a country is located on Western coast of Sub-Saharan Africa on coast of Gulf of Guinea and is bordering three countries. On east Cote de Ivor, on west Togo and on north Burkina Faso. Country was originally part of British golden coast and was the first sub-Saharan country that gained its independence on British crown in 1957. After independence Ghana struggled with self-rule and democracy as country went through several authoritarian regimes and military coups until in 1992 country went through first democratic elections which were won by Jerry John Rawlings as first democratic elected head of state and was reelected for second term in 2000s. In 2000 constitution prevented Rawlings from 3rd time

candidacy so his successor was elected instead. John Agyekun Kufuor from New Patriotic party was elected and transition of power was not challenged when he served for two terms as well. The third elected president of Ghana was John Alta Mills who was put into office by popular vote and take control of a country in 2009. The last elected president in Ghana was John Drahami Mahama who won presidential election in 2012 and is office president till today. This ensures continuation of democratic election and peaceful transition of power into tradition and successfully established Ghana as democracy in Africa and according to CISI study Ghana is placed economically and socially well to be in half of dozen sub-Saharan possible success stories in upcoming years [43].

Ghana in colonial era was as a part of British golden coast important source of natural resources for Britain. However the first Europeans to establish contacts with native Ghanaian Akan tribes were Portuguese. They established first trading post in 15th century called Elmina thus ensuring the name Costa de Ouro or Golden Coast. Portuguese were later joined by Dutch who started their own trading post in area and were able to eventually push Portuguese out of Ghana. During its colonial history several European countries were able to establish its trading posts including Denmark, Sweden and Germany. However which such strong European presence Ghana was able to maintain to some degree its independence on European powers. When Brits entered and established its presence on Golden Coast they were able to push other Europeans out of the region and pushing Akan Ghana into more confrontation. Eventually Ghana lost its independence to British Empire.

Administratively and politically Ghana is presidential constitutional democracy where president and vice president are elected in popular free anonymous election. Head of executive power is president as he appoints Cabinet of Ministers, legislative body of country is parliament. Which has 275 members and it seats in capital city of Ghana, Accra.

Accra is with 2.5 million inhabitants Ghana's second largest city after Kumasi respectively. Administratively Ghana is divided into 10 administrative regions with their own capitals, however the main power of the country is centrally controlled from Accra

2.1. Economy of Ghana

How to characterize Ghana in a terms of development and economy might look simple from European perspective as Ghana can be summarized as low-income country according to UN where average income per capita is 3,728 USD [27]. Newly discovered oil reserves in Ghana and its exploration helped to boosts its economic. In more recent perspective Ghana was able to increase its minimum wage from 5.24 GHS to 7 GHS [24] which is around 1.5 USD a day. This means that Ghana's minimum wage is below UN established poverty line of 2 USD a day. So from many economic perspective compared to Western world and standards Ghana is low-income developing country in fact one of many in Africa. However this perspective is in many ways deciding and ignorant in comparison to its neighbors in Africa. In this chapter this work will examine Ghana's economy according to available data to its regional and continental neighbors in Africa.

As mentioned in previous part of this work Ghana is experiencing strong economic growth after new oil discoveries in 2007. Ghana's GDP is steadily increasing by 5% since 2005, after economic crises of 2008 economy was rising 'only' by 4% but in 2009 recovered to 8% and by end of 2010 was reaching astonishing 15% and by end of 2014 GDP growth was 7.1%. It is now predicted that the economy will again decrease because of plummeting oil prices on beginning of 2015, but again Ghana should be able to easily maintain its growth above 4% GDP growth. If we take Ghana into consideration as economy as a whole it can be evaluate and examine by sector based value of GDP and its current prices in economy then agricultural sector contributed with 15,547 GHS millions in 2012, industrial sector with 18,592 GHS million and service sector accounted for 33,237 GHS million in 2012 respectively [2]. The following graph is showing sectorial contributions to Ghana's GDP in year 2013.

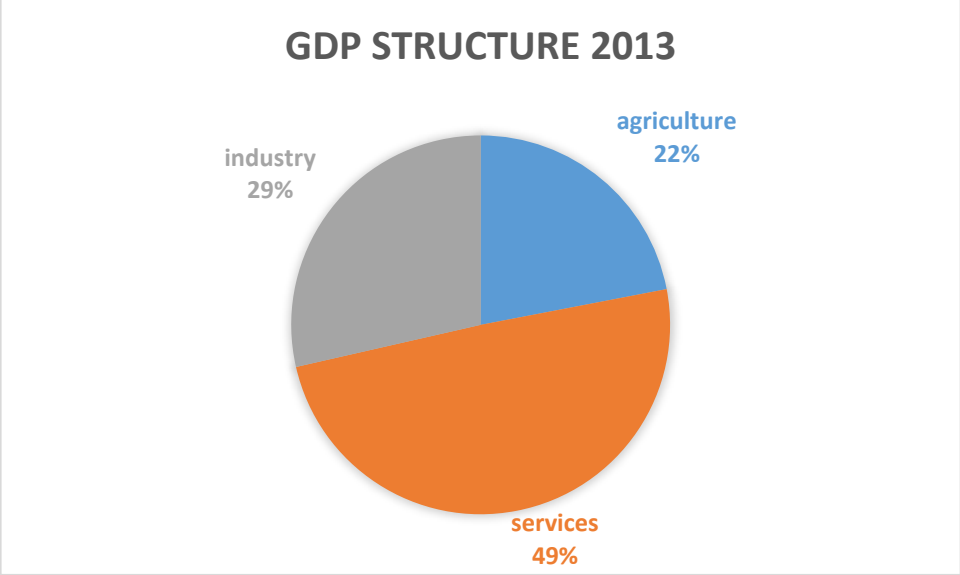

Table 1: Source: http://www.mywage.org/ghana/home/salary/minimum-wages

Same as in other African countries, agriculture plays vital role in GDP structure however unlike in other countries it does not play the largest or second largest contributor to GDP. In the size overall economic stats Ghana stands above African average and by African standards it is considered one of the more developed economies.

Regarding economic partners Ghana's traditional producer and exporter of natural resources and agricultural products. The dominant export items are from agricultural products particularly coco beans and timber products, from natural resources the main exports are traditionally gold and most recently oil. Economic ties are regarding exports of natural resources is traditionally oriented toward Western Europe particularly Nederland's and United Kingdom and important is also to mention African countries such as South Africa and Burkina Faso [4]. In aspects of imports again strong role are playing other western powers however the biggest importer to Ghana is now China followed by United Stated, Belgium, United Kingdom and France respectively. The overall trading deficit of Ghana for

2014 was -436.10 USD millions where total amount of exports was accounted for 2977.10 USD millions and overall value of imported goods was 3413.22 USD millions [4].

With aspects of overall standing of Ghana's economy and general economies of Africa inflation is playing a vital role to pinpoint position of economy as a whole. Generally with Africa many people associated high inflation rates and hyperinflation in many cases. In Ghana the inflation for year 2014 on average 15% per month [5]. Another important factor of economy status is the amount of governmental debt that country is baring. From last report in 2013 the governmental debt of Ghana was estimated to be 55.64% of GDP. The following graph is showing development of inflation in Ghana since 2000 till 2014.

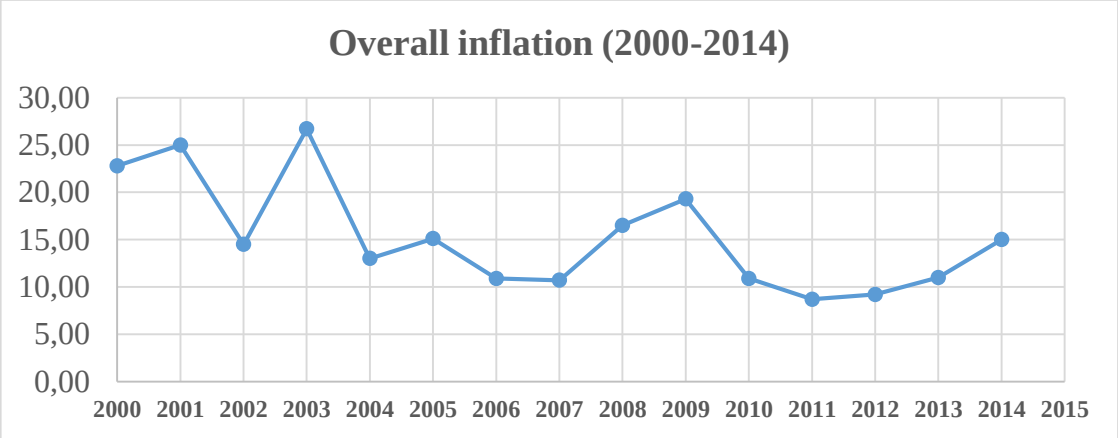

Table 2: own work based on [25].+[26].

From the graph is visible that inflation is changing rapidly and dramatically over time. One of the main reasons for that is the fact the overall exports of Ghana are predominantly consist from natural resources and agricultural products with low-value added. This leaves country exposed to external economic forces and gives little maneuverability for government to really address this issue.

2.2. Geography of Ghana

Location of Ghana from geographical perspective proven to be vital and important aspect of the country as it was proven throughout its history as own Akan kingdom and under European colonial masters. Topography of Ghana consists mostly of low lands and plains. In central part of country dominant position is taken by small plateau. Also in central part of Ghana is Lake Volta which is the largest artificial lake on world. This ensures favorable conditions for agriculture in central and south regions of Ghana. Northern parts are predominantly dry and soil is poorer with nutritious where climate is continental. On south Ghana has long coastline of 539 km on Gulf of Guinea. Overall area is 238,533 km2 from which 11,000 km2 are water area [8]. If we look into coordinates where Ghana is located (8 00 N, 2 00 W) then we notice that Ghana lays almost at equator which affects its climate and amount of sunlight significantly. Climatically speaking Ghana can be divided into two parts, southern more oceanic climate with warm and humid climate and continental hot and dry in northern territories. In general Ghana is located from global climate perspective in tropical area. This means that on equator is 12 hour day sunlight which also includes Ghana. The amount of sunlight will be important in next chapters of this work as it will provide insight of cost benefit analysis. In regards to seasons and weather patterns Ghana also benefits from its equatorial costal location as a stable seasons of long hot periods of summer and short rainy seasons switch during year. In aspects of topography Ghana is relatively flat country with lowest point being coastline (0 m) and the highest point being Mount Afadjato (885 m). The following chart is showing the amount of sunlight in Ghana.

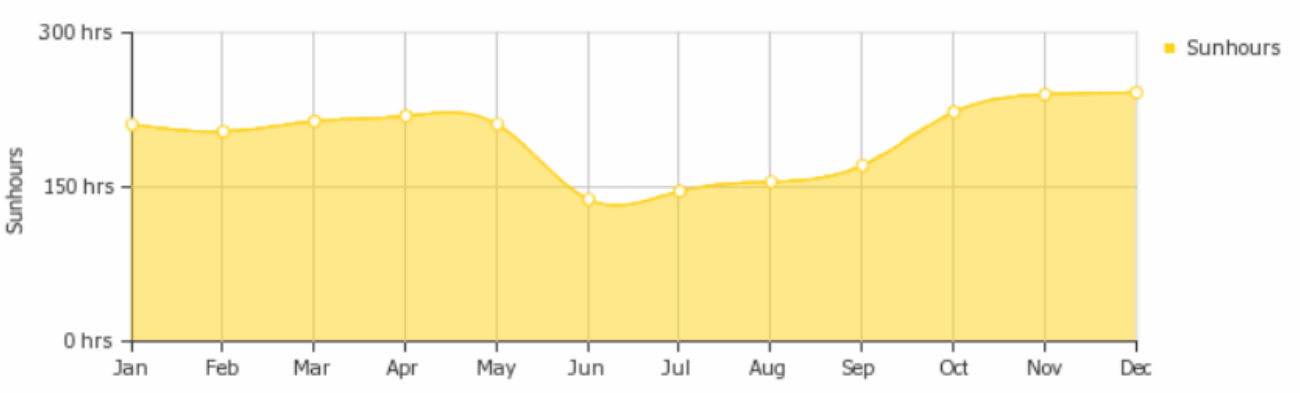

Table 3: Source: http://www.weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,Accra,Ghana

From the graph we can see that amount of sunlight is high for most of the year decreasing only from may till August but still remains high compared to other parts of the world. It also shows that the highest and driest temperature is from December till February. Correspond with this graph is following graph that shows amount of rainfall that Ghana experiences.

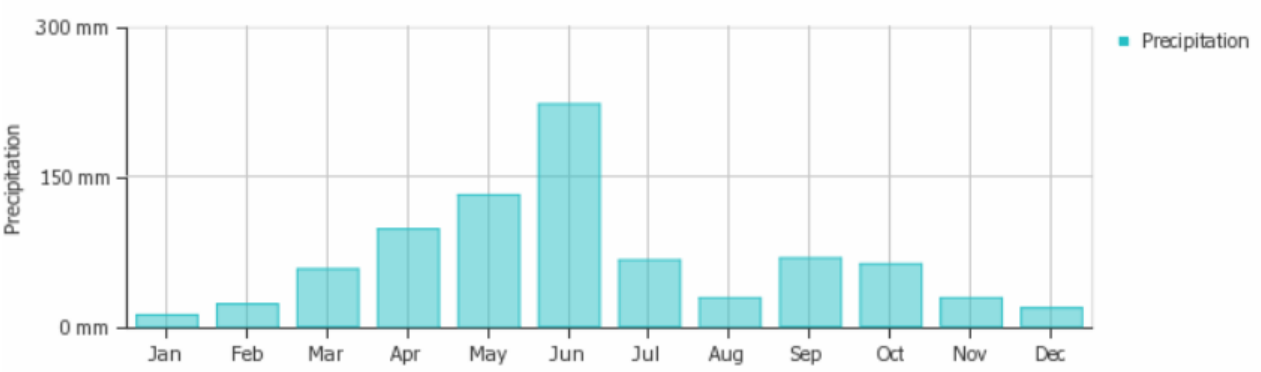

Table 4: Source: http://www.weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,Accra,Ghana

This graph confirms that rainfall and haze are relatively small during year and are high only for short three month period of year. Again predominantly thanks to its tropical climate and ocean proximity. Also it is important to note that the amount of rainfall is different between northern continental and southern oceanic part of the country.

Those disparities are marked and visible on map of Ghana as green areas are covered in higher density vegetation and brown is typically associated with harsher climate and less rainfall. The data also point that temperatures in Ghana rarely fall under 20 °C throughout year. In regards to humidity again rarely falls under 80% this however depends widely on measured location as humidity various throughout Ghana landscape and as previously more humid locations are on south of Ghana and less humid are on in northern territories [9]. The following map shows the topography of Ghana and its geographic conditions in more detail and it gives a hint into better understanding of geographical and climate realities that may affect or will play vital role in cost benefit analysis in next chapters.

Figure 1: Source http://www.pinstopin.com/ghana-physical-map/

2.3. Energy situation in Ghana

Despite significant reforms efforts in recent years, fuel and electricity subsidies are still pervasive in sub-Saharan Africa, Ghana being no exception, as the situation have worsen [42].

Current situation in Ghana is predominantly determined by often blackouts and not fully developed infrastructure and access to main grid. Overall access to energy is vital aspect of development for both human wellbeing and economic aspects and overall Ghanaian competitiveness. Generally electricity availability and access to main grid are the main obstacles that is government facing now. First it is important to note that Ghana is important energy producer in region. With its overall production estimated to be 8,213 billion kWh and estimated consumption to be 5,133 billion kWh Ghana is more than self-sufficient in energy production. As the main regional exporter it also exports 1,036 billion kWh to neighboring countries. Despite all those advantages Ghana is still experiencing blackout and electricity shortages. This is mainly due to low amount of infrastructure and its development. In 2007 access to main grid was only around 50% since than Ghana significantly invested to development of its electricity infrastructure and by 2012 installed additional 2.3TW and access to main grid improved and is estimated to be 74%. However the energy distribution remains widely different from region to region. Currently the Ghana's energy mix is not properly balanced as modern industrialized states. It is heavily relying on two primary sources, hydropower energy and fossil fuels. From economic point of view it is logical as Ghana has now new access to recently discover crude oil that can easily meet the needs of Ghana's fossil fuel power plants and strong hydro energy as it is home to biggest artificial lake in world. Fossil fuels represent 40,6% of energy mix and 59,4% is represented by hydro power [8.].

Even though Ghana made some significant progress regarding electrification still some 30% of population relays on biomass and firewood for heating. To closer examine energy sector in Ghana we need to address the fact that overall average individual consumption of electricity per year is low and is significantly lacking behind more developed

countries. In comparison the annual energy consumption is 343.74 kWh per capita in Ghana and in Czech Republic it is 6,288.53 kWh per capita respectively. The low amount of consumption is caused predominantly by lacking infrastructure and limited access to main grid, results of the current situation are often blackouts and energy shortages. Ghana's government reacted to current situation by adopting several curtail points in Ghana's national development plan Ghana vision 2020 where it addresses and identifies the access to electricity as one of the main obstacles for further development and addresses it. The following chart represents electrification of regions and access to main grid.

Regions	Population	Electricity Access	Households (HH)	HH with access	Pop with access
Greater Accra	4,010,054	97%	1,036,426	1,005,333	3,889,752
Ashanti	4,780,380	82%	1,126,216	923,497	3,919,911
Central	2,201,863	81%	526,764	426,679	1,783,509
Brong-Ahafo	2,310,983	67%	490,519	328,648	1,548,358
Eastern	2,633,154	70%	632,048	442,434	1,843,207
Western	2,376,021	68%	553,635	376,472	1,615,694
Volta	2,118,252	65%	495,603	322,142	1,376,863
Northern	2,479,461	50%	318,119	159,06	1,239,730
Upper East	1,046,545	44%	177,631	78,158	460,479
Upper West	702,11	40%	110,175	44,07	280,844
Ghana Overall	24,658,823	72%	5,467,136	3,936,338	17,754,352

Table 5: Source:

http://www.unepdtu.org/Resultat?qt=NetmesterSearch&fr=1&sw=ghana#tabs

From the chart is obvious that development and economic power is concentrated on the south of the country in costal and central area of Ghana and is slowly decreasing to northern parts where settlements are smaller and the distances between them are wider. This population scarcity also affected the speed and amount of infrastructure construction in each region. For better graphical decryption see map.

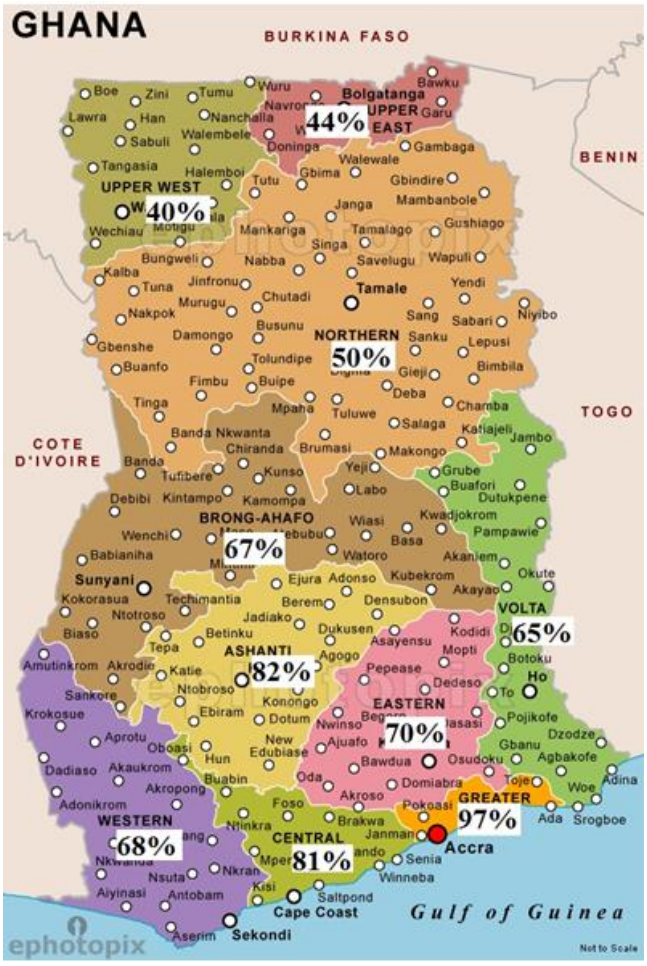

Figure 2: Source: Own work + <http://www.ephotopix.com/ghana_political_map.html>

The progress was steadily been made. However if the current trend of implementing changes and adopting policies from national development plan it is possible that Ghana can meet its goal of full electrification by 2020 as proclaimed by government. As the electrification took progress it is important to note that Ghana had on in previous century underdeveloped economy and infrastructure. Therefore ministry of energy was concentrating on creating constellation that will help develop infrastructure and integrate stakeholders into the process. The process of electrification started in 1989 under ministry of energy and it was called National Electricity Scheme (NSE) which has determinate conditions and ways how the electrification should continue and additional National Electrification Program (NEF) which helped to propose and build some small power plants on remote locations with providing Self Help Electrification Program (SHEP) that can help communities to start their own electricity production under certain conditions. From the following chart we can observe how the electrification process looked like on the end of 20th century in Ghana.

Table 2: Number of Electrified District Capitals and Other Towns (1996 - 1998)

Region	District Capitals	Other Towns	Total
Ashanti	**-**	**15**	**15**
Central	**2**	**64**	**66**
Eastern	**-**	**42**	**42**
Volta	**2**	**54**	**56**
Western	**3**	**93**	**96**
Upper West	**3**	**10**	**13**

Brong Ahafo	**-**	**-**	**-**
Northern & Upper East	**13**	**129**	**142**
Total	**23**	**407**	**430**

Table 6: Source:
http://www.unepdtu.org/Resultat?qt=NetmesterSearch&fr=1&sw=ghana#tabs

Data from many regions are missing are hard to find by or to be produced. This is often the case in many African countries. So we can see that the electrification process of Ghana started even before it was addressed in national development plan. However now it is taking more dominant position than before. The government program to fully electrified country by 2020 has also another main goal and that is diversify its energy mix, so it will include solar or photovoltaic asset and nuclear energy. However this is long shot for the government and electrification must be addressed first. To address the diversity the plane states that by 2020, 10% of Ghana's energy must come from renewable energy, particularly solar [23]. To address this issue and to promote commitment into renewable and sustainable energy Ghana started project Nzema, which is now under construction by Blue energy company and by the time it will be finish it will be the 4^{th} largest solar power plant on world with installed capacity of 155 MW it will be able to provide Ghana with 6% of energy witch is desperately needed and also will help diversify its energy mix. To adopt new policies and promote [23].

The process of electrification of Ghana was set by ministry on energy and will be done through NEF and SHEP programs. The NEF particularly describes the process of electrification based on prioritizing larger urban areas first, second smaller towns and third small villages by where populations below 500 will be the last to be electrified. The SHEP is to promote self-helping initiative. To achieve electrification, the government created following constellation to implement the goal of National Development Plan regarding electrification.

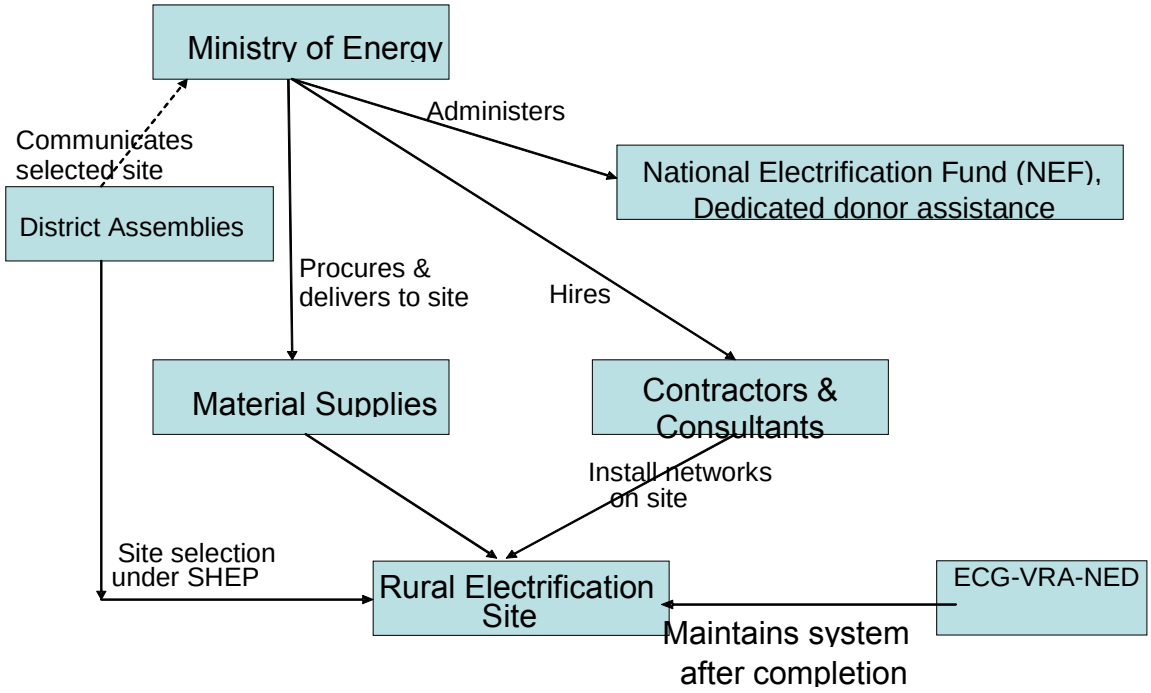

Figure 3: Source:

http://www.unepdtu.org/Resultat?qt=NetmesterSearch&fr=1&sw=ghana#tabs

The vital role is played by Ministry of Energy which provides Material supplies, construction and consultations and is the main controller of money distribution through NEF. Direct assemblies represent local government and other forms of local representatives. ECG-VRA-NED is operator of those facilities and will maintain the system after competition. However this does not show the ability to adopt to renewable energy in Ghana, only electrification process as a whole.

2.4. Renewable Energy

There are many myths and misinterpretations of possibilities that renewable energy sources can provide in regards to scale of production, quality of supply or financial aspects of sustainability and prices required to maintain those assets. In this part of the second chapter this work will examine the options of renewable energy and will straighten some facts about its true potential from possible aspects of sustainability, both in production and pricing.

Traditional sources of energy such as coal, oil or nuclear power have some advantages over renewable energy sources. The predictability of energy output, reliability of those sources and relative inexpensive costs of production are giving competitive edge over its photovoltaic or wind competitor. When available many renewable sources have variable that cannot be known for future etc. wind speed and intensity or amount of solar radiation in certain time when consumers need more energy for their production or usage [31]. This puts extra costs on renewable energy as it is hard to meet customers demand in short amount of time. Also other important thing is the cost of technology that needs to be accounted to final price of produced energy output. This cost is higher than in traditional sources which affects competiveness on free market therefore many governments adapt special programs and policies to help renewable energy to remain compatible on markets. The price of technology has changed rapidly when 1977 the price was $76.76/Watt and by the end of 2013 the price has fallen to its record lows of $0.76/Watt. According to Solabuzz the price will fall by 20% whenever the size of industry doubles. The new improved technology and increased production in industry has lowered the price of production for small scale producers to $2.43/Watt in retail prices. For large scale producers the price of $1/Watt was achieved. However this also depends on production output therefore location of power plant. If we take more recent predictions and calculations and compare renewables with traditional energy sources we can see the obvious disadvantage of renewables in terms of scale and price. In the following examples we can see how much energy can be extracted from 1 ton of crude material and then for what price it can sold on market. Than comparison to renewable source such as solar energy.

Energy comparison	Energy output
1 ton of coal	6,182 KWH
1 barrel of oil	1,699 KWH
1 cubic foot (0.028 m3) of gas	0,3 KWH

Table 7: Source: http://greenecon.net/understanding-the-cost-of-solar-energy/energy_economics.html

Energy costs	$ per unit	$ per KWH
1 ton of coal	$36	$0,006
1 barrel of oil	$70	$0,05
1 cubic foot (0.028 m3) of gas	$0,008	$0,03

Tablet 8: Source: http://greenecon.net/understanding-the-cost-of-solar-energy/energy_economics.html

Solar energy cost	Unit
Average system cost	$95 / square foot (0.093m2)
Average solar panel output	10,6 Watts / square foot (0.093m2)
Average solar energy system cost	$8.95 / Watt

Table 9: Source: http://greenecon.net/understanding-the-cost-of-solar-energy/energy_economics.html

From those charts we can see that fossil fuels have significant advantage in energy output production and also in cost of production, however their effect on environment is significantly worse than by renewables. Government therefore often try to balance this by reducing taxes on renewables and increasing high taxes on fossil fuels as a it is a significant pollutant. Without those measurements by government solar energy will be completely uncompetitive. However what is important to note are the low costs of maintenance of solar panels which is significantly cheaper than its traditional counterpart also the fact that life

expectancy of individual solar panel is stretching up to 20 years and with count to it some governmental subsidies program and lower tax rate than this technology can be beneficial and economically viable. Good example of such successful governmental program is Germanys 100,000 roofs program that helped Germany to develop and speed up process of implementation of solar energy on German market [35].

The rapid decrease of prices for photovoltaic cells and improvements in technology are now slowly taking its competiveness back and in many parts of the world solar energy becomes viable option even without government subsidies. In 1954 when research started photovoltaic panels were able to capture and produce 6% of energy now it is in most modern photovoltaics up to 40% and life expectancy of modules is above 20 years [13]. Energy lost during time is also relatively low as 20 years old photovoltaic cell will produce still 80% of its energy output. The most important feature is however the ability to operate without access to main grid in remote areas which gives chance to bring electricity relatively cheap even to developing regions and countries that have problem with addressing electricity demand.

However the most important thing will be always the question of economics and its economic effectiveness. To calculate economic effectiveness we must follow simple equation of cost of production we are able to produce and for what price we are able to sell it to consumer. In this case we must follow first physical aspects of transformation of sunlight into electricity by following equation and calculation.

Installed capacity X (90%) (conversion from AC to DC) X number of sunlight hours X 365 = Annual production of KWH

This simple equation will determine the energy output. Therefore for photovoltaic energy location and technology is key aspect to determine the amount of energy available to produce.

More closer to equator more energy production output is possible. This equation will be used in later stage of this work as it will help determine the output of power plant in Ghana.

Other important equation which is needed is to calculate the costs and revenues that will be produced by power plant during its lifespan and will be also curtail part of cost benefit analysis later in the work. Key aspect in any energy production is to determine and balance costs and revenues of the facility so the management and other decision making aspects can take those costs into decision making process and determine future strategy and prepare cost of actions for various favorable or unfavorable scenarios that might occur during projects lifespan. To calculate those "present value of lifetime revenues from the sale of the plant's electricity" we need to use following equation:

$$TLRpv = TLKCpv + TLOMCpv + TLFCpv$$

Where:

TLRpv = present value of lifetime revenues from the sale of the plant's electricity

TLKCp v= present value of lifetime capital cost

TLOMCpv = present value of lifetime operating and maintenance cost

TLFCpv = present value of lifetime fuel costs

Source: [32].

This calculation is generally used for calculation on all types of power plants not only renewables. In calculation regarding TLFCpv will be therefore used 0 as renewable energy doesn't need any fuel. Of course revenues cannot be earned until the facility is build which is also important to note. So it is possible that we will have to present value of lifetime revenue restated (TLFCpv) into other equation:

$$TLRpv = D_0 * R^t * \frac{1-R^p}{1-R}$$

where:

TLRpv = present value of lifetime revenues from the sale of the plant's electricity

D_0 = revenues per period, as known today

t = the number of periods for construction

p = the lifetime of the plant in periods

i = the inflation rate per period

r = the nominal discount rate per period

Source: [33].

With those calculations and based on those calculations project will be than determine if it is affordable for the country and if some external source of financing is needed to help establish those facilities as they are expensive investment with questionable revenues as is often the case in energy industry. In this part was then discussed benefic and negatives of renewable energy and how does it stands in compare to other traditional sources of energy and the calculations needed to calculate economic potential of any kind of power plant without any subsidies or assistance.

2.5. European Union and foreign aid

In 2012 the survey made by researchers shown that EU and its 27 countries are the biggest donor of foreign aid to Africa [14]. The Europe is focusing primarily on normative approach towards developing countries promoting predominantly common interest in good governments, civil society, human rights, sustainable development and peace and security. The foreign aid is often the soft power approach for which is EU predominantly known. For each world region EU has established different policies regarding foreign aid and relations

however they are also predominantly driven by those main objectives. In this work the main focus will be the African continent as it is in close vicinity of EU and it play a crucial role for Europe and vice versa Europe plays vital role for Africa. Currently there are several policies that are in motion and are affecting Africa. In 2007 EU and African states signed up new Joint African-EU Strategy that should establish three main goal in development of further cooperation.

- **Beyond development** which meant that EU and Africa will go further in dialog on problems and issues regarding both continents and expand their bilateral dialogue on issues of common interests in form of cooperation on such topics as governance, human rights, regional integration and human rights, energy, climate change, migration, mobility or employment
- **Beyond institution** by working towards more people oriented partnership which meant to increase participation of private sector and civil society in civil partnership oriented society which will benefit citizens of both continents
- **Beyond Africa** cooperation in tackling world challenges such as climate change or peace and security

Those topic should not only establish the framework for further cooperation but generally help switch Africa from becoming a reinvent of aid to full developed trading partner. Despite those proclamation Africa still remains the biggest receiver of European foreign aid. In 2012 43% of all developing aid from EU went to Africa which is estimated to by 24 billion Euros [14]. What is also important to note is the fact that despite economic crises that had tremendous negative effect in Europe, the commitment to foreign aid. From the graph we can see that despite tough economic environment in Europe after 2008 economic crash and rising economic crisis the aid for Africa didn't decrease and was maintained and even increased.

ODA to Africa from EU15 in Euro million and as % of GNI

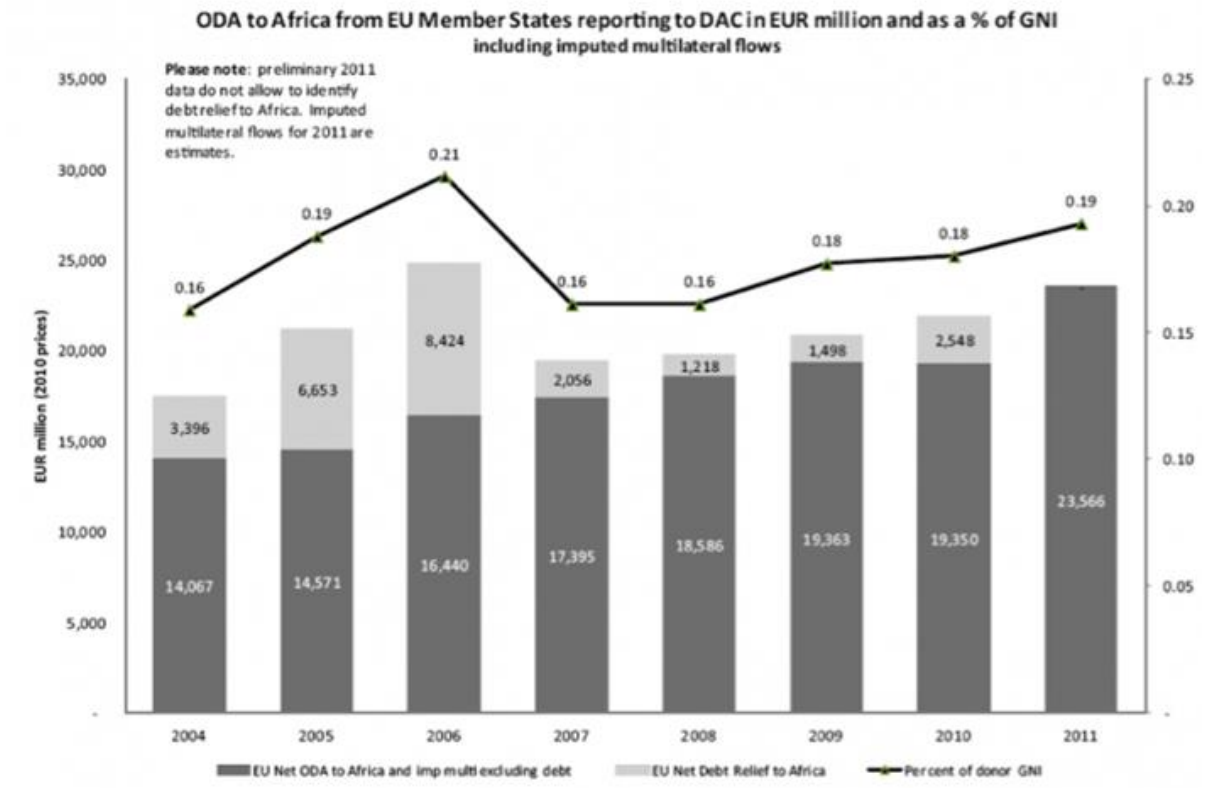

Table 10: Source http://www.africa-eu-partnership.org/about-us/financing-partnership

It is also important to note that not only EU contributes to developing aid to Africa. Participation of individual EU members is playing also curtail role. However the individual states may find other options and principles on which they donate their aid. The following list shows the individual courtiers aid towards Africa. With potential combination of EU funds and aid this can give Europeans some advantages as there is ever increasing presence of Chinese and US aid now targeting Africa. The following table shows individuals countries contribution to foreign aid to Africa and the amount spent since 2004 till 2011 and again we can see on some examples that despite having economic difficulties some countries still remain high donor of foreign aid.

EU ODA to Africa - Net disbursements (including imputed multilateral flows - Euro million, constant prices)

Country	2004	2005	2006	2007	2008	2009	2010	2011	Increase 2011/2004
EU15	**18,216**	**22,238**	**25,999**	**20,129**	**20,497**	**21,564**	**21,659**	**23,566**	**5,350**
Austria	259	273	658	503	265	340	406	190	-69
Belgium	729	816	996	777	794	903	1,247	974	245
Bulgaria								5	5
Cyprus							1	1	1
Czech Republic	25	37	41	41	46	42	50	50	25
Denmark	802	822	967	1,020	961	924	914	1,036	235
Estonia							5	6	6
Finland	226	254	308	316	339	392	405	376	150
France	4,639	5,391	5,880	4,135	3,903	5,090	5,083	4,610	-29
Germany	2,616	3,222	4,365	3,375	3,573	3,141	3,178	3,800	1,184
Greece	85	86	117	112	142	126	118	43	-42
Hungary	15	25	26	38	27	28	30	43	29
Ireland	296	311	428	439	507	411	396	415	119
Italy	957	2,016	1,545	1,215	1,245	1,050	1,044	3,396	2,440
Latvia									-
Lithuania									-
Luxembourg	108	111	126	141	139	142	141	140	32
Malta									-
Netherlands	1,693	1,783	1,573	1,802	1,613	1,353	1,528	1,047	-646
Poland	54	67	152	74	90	105	94	95	41
Portugal	791	171	183	177	256	201	305	408	-383
Romania							-	1	1
Slovak Republic	10	33	30	31	34	17	19	22	12
Slovenia	-	-	-	-	12	14	12	14	14
Spain	679	1,027	1,068	1,177	1,468	1,787	1,587	923	245
Sweden	825	1,149	1,162	1,267	1,284	1,318	1,157	1,826	1,000
United Kingdom	2,656	3,632	5,238	2,813	3,106	3,477	4,185	4,278	1,622
Total EU	**17,462**	**21,225**	**24,864**	**19,451**	**19,804**	**20,861**	**21,904**	**23,697**	**6,235**

Table 11: Source: http://www.africa-eu-partnership.org/about-us/financing-partnership

Africa and generally developing countries are most likely to be affected by climate changes as they lake technology, resources and crisis management. Therefore EU and African Union and other African countries are in commitment regarding climate change promotion and addressing this issue on world stage. On June 26th 2014 in Malabo in Equatorial Guinea conference of Committee of the African States and Government on Climate Change was held the committee after 23 round of ordinary sessions was able to estimate that Africa needs 15$ billion on talking the problem of climate change [15]. African countries does not have those resources or knowhow therefore they must rely on foreign aid into programs that will help

them. If we closer examine the foreign aid to particular country it can be seen that dominant portion of sources are focusing primarily on agricultural climate change civil society promotion and human rights improvements and sustainable development .

To better illustrate the individual programs and aids example study can be show on relatively recent program which was negotiated between Ghana and European Developing Fund on 22nd June 2010 in Luxemburg. The program period years will be 2014-2020 and it's corresponding with Ghana's national development plan. The National indicative program is focusing to help Ghana develop 3 focal sectors and 2 cross cuttings to address issues which are corresponding with previously state proclamations of foreign aid. Overall 323 million EUR was made available for various projects to help improve living conditions and promote sustainable development. However this National indicative program is not direct aid as the new form of promotion is mainly focusing on cooperation among EU and African states rather than just simple donating. The 323 million EUR was made for Ghana available to co-finance those projects of address governance, agriculture, employment, civil society promotion and supporting measures. This will not only help EU to better see if the resources were used transparently but eventually will help Ghana to modernize some of those sectors [16]. The following char is showing percentage of how much resources will be directed into which sector of national indicative program.

Focal sector 1: Governance: Public sector management and accountability	**73 mil. EUR**	23%
Focal sector 2: Productive investment for agriculture in Savanah ecological zone	**160 mil. EUR**	50%
Focal sector 3: Employment and social protection	**73 mil. EUR**	23%
Cross cutting: Measures in favor of civil society	**9 mil. EUR**	3%
Cross cutting: Support measures	**4 mil. EUR**	1%
Total:	**323 mil. EUR**	100%

Table 12: Source: <http://eeas.europa.eu/ghana/index_en.htm>

Overall to conclude this chapter it gave a look into how European foreign aid works and what topics are curtail and main focus of this aid. Sustainable development, climate change agriculture and civil society promotion and development are main objectives of EU regarding foreign aid. Also on example that was given on Ghana this work shown that EU is focusing on transparency in aspects of its aid and requires co-financing and active participation on projects so the stakeholders in this case Ghana and EU keep focus on the individual objectives set by the project to which the aid is addressed so there won't be ineffectiveness in allocation of this aid.

Chapter 3: Methodology

. Methodological approach can be divided into following parts which will all play crucial role to success of this thesis. Each aspect and part of it will be introduced and explained as what part it will play in this work. Therefore the methodology consists of:

1. Hypothesis
2. Overview of methods available
3. Operationalization
4. Data collection
5. Cost-Benefit analysis: Definition
6. Logical Framework Matrix
7. Funding (source, required PV amount)
8. Time schedule (Gantt Chart-proposed models)
9. Costs (CF,PI,NPV)
10. Benefits (oil savings, social aspect)
11. Results (costs +benefits=summed up)
12. SWOT

13. Discussion (would produce conclusion+ recommendation)

This part of methodology will closer examine each step of procedure to introduce sequence of actions established in methodology to address the main objective of this thesis.

1. Hypothesis was already introduced in previous parts of this thesis as the previous chapter established situation and its realty in which each actor is at current position. Hypothesis suggests that investment into renewable energy in low-income country such as Ghana should bring in long term economic and social benefits however it should not be used as short term solution to achieve political goals even as important as they are in aspects of short term solution to lacking access to main grid. The objective of this work is to provide empirical data to support or repulse the proposed aid into renewable energy sector.

2. It is important to establish the best possible approach to confirm or repulse proposed hypothesis suggested in previous chapter. Best approach to address this task would be to create possible scenarios and establish fictional settlement based on hard data provided by domestic and international institutions to calculate possible outcomes of such proposed project. Geographical and climate position of Ghana and lacking infrastructure with rising demand of energy makes it ideal subject to propose photovoltaic power plant as alternative to traditional fossil sources that can take long periods of time to develop and implement to consumer. The hypothesis of this work is that photovoltaic power plant might be able to provide sustainable development for the region and its inhabitants and prove of economic and social benefit generated by this investment. This method proves to be most viable as it can be used for future project proposals if the results of this work will be sufficient enough.

3. The pilot project will be following fictional settlement of 500 inhabitants and will calculate its electricity consumption based on national average. This will set the

hypothetical demand for electricity and based on this demand photovoltaic power plant will be established to provide supply. This supply will be calculated based on geographical condition of Ghana based on sunlight and chosen model of photovoltaic panels used in current (2015) market values. Those calculations will give firm base for project as it will provide the required expenditure to establish such power plant.

4. Data collection is necessary for any further progress in project as the project stands on data provided by national institutions and international organizations such as EU and UN. The necessary data for the proposed project are average energy consumption which will be obtained from UN statistics (343 KWh/annually in Ghana). The data required for cost-benefit analysis will be provided by national institutions of Ghana such as inflation rate (18%) and discount rate (25%) as well as market value of oil and electricity which are crucial in cost benefit analysis. Therefore the sources used will be not older than 2012 and in aspects of inflation and discount rate the most recent will be used (2015 May).

5. This is the most important part of methodology as it establishes the definition of cost benefit analysis and determines which indexes will be calculated and evaluated for economic part and which for beneficial part as well as establish base on which the project will be proposed. Definition must include from technical and organizational point of view to describe the nature of the project to set financial planning and also define barriers for project. It will also include and describe the basic structure on which logical framework will be build and defined.

6. Logical framework matrix is the core of the project as it establishes the actors as well as roles and objectives which the project must fulfill. What are the stakes and who are the stakeholders and what is expected from the proposed project, main goal, outcome, possible output and activities as well as well as project summary, indicators, means of verification and expected assumption. In this part of the project it seminary work of Stankovic & Latalova will be used to illustrate LFM. This subject is energy and its effects on development are long term object specialization of claimant.

7. After logical matrix will be established the source of finance and the cost of project must be established. In situation overview was established potential source of funding from one of negotiated programs of foreign aid from EU via EDF. This will be established as source of funding from Euros Focal sector 2: Productive investment for agriculture in Savanah ecological zone which will be the main source of finance. Next in this segment of work the cost of proposed project will be estimated on market value. This part of work is strongly correlated with 3rd part of methodology as the results from this part will strongly influence price of this project and therefore the viability of this analysis. Calculations are based on 305 watt/day photovoltaic panels sold by 20 pieces for price of 5,500 USD. This was set as average value of PV panel with average energy output which was token as an example PV panel. The calculations to establish energy needed for this settlement was proposed in Chapter 2.4. Renewable Energy. The amount of PVs required will be than added to Table with estimated costs for installation (3000 Euro) maintenance (500 Euro) and revision (500 Euro). Those values are set as estimation and are used as constant in future calculations.

8. Time schedule for the project must be established in form of gantt chart. Here will be proposed two possible conditions that will be later used for model proposal in following parts. Short 5 year plan and long 20 year plan. This is necessary to

establish if the hypothesis stays correctly on fact that long term benefits of the renewable energy should outweigh short term negatives in terms of profitability, rate of return and investment rationality.

9. Cost will be the 1st part of actual cost benefit analysis. First it will be important to establish what will be calculated in costs aspects and what will be the cash-flow. Cash flow calculated will be based on consumption of electricity and tariffs. In this part of work crucial aspect to determine costs will be Profitability index (PI) and Net present Value (NPV) however because there ae many variants and hypothesis stays on statement that long-term investment into renewables should be profitable/beneficial rather than short term investment it would be necessary to calculate both PI and NPV for short and long term cases. It is important not to mention fact that market conditions can change rapidly this analysis must take into consideration positive and negative perspective into the future therefore positive and negative prognosis will be made for both cases of long and short term prognoses of both calculated variables of PI and NPV.

10. Benefits will be 2nd part examined in this analytical part of the work. For this part of analysis social aspects of the renewables will be taken into consideration as well as possible savings on fossil fuels that would normally be required to create this certain amount of energy. The main focus will be savings as it will be easy to quantify and later compare to "cost" part of analysis. Also in this case two conditions will be proposed. Short 5 year and long 20 year business plan but in this case it will be based on prices of oil and the amount of saved oil. However in this case there will be set of two scenarios of for oil prices (good prognosis and negative prognosis) as well as in previous "cost" part two scenarios for ideal conditions and real conditions regarding cash-flow.

11. Finishing both parts of cost-benefit analysis the two calculated variables will be combine to provide overall results of this analysis. Here it should be seen if the economic terms and social aspects are being delivered by the proposed pilot project and if so in how many scenarios from all proposed. This part of the work should give first estimated look into hypothesis that renewable energy can be vital source of energy for long term as an investment as short term profit oriented investment and provide some data that will support or repulse proposed hypothesis.

12. The results provided by cost-benefit analysis will be than processed in SWOT analysis where other aspects will be taken into account not only the result of costs and benefits. Those aspects being overall social benefits, availability of technology or the fact that this project is dependent on foreign aid and the source of funding for it is out of reach for government. The SWOT analysis should take all aspects into consideration and provide results on all aspects and not just on terms of financial viability.

13. In this final part of methodological process proposed for this work the results of SWOT analysis and cost-benefit analysis and its outcomes and results should be presented into discussion where all possible scenarios should be addressed. This should be place where hypothesis should be closer examine and compared to result of SWOT analysis of proposed pilot project. The outcome of this discussion should result into final conclusion and recommendation if the hypothesis was confirmed or repulsed. The diploma thesis should then be closed in conclusion.

This steps will be divided into sub-chapters which will be presented in content for fast access and better orientation. This methodology was chosen as best possible structure for current proposed topic of this diploma thesis to address the proposed hypothesis.

Chapter 4: Results and Discussion

Cost Benefit Analysis

This part of work is focusing on analytical part of this thesis. It is important first to determine the definition, purpose and objectives of cost benefit analysis of the proposed project regarding investment into photovoltaic power plant in region with low access to electricity grid. The core will be to determine costs and benefits of this project and find a way to quantify it and propose economic solution in case of pilot project in one of the upper regions in Ghana. First will be done cost benefit analysis of traditional photovoltaic power plant and then the project will be descripted in logical framework matrix. Some aspects such as time duration of projects construction and running costs and other aspects will be used in both parts of analytical part of this work and will be included in both cost benefit analysis and logical framework matrix. The analysis will be in corresponds to Ghana's national development program and foreign aid policy of EU and common policy of EU and Ghana mentioned in previous chapters of this work. Also in analytical part of this thesis it will important to determine economic benefits to local community regarding aspects of electrification and find the way how to quantify such variable as access to main grid and benefits of electricity to economic activity, employment and other social economic aspects that will be determined in benefits part of cost benefit analysis. The evaluation and discussion of analytical part of cost benefit analysis and logical framework and its positives, negatives and potential solutions will be discussed in last chapter of this work in part Discussion,

4.1. Cost Benefit Analysis: definition

There are several ways how to approach definition of cost benefit analysis. However this work must take into consideration the fact that are objects an purpose of structures such as photovoltaic power plants are different from other development aid projects that does not create certain economic output to be exact electricity. Therefore it is important to take into consideration not only economic aspects but and economic perspective of the project but also the beneficial that cannot be summed up with economic value. This work will be working with definition that is mostly able to count those aspects into consideration.

For processing CBA analysis this work will use this procedure:

- Description of the nature of the project (from technical, and organizational point of view)
- Creating a financial plan for the project from the perspective of an investor
- Defining beneficiaries, i.e. the entities to which the project impact
- Description of options of the project:
    - Zero option - means a state without the project
    - Investment option (or options) - the project will be implemented
- Defining a maximum of benefits and harm throughout the life cycle of the investment, their division into quantifiable and non-quantifiable
- Converting quantifiable benefits and harm to the cash flows
- Determination of the discount rate and calculation of criterial indicators
- Interpretation of the results, the decision whether the investment is acceptable

Source: [17].

Therefore the first this this work will determine first the basic aspects of the project, stakeholders and benefiters of the project. The source of financing and planning will be from both EU and Ghana's ministry of energy. To establish basic structure of the project pilot

project will be proposed in diploma thesis with corresponds to data and information from previous chapters of this work. Then after the project proposal and logical framework calculations of costs and benefits will be done in analysis.

4.2. Logical framework: pilot project description

In this part it will be pointed out the goals and outcomes, objectives and outputs of the photovoltaic plant. To better understand the stakeholders and benefiters of the photovoltaic plant build in one of less developed regions of upper Ghana. The following logical framework was produced by Stankovic & Latalova on Brno Mendel university class project for developing project proposal in 2014.

Goal

Goal of the pilot project is to provide access to clean renewable energy by photovoltaic technology to ensure continuation of Ghana 2020 vision that will be 100% electrification of the country by the end of 2020 that can be funded and sustain from foreign aid funding.

Indicators of this goal will be improvements and extended usage of electricity by electrical devices that will be used by households or individuals that can be counted by installed electrometer thus showing the relevance of this project and its continuation.

To verify those information's and goal annual report must be produced on governmental level from Ministry of Energy and National Electricity Provider to ensure that main goal is going to be meat and course on 2020 national plan regarding electrification is achievable with addition of this photovoltaic system.

Prediction of pilot project and its main goal is the improvement of human living conditions regarding social and economic aspects in region. Access to electricity might start

to improve living condition by providing additional sanitation or heating in social aspects but also encourage spending on electricity devices and improving regional economy. There is also probability that local population won't find new source of energy beneficial for them and will neglect it.

Outcome

With aspects regarding main goal the outcomes are to be access to electricity (later main grid) and speeding process of electrification of rural areas in Ghana.

Indicators of the outcome will be traced by electricity consumption in region as well as economic activity in region. With those two indicators after certain amount of time the data will provide conclusion if the pilot project was success or failure.

Means of verification will remain the electricity consumption from electrometer as it is the main provider of information regarding the outcome of this pilot project.

Prediction of outcome will be the increase in consumption of electricity in region as well as increased speed of electrification of rural areas in Ghana.

Output

Photovoltaic power station which will provide and create necessary electricity from sun will be the main asset of this project for local community that will be later transformed and added to national's main grid.

The main indicators of pilot project will be the installed capacity of Ghana's main grid and its expansion and the overall usage that can be monitored via maintenances reports.

The verification of pilot project will be done as mentioned before via maintenance reports from Ghana's national provider of electricity in quartile reports that will be published and presented to public and official representatives of Ghana, region and EU.

Prediction it is expected that photovoltaic station will reach its full installed capacity and production before 2020s Ghana's national plan and will contribute to electrification of nation.

Activities

Construction, funding, maintenance and governmental agreements will be playing crucial role in success of this project. As constriction of the photovoltaic station will take place with corresponding funding of construction and substitution for first period of production it will be necessary for facility to maintain professional maintenance list for evaluation of this pilot project. So governmental and private agreements can be negotiated on local, regional and governmental level to make sure the continuation of facility after period of substitution will end thus ensuring sustainability of this pilot project

Indicators for this part of logical framework should be number of operations and negotiations done by government with respect to aspects of this project. This regards such parts as budget and its redistribution in private or governmental contracts in balance sheet.

For verification of this project and activities regarding this project quartile meetings will take place between governmental official, regional representative, Ministry of Energy and EU official to discuss and address the balance sheet for future evaluation.

The outcome of those actions is predicted to be improvement of basic know-how of how to manage electricity providing from renewable energy and efficiency in distribution of electricity in region as well. Later as the facility will be added to main grid it will provide additional electricity to grid, thus also showing viability or importance of renewable energy in future rural development of Ghana.

	Project Summary	Indicators	Verification	Assumption
Goal	provide clean renewable energy by photovoltaic technology	improvement by wider usage of electricity devices	Annual report from Ministry of Energy, Governmental report on 2020 Ghana vision (annual)	improvement in social and economic being in region
Outcome	access to electricity, speeding electrification of Ghana	electricity consumption in region, economic activity	measurement of electricity consumption	increase of electricity consumption
Output	Photovoltaic power station, future addition to main grid	installed capacity of Ghana's main grid expansion	maintenance reports from Ghana's Electricity provider	usage of station will reach its full installed capacity within 2020
Activities	construction, funding, maintenance, governmental agreements on local level	Governmental contracts, private contracts, budget	quartile meetings of governmental officials from government, MoE and EU representative, balance sheet	improvement in know-how management regarding electricity provider, efficiency in electricity distribution

Figure 4: Source: Own work - Logical Matrix Framework: Pilot project

The chart above is showing logical framework matrix regarding pilot project of potential photovoltaic power plant.

4.3. Funding and investment plan

Before crafting investment plan it is important to calculate the electricity production of the facility and the number of consumers it will be providing its electricity. This has to correspond with Ghana's national development plan. The source of finance for this development aid project will be the 323 million Euros from European development fund negotiated in 2010 as mentioned in previous chapter. From those negotiated finances there are 160 million Euros Focal sector 2: Productive investment for agriculture in Savanah ecological zone which will be the main source of finance. If the project will be successful it is important to calculate first the electricity based on number of sun hours and amounts of panels required to satisfy demand in local micro-region. From previous chapters it is known that average annual energy consumption is Ghana is 343 KWh per capita. Other important fact to take into consideration is the way how national electrification is progressing and what the plans are. The electrification will progress from high density urban areas to lower and smaller villages and settlements out from the center. The last category to be electrified are settlements with less than 500 inhabitants. The pilot project for photovoltaic power plant doesn't have any precious destination so no demographic data were required however for the purpose of the project it will be working with the model village of 500 inhabitants to demonstrate effectiveness or ineffectiveness of this project. However the aid from the fund can only cover maximum of 85% of project respectively. Therefore Ghana is required to pay the remaining 15% of the project. This was stated in previous chapter of this work where EUs development aid is focusing on collaboration and active participation of domestic government or local community.

Average retail price for one solar panel is between 200 and 300 USD depends on watts production and number of pallets you have in one panel. In general we can calculate that for this purpose it will be needed 305 watt production panel with 20 cells. The fact that

Ghana is almost at equator means that sunlight and amount of hours of sunlight is high. Here is the way to calculate efficiency of photovoltaic power plant as was mentioned in previous chapter

305x20=6100 watts for 1 panel

6100x10=61,000wattt/hour or 61 kWh

Conversion to alternate current is 15% so daily production of panel is 52 kWh.

This 10 hours of sunlight average means that we can produce in 1 day 52 kWh from 1 panel of power plant. Price for this one panel in retail in 5,500 USD which puts price per watt on 0,90 USD. Average electricity consumption in Ghana is 343 kWh per capita which can be transferred to 0,94 kWh/day.

This project is being settled for settlements of 500 inhabitants so the average day electricity consumption of settlement should be:

500x0,94=470 kWh/day

470/52=9 stations

9 stations which are required for smooth running and providing electricity will cost 49,000 USD which is approximately 40,000 Euro. This means that for electrification of small settlement with 500 inhabitants with average Ghanaian electricity consumption is required 40,000 Euro to electrify settlement. If we take into consideration some possible discount by producer of panels and some assistance from local government regarding workforce than the price can be reduced to less than 40,000 Euros as following chart shows in practical example.

Name of activity	Quantity	Cost in Euro
PV panels	9	35000
maintenance	1	500
installation	1	3000
revision	1	500
Total		39000

Table 13: Source: Own work – Pilot project costs proposal

4.4. Gantt chart and investment duration

Important part for analyzing this project in cost benefit analysis will be to determine the duration of pilot project and its rate of return. For that part it is important to set time schedule and scenarios that will be used to calculate aspects of cost benefit analysis. There are two scenarios possible for this project to run. First scenario is 5 years as it will be in consistent with Ghana's national development plan and should end with it by the end of 2020. This is the focus of pilot project and should show the viability as a development aid program and means of development policy on regional level. Second option is 20 years long period to correspond with life expectancy of photovoltaic panels and should end by 2035. This is business oriented approach searching for profit maximization. For both scenarios it will important to gather data regarding consumption of electricity so it can be determine the effectiveness. However this should be the main goal of first scenario and its main goal as development aid proposal as the longest time will be spent on data consumption and evaluation as it is necessary to find according to logical framework if the consumption in location will increase and will improve living standards. Maintenance and revisions will be taken occasionally depending on results of gathered data, however they might be set for 3 or 6 months intervals. Based on logical framework and budget capabilities there were identified several aspects that will be necessary to ensure the output and outcome of project to achieve

its goals. Those aspects are transportation, installation, maintenance or revision electricity production and evaluation based on this electricity production and this counts for both scenarios. The gantt chart looks flowingly:

Scenario 1: Duration of project 5 years form of development aid

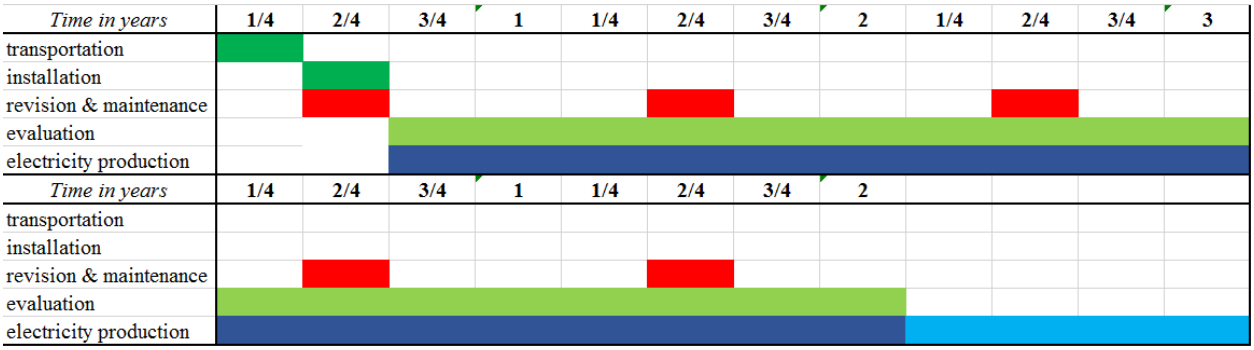

Figure 5: Source: Own work - Gantt chart 5 year Scenario

Second scenario Gantt chart after 5 years period of development aid was finished (20 year scenario)

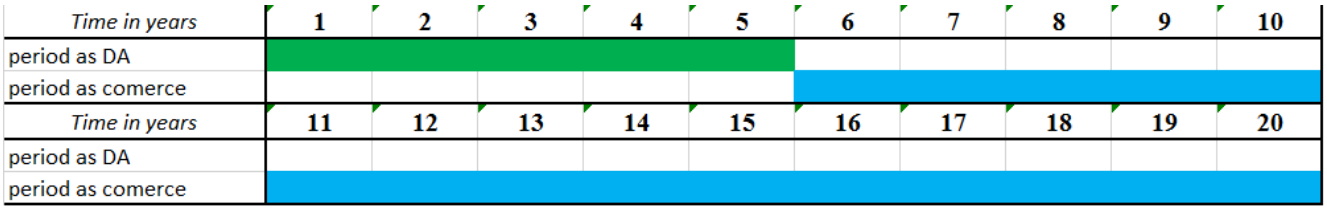

Figure 6: Source: Own work - Gant chart 20 year Scenario

Transportation

The chosen regions where is the access to electricity and general electrification of Ghana least developed is lacking modern transportation infrastructure therefore it should be located in relative accessible location by plane or motorized vehicle. The parts and equipment will be shipped to via boat and will later be transported by governmental officials by plane

or car. The transportation will be set to minimize costs so the budget cannot surpassed 40,000 Euro

Installation

For second planed period the installation of device is predicted to take 2nd quarter of 1st year. To select the best tilt for panels and preparation of device will not be difficult task but it will be necessary to provide adequate training for supporting personal from Ghana's National Electricity Provider and Ministry of Energy so the inspections and revisions of panels can be conduct. After successful installation of all hardware and training of personal will be finished, the project will starts its unofficial run of initial phase.

Revision and Maintenance

Revisions and maintenances will be done according to ganatt chart every 2nd quarter of project duration. Photovoltaic panels does not require high maintenance costs as their durability and quit high can withstand and produce electricity unattended for decades if maintained and installed correctly. As the station will be consisted from several photovoltaic panels it gives chance for maintenance team to adjust their schedule according to flaws they might possibly occur. One quarter of duration was selected as after maintenance ordering and resupplying new parts will be required. This is the reason why identification and correction of failure is so long. However it is highly improbable that all 9 panels will be shut down for some failure.

Evaluation

The data gathering for project evaluation will start as soon as electricity production start. It will be evaluated on several terms that were closely described in logical framework matrix. Evaluation team of project will consist from several representatives from Ghana's Ministry of Energy, National Electricity Provider and selected European official. Recommendations and knowledge learned from this project will play crucial role in further development of photovoltaics in Ghana for electrification purposes of rural areas. The

evaluation will personally by chosen representatives from established team. This collection of data is vital for projects success therefore it will take entire 5 years of project as development aid duration. After this duration for next 15 years it will be operated as commercial or state power plant.

Electricity Production

The main purpose of this project and power station is overall production of electricity and evaluation of its access to live improvements. It is highly probable that power plant will be able to produce electricity after those 5 years. However the main question is if there will be demand for electricity from this project and if the project can be sustain without serious interventions from other actors or alternative constellations. After the end of pilot projects duration the facility will be added to portfolio of Ministry of Energy and will be run commercially or as governmental social program.

4.5. Costs: Economic effectiveness

First it is important to calculate net present value (NPV) of the investment in this case the photovoltaic power plant. The NPV is financial variable that represents overall financial flows in investment project in present time. To calculate the NPV the following equation must be followed:

$$NPV = \frac{CF}{(1+i)^n}$$

It is important to mention that the cost of 1 kWh in Ghana is 0.2054 GHs or only which roughly 0.05 Euro [19]. The following calculation is calculated based on average consumption of 343 kWh per capita annually and represents perfect consumption of inhabitants of settlement with population of 500 inhabitants. Discount rate settled by BOG on 5th of May was 20.83% for next 14 days and inflation for last 14 years in Ghana were 18%

on average as was mentioned in previous chapter. The following calculations were taken under ideal condition. This means that it will be calculated with perfect demand for electricity and 100% consumption of production and with ideal discount rate of 18% as average inflation for last 14 years and last the production of electricity wont decrease over time as it normally would and no additional costs will be needed for maintenance or service.

***Case I. 1**: Ideal condition*

In 5 year scenario:

CF = population X consumption/price X time

CF = 500 x 1.37 x 12

CF = 8220

$$\text{NPV} = (-40{,}000) + \frac{8220}{(1+0{,}18)} + \frac{8220}{(1+0{,}18)^2} + \frac{8220}{(1+0{,}18)^3} + \frac{8220}{(1+0{,}18)^4} + \frac{8220}{(1+0{,}18)^5}$$

NPV = -25 619 Euro

First part of project was 5 years and after those years project was 14 381 Euro short to becoming even. The thing however changes if we take into consideration 20 years of minimum lifespan of investment.

In 20 year scenario:

$$\text{NPV} = (-40{,}000) + \frac{8220}{(1+0{,}18)} + \frac{8220}{(1+0{,}18)^2} + \frac{8220}{(1+0{,}18)^3} + \frac{8220}{(1+0{,}18)^4} + \frac{8220}{(1+0{,}18)^5} \ldots + \frac{8220}{(1+0{,}18)^{13}} \ldots + \frac{8220}{(1+0{,}18)^{20}}$$

In 20 years scenario under ideal conditions the results are more interesting as the project set at current form and financing will be able to pay itself by 13 years and should achieved profit of 264 Euros from original NPV and by the end of 20 year investment scenario the project should generate positive cash flow of 3905 Euro. This is under ideal

conditions which favors the project however real world case should not be that generous for both of our scenarios.

Under real conditions it is important to take into consideration 500 Euros of annual maintenance and service costs mentioned in projects logical framework matrix which will negatively influence cash flow. Than it is necessary to take into consideration the 20.83% of discount rate of CBG and inflation with risk rate which will easily push interest above 25%. On technical terms production of electricity should decrease by 1% annually. That means from installed production capacity of 1 panel being 305 watt/day to only 244 watt/day. However the biggest problem being the social and economic aspect of project and that is lack of interest from native population into electrification that might hinter entire project. Taking this into consideration the calculation will work only with 250 people or 50% of population interested into electrification for the following calculations.

***Case I. 2**: Real condition*

5 year scenario

CF = (population X consumption X price)-500

CF = [250 X 28,583-(1% annually) X price]-500

CF = 3610

$$\text{NPV} = (-40{,}000) + \frac{3610}{(1+0{,}25)} + \frac{3610}{(1+0{,}25)^2} + \frac{3610}{(1+0{,}25)^3} + \frac{3610}{(1+0{,}25)^4} + \frac{3610}{(1+0{,}25)^5}$$

NPV = -30 301 Euro

In first part of the projects 5 year scenario was still in lose to its NPV by -30 301 Euro. Which is difference by -4682 Euro. What was not taken into consideration was the amount of consumers which was remain constant on 250 as it is only scenario calculation and it will be difficult to calculate behavior of rural tribe economic activities towards electrification however this is not the main objective of this work therefore the willingness

to participate was suggested to be only 50% of total population however it is likely it can be even lower. The decreasing production of photovoltaic panels won't be a challenge as the project was set to address 3 people per panel in settlement, but next scenario the supply outweigh demand.

In 20 year scenario:

CF = (population X consumption X price)-500

CF = [250 X 28,583 X price]-500

CF = 3610

$$\text{NPV} = (-40{,}000) + \frac{3610}{(1+0{,}25)} + \frac{3610}{(1+0{,}25)^2} + \frac{3610}{(1+0{,}25)^3} + \cdots + \frac{3610}{(1+0{,}25)^{20}}$$

NPV = -25 741 Euro

Again the calculations concluded that the NPV will be still in lose even in 20 year period which rises question of effectiveness and importance of invested funds. Even in the 20 year period the project was unable to pay for itself and it will likely produce and further increase the loss of investment into this project.

With those data this work will now calculate the profitability index and determine if for each of two cases and its two scenarios there is possible profit of the investment so it can be used in beneficial part of this analysis.

Case II. 1: *Ideal condition*

5 Year scenario

PI = SHCF / K

PI= 25 619 / 40 000

PI = 0,640475

In 5 year scenario the profitability index was 0,640475 which lower than 1 therefore there will be no profit made during this period. This scenario in ideal conditions is obsolete. Next scenario with 20 years in ideal conditions should be however profitable.

20 Year scenario

PI = SHCF / K

PI = 43 905 / 40 000

PI = 1,097625

With profit index at 1,097625 or above 9% in 20 year scenario of ideal case this would be considered a good profit odds by public sector standards and medium by private sector. As for private sector 9% return is really good however the time spam of 20 years is not seen as favorable or on edge of acceptable. This calculations on positive long term ideal conditions support the fact that this project is able to be successful if managed correctly and will be supported by active participation of all stakeholders.

The following calculations are taking into consideration negative prediction and scenarios which were already mentioned in this chapter of this work. It is obvious that the project with negative prognosis cannot by sufficient enough to ideal conditions however this calculation will show the negative scenario and reveal the possible threats to this project and its evaluation.

Case II. 2: *Real condition*

5 Year scenario

PI = SHCF / K

PI= 9699 / 40 000

PI = 0,242475

Profit index in 5 year scenario was not surprising only little short of 25% regarding return of the investment. This scenario is least productive and beneficial for all stakeholders as time duration of project is to low and estimated consumption of electricity by native population is low as well. The final negative impact is high discount rate with inflation making it almost difficult to set a proper investment plan for this project.

20 Year Scenario

PI = SHCF / K

PI= 14 259 / 40 000

PI = 0,356475

The 20 year scenario show again as previous 5 year scenario in real condition that this project will not be rentable under those circumstance. The fact that it took 15 years to rise profitability index by 11% is due to high discount rate and inflation. Low consumption is also problem but that can be solved throughout correct management. The main problem regarding this pilot project of photovoltaic power plant remains the economy management on both local scale with respect to demand and on macro scale as it is required from Ghanaian government to take stronger grip on inflation. The following char graphically shows each condition and each scenario for better overview.

Case 1: Ideal condition	***CF***	***NPV***	***PI***
5 Year Scenario	8220	**-25619**	0,640475
20 Year Scenario	8220	43905	1,097625
Case 2: Real condition	***CF***	***NPV***	***PI***
5 Year Scenario	3610	**-30301**	0,242475
20 Year Scenario	3610	**-25741**	0,356475

Table 14: Source: Own work – Cases 1 & 2 comparison

The chart shows that from 4 scenarios and 2 conditions only 1 option is vital. This can be addressed by proper management and participation of all actors in constellation to ensure the success of the project. As it was shown in cost efficiency part of cost benefit analysis which might work for project. In first condition of second scenario could generate profit means that good strategy and active policies are important for future success of this project. In next part it will be examine the positive effects of electrification on social and economic aspect of community in Ghana and will help determine the project proposal. Despite possible economic benefits and viable options the key aspect remains markets in many developing countries are challenged by a lack of standards, leading to use of inferior products and poor installations, which have undermined solar thermal's reputation. [41].

4.6 .Benefits: economic savings & social aspect

Economic

The economic aspects and benefits of the project were partially pointed and cost analysis as it is important to set and achieve the right scenario which will require more active approach from all actors of constellation. However there are different aspects regarding economic benefits then just profit which was calculated in previous chapter. Generally the availability of electricity opens options for individual residents to increase their standard of

living and participate in job creation and entrepreneurship. The average consumption of electricity in Ghana is 343 KWh for year or less than 940 watts a day. With current set of prices in Ghana to be 0.2054 GHS for 1 KWh in residential area or just less than 0,05 Euro it gives greater options for economic development. The costs of electricity, when considering grid extension, are determined by the load density (measured in households per square kilometer), the number of households connected and line length among others. For most of the Sub-Saharan African rural areas, this information is still available unevenly [39]. The biggest problem in Ghana is accessibility to main grid rather than inability to pay as was mentioned in previous chapter. The following table shows latest prices of electricity in Ghana which were used for calculations in previous chapter.

Tariff Category	Effective October 2014, Billing Cycle GH¢
Residential	0.2054
0-50 (Exclusive) (GH¢/kWh)*	0.4121
1-300 (GH¢/kWh)	0.5348
301 – 600 (GH¢/kWh)	0.5942
601+ (GH¢/kWh)	3.88
Service Charge (GH¢/month)	

Table 15: Source: http://summits.au.int/en/23rdsummit/events/committee-african-heads-state-and-government-climate-change-meet-malabo

There are several examples from developed countries that show beneficial effects on local market as well as on state to state business deals that are directly or indirectly connected

to development of solar energy or other renewable energy source. In next few section each positive benefit will be examine and evaluated to support positive effects of renewable and particularly solar energy.

Economic-Resources preservation

As mentioned on beginning of this work in structure of GDP and other economic aspects Ghana is achieving relatively high GDP growth and economic increase thanks to oil exploration and export of crude oil. This oil can be used to create electricity for domestic used and not exported to foreign countries thus loosing potential profits from sale. In case of photovoltaic energy this crude oil can be exported and doesn't have to be used for electricity production thus helping to balance Ghana's trade balance on world markets. In example 1 barrel of oil can produce 570 KWh of electricity [21]. In case of our pilot project of photovoltaic power plant we can have following additional savings:

Oil savings = [(Individual consumption X population) / 570] X price of oil {Euro}

Oil savings = [(343 x 500) /570] x 53,88

Oil savings = 16 211,26 Euro

It is important to note that those savings are not going to be spend in domestic market but rather sold on world markets thus creating even better income. 16 211 Euro annually is important factor if we take into consideration 5 or 20 years plans which were calculated in previous part of this analysis. The price of oil can also change when in 2015 it reached its lowest prices at around 50 USD per barrel or can reach up to high prices in 2008 being 138 USD. If the oil saving needed for creation of those 343 KWh needed for annual Ghanaian

consumption will be calculated with the highest price of oil than savings can reach up to 37285,72 Euro almost paying entire project in one year alone. It can be calculated for several scenarios which were discussed in previous chapter and it was calculated in following chart. For calculations were used scenarios and conditions discussed in costs part of this work with accordance to prices that were achieved in recent history and present market values. The prices were set at today's 53 Euro per barrel and with the highest for oil achieved in history or 124 Euro per barrel of crude oil.

	Savings on oil according to price	
Case 1: Ideal condition	53 Euro	124 Euro
5 Year Scenario	79 732	186 543
20 Year Scenario	318 929	746 175
Case 2: Real condition	53 Euro	124 Euro
5 Year Scenario	39 866	93 271
20 Year Scenario	159 464	373 087

Table 16: Source: Own work – Comparison 1& Case

From this char we can see that each scenario was able to generate enough savings to pay for the pilot project of photovoltaic power plant. The ideal scenario with most optimistic prognosis and most high oil prices was able to save up to 746 175 Euro and most negative scenario with current oil prices was able to produce only 39 866 Euro However if we count it with the profits made by each scenario than the project proves to be economically successful on terms of all conditions and scenarios.

Economic-Local economy

In contrast to central one large power plant with large production of scale highly centralized and with extensive infrastructure and supply chain the photovoltaic power plant works on local level able to address needs specifically to certain group of consumers. This forces the consumers to participate in economics of the facility as it is requires their contribution as well. In example in many cases the location of facility is in near proximity of final consumers thus the owner of power plant must buy or rent the location of such facility thus stimulating local economy. Other aspects being creation and promotion of jobs on local level. The rapid increase in photovoltaic energy sector in developed countries stimulated employment growth. In example of increase in USA from 2009 till 2010 an 67% increase created 100,000 jobs in sector alone [20]. Significant improvement will happen after implementing this power plant into main grid allowing access to new consumers and diversify its customer base. After successful construction and connection to main grid it will also help to address the problem Ghana is facing now with power shortages.

Social-political

Ghana is trying to address in its foreign policy climate change and it is promoting it into active policies. The Ghana national development plan is counting on significantly diversifying source of electricity and overall energy mix. Promoting renewable energy is one of those as in national development plan stays that by 2020 10% of consumed electricity in Ghana should come from renewable energy, excluding hydropower energy. The sources in which solar energy should play vital role. This will not only bring economic benefits as savings in oil sales and profits from energy sale but also bring higher value added education and jobs as it is step towards more developed society. Adding electricity option to people who were lacking access to one of basic necessities of 21st century will also show strong impulse into Ghana and out to the world that Ghana is modernizing.

Another important feature is the ecological awareness and importance of sustainable development which is perfectly represented by renewable energy. The countries that will be

most affected by climate change are poor or low-income developing countries in equatorial geographical location. There are several countries in region that are or will be affected by climate change in near future as an example a regional neighbor Nigeria or other African countries like Sudan or Sierra Leone [22]. By taking this into consideration and actively promoting and working with renewable energy Ghana is acknowledging the threats of climate change and is showing political will to address this issue by redirecting funds and cooperation with EU to establish such a projects.

Overall the most important aspect of this project is providing electricity into rural community thus increasing their standards of living. The necessity of 21st century and it accessibility and viability should remain the main focus of this project as it was established to be main target of this development aid case study. From economic aspects the project shows some ratability on profit and savings of Ghanaian government however the biggest benefit will not be the profits and savings but the options and opportunities that this project will bring into this rural area. Therefore this project should not be measured on economic terms but rather on social terms as how many people will be this project able to lift from poverty and improve their living conditions. Unfortunately can be only measured after implementation of this project into action.

4.7. Result interpretation

In 1st part of the cost benefit analysis the logical framework and gantt chart for project were established based on data provided by Ghanaian institutions and international organizations where the average electricity consumption per capita was established as main core data for calculations to come. In logical framework goals, outcomes, outputs and activities were established as well as project summary, indicators verifications and assumptions. The core of the project still remains the energy consumption per capita as it is key aspect in all those measured and established categories. The project was than introduced to gantt chart where two time scenarios were proposed as first being 5 year period of

expectation or pilot phase and then 20 years assumption as it is average life expectancy of photovoltaic panel. The assumption took into consideration also aspects of development aid as ways just to spent money on short period in this 5 year scenario, but also took into consideration the more pragmatic business investment driven approach which was more expanded in 20 year scenario.

Following first part in next part were sources of funding introduced and contributions from different actors in constellation were presented as well some first calculations took place regarding production of electricity specifications regarding population and awaited consumption as well as anticipated costs regarding installation, maintenance revision and overall costs. Based on data and plans regarding electrification of Ghana by Ministry of Energy it was established that the pilot project will be built in one of less develop regions I Upper East State where settlement with population of 500 inhabitants will be chosen where project will take place. Than based on steeled framework and expectation the potential consumption of electricity was calculated. The amount of sunlight, average consumption and total population were taken into consideration to calculate estimated potential demand from population of this settlement. Based on those calculations project of power plant was established and calculated on current market prices of photovoltaic panels. The calculation showed that the investment will require 40 000 Euro to start this project.

In 3rd part of the cost-benefit analysis the net present value and profit index will be calculated based on cash flow. The cash flow will play crucial role in determining if the project will be economically successful and will turn on profit. To calculate cash flow it was important to examine price of electricity in Ghana as well as total population of settlement and its electricity consumption. Again the consumption will be calculated based on national's average. To calculate net present value and profit index this cash flow will be than integrated into equation where time of investment will be new important variable. For this case the ideal and real conditions were proposed with again two scenarios. One with 5 year investment time and second with 20 years investment period. Total of 4 models were established were calculations took place. This is the most important part of the project evaluation as it will

provide answers regarding profitability and rate of return of the investment. In first ideal case for 5 year period plan the cash flow was established at 8220 Euros with -25 619 Euro net present value and profit index just above 0,64% from original 40 000 Euro investment. In second scenario of 20 years investment period also in ideal case conditions the cash flow was the same of 8220 Euros however extended period allowed project to be economically successful as net present value was 43 905 Euro and profit index of 1,097 was achieved or almost 10% profit from original price of the project. Also the project will be able to pay for itself in 13 years from starting the investment. To counterbalance those two proposals a skeptical more realistic cases were introduced again with two different time periods. First 5 year scenario and second 20 year scenario. In first 5 year scenario of real conditions the cash flow was significantly reduced as cost of maintenance and revisions were included for each year plus only 50% of population of previous calculation would participate in project. This decreased cash flow to just 3610 Euro thus negatively effecting net present value to -30 301 Euro and profit index was 0,24 from original investment of 40 000 Euros. In second scenario of 20 years investment period the numbers were still lacking as the cash flow remained the same of 3610 Euro the net present value was -25 741 and profit index was 0,36 from original investment which is only slightest improvement from previous 5 year scenario on 15 years additional project investment duration. With those results the costs were concluded for each condition and scenario into a final chart.

For the 4th part the benefits were taken into consideration. Again in benefits were two set of approaches: the social-political approach and more economic related on resource management. In social-political approach the benefits of project were discussed from social development point of view where what availability of electricity to rural community might bring in from of social development. The political commitment to develop renewable energy sources and proclaim focus on sustainability of economic development throughout renewable energy. This was brought out in more philosophical and social aspects then will bring benefits to local population in terms of access to electricity and options that it opens for the community and individuals. Following the analysis of benefits was later discussed if the

photovoltaic power plant will be able to provide savings in respect to oil consumption required for electricity production as Ghana's oil export is increasing its importance to GDP contribution. Again the savings regarding oil and its consumption were divided into 2 cases with 2 scenarios with set of 2 prices predictions each, overall 8 models. In 1st Ideal case scenario where investment period was 5 years the price was established on today's 53 Euros for barrel. The savings in this scenario were able to achieve 79 732 Euros for duration of investment. If we take into consideration the highest possible price achieved on world market than the savings in 5 year scenario would be 186 543 Euros. The second calculation in ideal scenario were taken for 20 years and this shown some positive results as well. Where in prices of 53 Euro per barrel the savings were 318 929 Euro for this duration however in 128 Euro per barrel positive prediction the savings were able to achieve staggering 746 175 Euro. It is important to note that this is unlikely scenario however if true can bring significant profit for Ghana. To counterbalance this ideal case as in previous chapters the more real or pessimistic conditions were taken into consideration. In real condition the 5 year scenario with today's prices were able to create savings of 39 866 Euros. If taken into consideration the 124 euro prices per barrel the savings were 93 271 Euro. The final scenario with 20 years investment period and real conditions is the last to be examine as it will show that even under those condition project will be able to turn significant savings. When taking into consideration 53 euro per barrel price tag than the project will be able to save 159 464 euros and if we take the extended price of 124 euro per barrel than the project will be able to save Ghanaian government in 20 years period 373 078 euro.

This final part is concluding the project by putting the costs and benefits into unified sum and proposal from which it will be decided if the project will bring benefit and turn out profit from economic point of view and bring development for affordable price to community. The following chart combines all previous results from calculation and sums them up in final chart of results where costs and benefits are summed up.

				Savings on oil according to price	
Case 1: Ideal condition	***CF***	***NPV***	***PI***	***53 Euro***	***124 Euro***
5 Year Scenario	8220	**-25619**	0,6405	79 732	186 543
20 Year Scenario	8220	43905	1,0976	318 929	746 175
Case 2: Real condition					
5 Year Scenario	3610	**-30301**	0,2425	39 866	93 271
20 Year Scenario	3610	**-25741**	0,3565	159 464	373 087

Table 17: Source: own work

Total rate of return for investment with savings

Case 1: Ideal condition	***53 Euro***	***124 Euro***
5 Year Scenario	54 113	160 924
20 Year Scenario	322 834	750 080
Case 2: Real condition		
5 Year Scenario	9 565	62 970
20 Year Scenario	133 723	347 346

Table 18: Source: own work

The chart showed that estimated investment of 40 000 into pilot project of renewable energy in Ghana has enormous potential to bring savings and profit for government. The scale of profit and benefit combined with savings on oil that would normally be used for domestic market but instead now can be exported on to world market was the toping point of the project. However the difference between maximal investment duration with ideal conditions and shortest investment duration and real condition is staggering it doesn't change the fact that by the end of pilot project duration all options were able to bring profit. The economic benefits cannot be doubted if we take the resource savings that are provided by this

photovoltaic power plant. The economic benefit of project itself from microeconomic perspective can turn profit only in one scenario mentioned in previous part of this work, however if the project is taken into consideration from macro perspective of the government and not only small region the picture is significantly different. The ability to create profit in macroeconomic perspective of the project and benefits which are included for local population are surprising even for the researcher who conducted on this topic. This brings the question why this option is not more explored and put into use over Ghanaian territory in more locations. On this part will be done final discussion and conclusion in last chapter of this work. However the pilot project than divided into macro and micro perspective will give two answers regarding efficiency. The pilot project was able to bring on micro-level social development and increase in human living condition by providing additional energy source necessary for life in 21st century giving people option to improve their lives and get the means to lift themselves out of extreme poverty. On economic terms project was able to achieve profit only in one ideal case scenario on micro-level with all ideal conditions and by full participation of all actors in constellation. However on macro-level the project was able to deliver social and political goals that were promised and selected by Ghanaians government in national development plan. It promoted renewable energy and increased energy mix for the country which was also one of the goals set by government and finally in aspect of increasing exploration of oil in Ghana it gave the government option to redirect explored oil that would normally be used for domestic consumption into electricity production to sell them on world market with greater profit. This is the example of one of the major pros of renewable energy and that is the fact that it is hard to make them profitable in short term microeconomic level scale. However on long term and macroeconomic level it will bring generous benefits and improvements on both social aspects as increase of living standards and decrease of pollution as well as economic aspect as possible long term profit with increase of effectiveness of goods allocation and energy management. The project should not be look on as development aid proposal by EU to Ghanaian government but as a long term investment from EU to Ghana that can have positive outcome for all associated actors in this constellation both economically and socially. Thus succeeding the proclamation of both

parties EU and Ghana disused in previous part as going beyond aid, beyond institution and beyond Africa.

4.8. SWOT Analysis

In the SWOT analysis of this discussion one point will be made for each strength, weakness, opportunity and threat that will be addressed. The major point that is the core of the analysis must be examine and addressed so it will propose certain solution to established problem. The core of this analysis will be the conclusions of cost benefit analysis that were calculated and presented in this work as well as addressing certain points in logical matrix and gantt chart that were establish on the beginning of cost benefit analysis. The examination of development aid which is focusing into energy sector and particularly the aspects of renewable energy as the main topic suggests. The aspects being renewable energy and photovoltaic power plant established as pilot project of development aid into energy sector of Ghana as it fulfills all social, political and economic aspects established and proclaimed by both actors in constellation.

Strengths

The key strength of energy sector in Ghana as a whole lays in supreme geographical location of country on equator. This with combination of hot dry climate puts Ghana into ideal position to harvest energy from the sun via photovoltaics or solar plants as the climate ensures stable production of renewable energy. The potential of Ghana to harvest this energy is tremendous as the country is experiencing often blackouts and energy shortages. Ghana is already using some photovoltaic and solar power plants but the government proclamation to follow the way of renewable energy to address nation's energy needs was already established in several governmental strategies and studies. The willingness to dedicate resources and

focus into this topic with combination of ideal geographical condition is definitely accounted as strength and needs to be exploited by actors in constellation.

To address this Ghana needs to focus more into constructing and promoting renewable energy sources and particularly photovoltaic and solar energy as it may help address increasing demand for energy in Ghana that government have problems to keep up with. The fat that relatively recently Ghana had discovered oil on its territory gives country even more options as the revenues from the oil can be redirected into energy sector and particularly into renewable energy instead of resources such as Ghana's oil that can be sold with greater profit on global market thus increasing and improving Ghana's GDP and trade balance. Generally Africa's largest infrastructure deficit is more pronounced in energy sector, whether measured in terms of energy consumption, generation capacity or security of supply [37]. Therefore it is most vital and important to focus on resources and options available on local or regional level. In case of Ghana on solar or photovoltaic energy as the pilot project showed its rent ability for Ghana as a whole.

Weaknesses

The main problem of renewable energy as a whole is the overall cost of production and the amount of technology and training required to successfully operate and produce electricity from such sectors. As renewable energy faces many barriers to greater use in production of electricity, but foremost among these is the perceived expenses [34]. This was shown in this cost benefit analysis as there were several economic models proposed only one model was able to show economic reliability. However this model was the most optimistic and with no additional costs expected. The altering assumptions can make a tremendous differences in the calculation of levelized costs, including the bedrock assumption about what discount rate to use [34]. This was as well shown on various models calculated in cost parts of cost benefit analysis as discount rate even without the necessary cash flow was able to significantly affect the result of overall investment. The rationality of investment form

private sector is more than questionable as in many cases around the world the photovoltaics are subsidies or have 0% taxation to help compensate the cost of technology and the process of electricity production. This will remain the quintessential problem of renewable energy as the costs remain high. However on beginning of this work it was established that cost of electricity from photovoltaics was in 1977 the price was $76.76/Watt and by the end of 2013 the price has fallen to its record lows of $0.76/Watt therefore it is estimated that the price can fall in near future even lower than today's prices as production processes are improving and technology becomes more available.

Opportunities

This study gave already several answers how it is important to invest into photovoltaics in Ghana as on macroeconomic level is able to bring significant economic improvements as the main key aspect of photovoltaics is on savings. The savings can be summed up as future investments and the main opportunity lays in future investment in full electrification and completion of main grid and access to it. The possibilities that this project can have on energy mix and electricity supply are tremendous if it will be reconnected into main grid. After finishing the electrification network the access to new consumers of electricity will increase the viability of photovoltaic power plant as rational business option for commerce use and not only as a development aid project. The fact that the pilot project can work by itself and without requirement to be connected to main grid gives it also perspective that it can maintain dominant almost like monopoly position in local region of its activity. The opportunities lay in strategy based on access to main grid as it determines the behavior of the project as if it will be added to main grid and potentially expand and play more important role on macro-scale of energy finance or if it will solidify its importance as dominant energy provider on micro-scale of electricity production. The project proposal as development aid project should definitely favor the first option. Appropriate reaction would be required from all stakeholders and actors in constellation. To appropriately address those

opportunities it is necessary to establish some behavior model that will address all those aspects. This model can also take into consideration other aspects mentioned in this SWOT analysis and not only opportunities.

Threats

The threats for this entire projects are obvious from the calculations made in cost benefit analysis as all equations are based on cash flow of native population and willingness to consume electricity from this pilot project established for calculations of development aid assistance into energy sector. If the population will not consume the electricity that was produced by the photovoltaic power plant or the price will be set to high for the project than the probability of failure and ineffectiveness of the photovoltaic pilot project will be high. The actors in constellation must ensure that the consumption is maintained. In calculations of costs in cost-benefit analysis only one model was able to bring economic profit and be beneficial in those terms and it was the most optimistic model. If the project needs to succeed on those terms some additional governmental program is need to be added to constellation or to establish certain programs to promote it. In 1990 the lunch of 1000 Roofs Program in Germany was designed to generate momentum for photovoltaic technology [36]. This program was initiated by federal research ministry and financed by federal government in Germany. The effects were satisfactory enough to encourage further use and promotion of this technology. Other main threat for this development of renewable energy lies in economy and financing. The profitability as one of main terms of success determination of the project is not only highly dependent on consumption and demand from local population but also the fact that it is financing predominantly from external source such as EDF. Government contribution must be addressed and share of investment must be divided into all stakeholders in constellation. That means that Ghana must actively interact with project. In fact the EDF will be able to only pay certain sum required for the project as in regards to development aid it is required by European foreign policy regarding foreign aid as it was mentioned on

beginning of this work. The last and final main problem that is Ghana facing with respect to this problem is the state of its own economy. In previous chapters rereading Ghanaian economy it was shown that for last 14 to 15 years the inflation in country was on average 18%. In all models of calculations both positive and realistic models the inflation rate or discount rate played crucial role to variability of the project. The fact that money is losing value so fast and the availability of funds from domestic Ghanaian economy is so low had tremendous negative effect on pilot project. This high discount rate and inflation harmed the ability to maintain value and generate profit from this photovoltaic power plant more than significant 50% decrease of cash flow as the calculations have showed.

The following chart shows graphic depiction of each aspect of SWOT analysis and displays it:

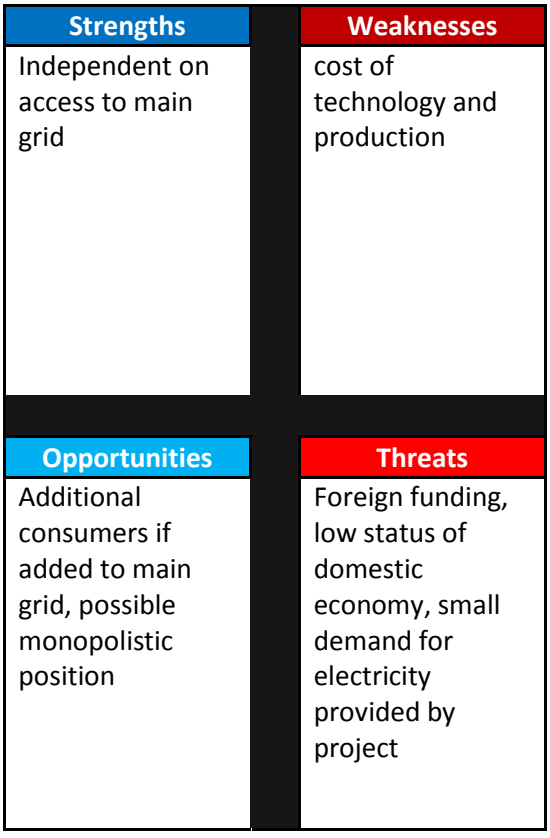

Figure 7: Source: Own work- SWOT analysis, Graphics

The SWOT analysis shows the main aspects of the pilot project and therefore ideally reflects the possibility to invest and develop energy sector in Ghana with focus on renewable energy, particularly photovoltaic energy. This SWOT analysis sums up the outcomes and calculations made in cost benefit analysis as it points out all aspects that might contribute to success or failure of this development aid proposal.

The main aspect of strength remains the independence of main grid and ability to operate without access to it. This gives edge to photovoltaic over traditional sources of energy however it is balanced with high costs of production as the technology required to obtain for such a project is expensive and often out of reach for developing countries such as Ghana. The opportunities and threats are more local specifics as their primarily depend on environment in which the photovoltaics are established. This was also confirmed by calculations in cost benefit analysis as the opportunities lay in correct management and set of priorities where the plant can act as monopoly on local level or as an asset to fulfill Ghana's growing energy demand and could play more vital role on national level as additional electricity producer if connected to main grid. However the main threats and problems that this project is facing and generally renewable energy not only in Ghana but also in developing world is the fact that weak economic status in country and in local economy can create negative cash flow and with discount rate and high inflation could halted any investments into this sector. This was also proven in calculations as the 3 out of 4 calculations showed that achieving profit is difficult even in long term horizon of 20 years investment period. All the indicators would need to be set ideally and all actors in constellation must be actively involved.

4.9. Discussion

During this thesis the work and analysis was constantly balancing on economic rationality of proposed project and development aid terms of success. The fact that economic and social terms of the same project are different and yet the project remains to be aimed at

the same population and the same region should bring no surprise. As the project as it is set showed it can be used both as regional development program to provide electricity to impoverished population as well as economic model that can be oriented for business and to generate profit. However as the cost-benefit analysis and SWOT pointed out the project is not really successful as neither of those proposed options. If we take into consideration the economic aspect first than we can see that from all proposed models the pilot project was able to succeed to bring profit only in one case scenario in cost section and even under ideal condition and long term investment scenario. The fact that most companies are not willing to invest in long term horizon in low-income country and especially in African continent makes it highly improbable that this project might be taken into consideration by foreign investor. Economic situation in Ghana with low-profit margin high exposure to risk environment in form of ever preset high inflation cannot balance out the relatively good economic environment in Ghana compared to other African nation as sufficient enough for investors to take risk as well as the fact the probability of ideal conditions for long term business investment in Ghana are very unlikely to happen and even less to sustain for longer time period.

In other aspect if we take this project into consideration from development aid perspective and we look on it as possible solution for sustainable development and life condition improvement plan where costs are not that important and long term savings are they key to success than this proposed project was able to deliver some positive results. Savings in long-term were able to surpass the initial investments or at least match it. The economic and social aspects cannot be denied as well as social and economic improve should follow. This shows that renewable energy is not high return short time period profit oriented investment as it requires time to return invested funds via savings. This aspect of pilot project makes it ideal for long term investment or as "one way pay" development aid. Unfortunately the SWOT analysis pointed out some crucial aspects of this project that needs to be addressed despite the fact that hypothesis was mostly confirmed. The vulnerability of the project despite its benefits as development aid lays in foreign funding, low status of domestic economy, and

small demand for electricity provided by project if we combine it with high costs of technology the pilot project can be proposed predominantly only as development aid program and not as possible domestic form of self-aid by Ghanaian government. As a form of foreign aid it still requires attention from government or ministry of energy or local official to ensure the smooth running of the project which can create additional costs and yet it is still not technically owned by government. If Ghana would try to propose such project it is unlikely that it would be able to master enough funds to invest into photovoltaics on such small scale and maintain active presence as more integrated actor in constellation. The inflation rate will soon take hold on investment and NPV would take longer to pay for itself that life expectancy of one photovoltaic panel. It is shame that the hypothesis was confirmed and the benefits are real and access to local and national government is able to reach it, however only in form of development aid.

The best way to address such issue would be to propose special approach which will be able to combine both aspects of proposed scenarios. This means it will include economic and development aid approach and stakeholder will each share different positions in constellation and both will proceed to follow their own independent goals. This is however very unlikely and difficult to manage as both approaches in their core idea negate each other. It is important with this approach to understand 1st that consumer of electricity remains the same inhabitants of settlement. This actor in constellation remains always the same only its position changes as customer or receiver of development aid. Second in constellation is government or local authority. This position in constellation can be however changed as it can act as provider of electricity by entering into constellation as producer of electricity and receiver of development aid or as donor of development aid and receiver of electricity. Other stakeholder in this case EU can act similar. It can play provider of development aid and receiver of electricity which will be transferred to final consumers or it can act as receiver of governmental aid and producer of electricity. It is important to find balance and responsible approach to establish potential model of constellation which will benefit all stakeholders and will not have negative effect on final consumers.

The aspects and conclusions provided by SWOT analysis and costs and benefits invested and receive from this project are likely to be interpreted differently mainly based on approach chosen to this topic. However the description and objective of this topic is to provide cost benefit analysis of energy sector focusing on development aid into renewable energy. Ghana's status of low-income developing country makes

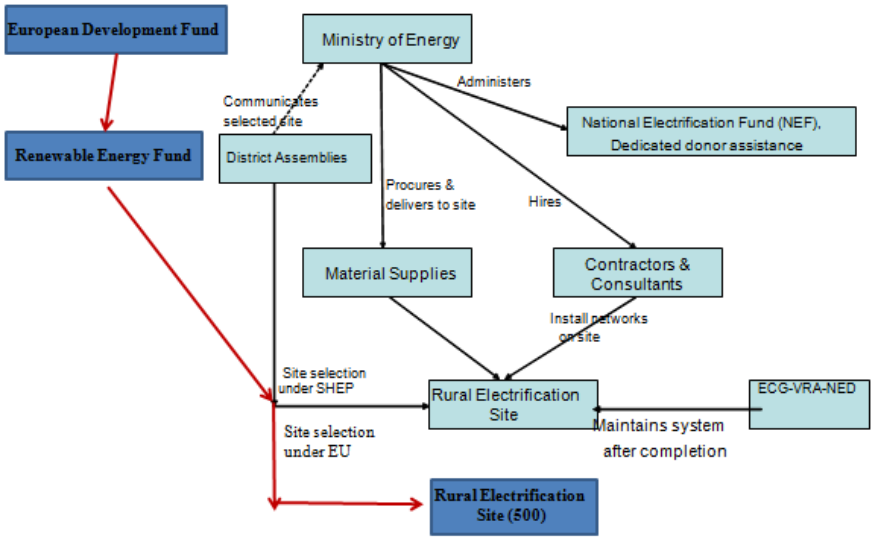

Figure 8: Source: Own work – New constellation proposal

This figure shows possible new form of constellation as it includes all actors in new constellation. Rural electrification 500 is represented by inhabitants of proposed pilot project. The light blue color is representing ministry of energy and therefore government and finally there are EU representatives using EDF as source of subsidy for this project. The proposed constellations can vary but this one is most like to implemented and which should be implemented if there will be possibility

5. Conclusion and Recommendation

The objective of this work was to determine by cost-benefit analysis if the development and aid to energy particularly renewable photovoltaic energy could bring economic and social development. For this objective to be achieved pilot project was set in one of the regions of Ghana to determine if it could stand on its own and what kind of benefit if any will it be able to bring to all actors involved in this project. Based on this pilot project it will be decided if the idea have any potential value as asset for Ghana. In first part of the work the geography, economy and administrative structure as well as energy sector of country were examined to see if the project could have some real commitment and willingness to participate in it is real and not only political proclamation. From geographical point of view the project was more than suited for Ghana as the location on equator gave it natural conditions that would benefit the project significantly. In economic aspect Ghana is still low-income country and high inflation and poor diversification of sectors can be felt strongly on GDP structure and contributions. Plus recent discoveries of oil give Ghana additional source of income and possible energy source. However the main exporting article still remains coco. However if examined and compared to African neighbors and standards Ghana's economy is more diversified and also politically more mature than other African countries. Finally in energy sector Ghana relies predominantly on hydropower and fossil fuels but it is suffering from often blackout, electricity shortages and low access to main grid. To address this the strategy was adopted and presented in Ghana's national development plan for 2020 where electrification and access to main grid are one of the key aspects. Diversification of energy mix and increase of solar energy in this mix should play a vital role. In next part of the work the EU foreign aid was examine and deals between EU and Ghanaian officials were shown as both entities proclaim common goals and objectives with aspects such as security, stability, climate change or sustainable development. This showed that basic funding of potential project if such one should be established. Then the economy behind

electricity production from renewable energy sources was examined and potential for Ghana was determined.

In next part the logical framework and gantt chart was established for this pilot project. This helped to determine the goals and objectives of the pilot project and predicted outcomes and outputs. When this was settled cost benefit analysis was started as for costs part of the project the cash flow will be estimated based on four scenarios from which NPV and PI will be calculated to determine the economic viability of the project. The results showed that from 4 models only the most optimistic was able to show profit in long investment period. In benefit analysis the social aspect was taken into consideration as eradication of poverty and life improvements give general believe into viability of the project. However in economic terms of benefit part of analysis the project showed overall significant economic potential if we take into consideration the savings that it is able to produce with respect to Ghana and its potential oil consumption and exports. If the project will be set and managed correctly the savings it will bring to Ghana on macro-level and governmental level will surpass any profit or loss created by the pilot project. This gave the project competitive edge from previous gloomy predictions. In this part the cost-benefit analysis was able to provide some core decision-making data to determine the potential future of this project. However it brought out some aspects of pilot project, photovoltaic energy and Ghana as whole out on the open to be examined and questioned.

Those aspects were summed up and SWOT analysis to determine the biggest possible challenges and aspects that might influence the project as a whole and are vital to its success. The main focus should be the threats as they are the most significant factor in this aspect. The strength of the project lays in its independence from main grid was already examined and so was the weakness of the cost of production as it is expensive and difficult to be afforded by poor countries such as Ghana. However the opportunities and threats can be strongly influenced by the actors in constellation as in opportunities showcased it is to determine if the plant should work as local monopoly as energy provider or after compellation of main grid should be integrated into it as additional source of energy. This

should be decided by the actors. The same goes for threats as the main threat is the demand and willingness to consume electricity from this plant. The economic success and possible savings purely depend on this cash flow. The macro-economic aspect of Ghana as a country comes to question as well as economic instability such as high inflation or discount rate significantly undercut any effort to establish successful project. Also the source of funding needs to be clearly established and determined by EU and Ghana and by other actors as well. The potential external effect can have dramatic effect on Ghana's domestic affairs and local inhabitants as well. There for it is important to establish certain models and policies that will address those issues and will provide stable environment in which to project can be developed. Following image shows possible example model of actors in this constellation.

The closing conclusion for the researched topic for this work showed that the potential, ability and willingness to invest in such energy source as renewable energy and particularly photovoltaic in aspect of developing country and investment with aid into energy sector is challenging but not impossible. There are several things that need to be taken into account however based on cost benefit analysis of pilot project and the possibility to bring true development is more than confirmed. The main issue lays in definition of roles for each actor in constellation and to maintain the positions until the end of running projects. This investment might not bring to enormous profits or solve extended electricity problems that is Ghana facing nowadays. However it showed that the renewable energy with contribution from developed country or active participation from native government can bring beneficiary results for all stakeholders. The renewable photovoltaic energy might not be the final solution for energy requirements of developing nation, but it is definitely the step into right direction as the economic, social, environmental and political benefits from it can match and outweigh the costs of such projects if managed and maintained correctly and if the models and actors in constellation act and behave according to established strategy the outcome might be positive sustainable development. Similar project were established by Germany in Senegal however they were using hybrid power plants with combination of Photovoltaics and diesel in locations of 800+ population and with at least one social building (school or clinic) to

ensure demand for electricity producer [38]. This shows that the project can be sustainable and beneficial if managed correctly and used correct models of financing and aid as suggested in this chapter. At the prevailing tariff conditions in the country, this project can be considered as not financially viable except with feed-in tariff scheme or other incentives such as grants/capital subsidies are applied as was proven other cases as in Africa, Ghana and even in this work.

The work can be concluded as follows: Both hypothesis were confirmed by Cost Benefit Analysis. In respect to first hypothesis that it is falls as low-income countries are lacking resources required for such high value added technology such as photovoltaics. They can invest into this technology, however it is strongly unlikely that this will bring immediate economic benefits that those countries often hope for. On case of Ghana it was shown that the low status of economy especially with high inflation and discount rate forces developing countries to search fast investments with high return. This is not the case of renewable energy and attempt to try use this technology without fully understanding possible consequences for country in terms of debt and efficiency can even harm the government of such developing country. This work cannot advise not to do such investments however it will not recommend it to such developing countries.

Second hypothesis also confirmed that the renewable energy if able to pay for itself in terms of savings and can even achieve limited success in developing countries, however only in form of developing aid as it was proven that low-income countries might not have enough economic power to withstand support such ambitions advanced project as it will drain resources out of them. This concludes the hypothesis that long term profit and return via savings is possible, however the developing countries will not be able to withstand such long periods of investments

The research question from beginning of the work was asking if the hypothesis proves to be true is there possibility so suggest a constellation from which all actors can benefit? To answer this question the new constellation was proposed in previous chapter that included all stakeholders and actors into this constellation. This project combines all aspects of cost benefit analysis and redistributes it among actors equally so they can follow their objective.

This form of aid proved to be successful in many other regions where they use similar system to address need of local population that native government is unable to provide. This proposed constellation is in correlation with all requirements of European foreign aid program as it provides necessary form of life improvement with active participation of local authorities and population so the project is based on cooperation of all actors ensuring duration of project even after one stakeholder or actor left the constellation.

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List of Abbreviations:

BOG	Bank of Ghana
CBA	Cost-Benefit Analysis
CF	Cash Flow
EU	European Union
EDF	European development fund
GHs/Ghc	Ghanaian cedi
KWh	Kilowatt hour
LFM	Logical Framework Matrix
MoE	Ministry of Energy
NPV	Net Present Value
PI	Profitability Index
PV	Photovoltaic