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Integrated Electricity Tarrif Model for Kenya

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Abstract: Tariffs and tariff structures has been changing over a period of time all over the world. This has acted as a key factor which limits development in third world country. This project therefore seeks to detemine the best tarrif model that can be used in kenya to improve on the electricty consumption, the research explores all the factors which affect the costing of electrical energy. The tariff model is developed considering fuel prices, the economic factors such as inflation and the puchasing power of the consmers ,and the other factors asssociated with sytem costs ie capital cost and running costs above all these it seeks to elliminate the electricty energy poverty by encouraging many consumers to connect to the grid. In additon, some recent developments and significant trends in distribution and pricing of the electrical enegy such as pre-paid metering . It is expected that this will help Kenya to develop better tariff structures and more reasonable charging rates. The research uses the data provided by the KPLC to analyse the consumer puchasing trends and and uses the current tarrif sytem as a reference to see how best the power company can supply the energy to the country at a cost which is balanced and which encourages industrial development. The resaerch develops a tarrif model which is gradual in nature and one which excludes the fixed changes but the consumers are charged on a gradual basis where the price will increase with the increase of the Kwh consumed.

Keywords: Kenya Power Integrated Tariff Structure, Using Visual Basic Programming and Excel

1. Introduction

Poor electricity tariff system in Kenya due to lack of proper integrated tariff model has led to few number of people using electricity in Kenya therefore this has led to slow economic growth for the nation.

The current electricity tariff system used in electricity billing does not balance the factors especially the economical factors for both the consumers, the power and generating companies in electricity generation and distribution and therefore this makes tariffs to be very poor and unfriendly compared to other developing countries Africa. This indeed is a problem which needs to be addressed for the country to realize it millennium goals. The method used by the power company to review the tariff every time is punitive and cost ineffective to consumers thus many people has resulted to using alternative sources of energy since they cannot afford to purchase the one provided by KPLC. The research involves the analysis of the factor s which influence the setting of the price of the electricity and the best way to develop an economical tariff for the power energy for all consumers

The research looks at the best formula which can be used to come up with the affordable amount of money per kilowatt, this is done by analyzing the current retail price of the electricity and the amount of fixed charge money for different consumers.

The analysis of the retail cost is answer the question of which is the best price for the electricity which will be economical for the industrial and economic growth of the country. Its purpose is limited to providing information and analysis to shed light on the sources of electricity retail price movements in Kenya in recent years. Nonetheless, the analysis involves discussions about the effectiveness and the extent of retail electricity market in Kenya.

The research seeks to develop the proper returns for the the generating stations(KenGen), power company(KPLC) and the consumers this is done by fixing tarrif for each specific consumer the research take the account of the economical value of the tariif.

The research explores all the other ways which should be used to ensure that the cost of electricity is cheap, consumers are encouraged to use power during off peak hours and penalised for high loads demanded at system peak by making provision for higher demand charge.

1.1. Factor Affecting the Cost of Electricity in Kenya

Electricity generation costs vary according to the technology; a feed-in tariff design should provide technology-specific tariff levels. The following factors influence the power generation costs and therefore it should be taken into account when the tariff levels are determined:

- Investment for the plant
- Other costs related to the project, such as expenses for licensing procedures
- Operation and maintenance (O&M) costs
- Fuel costs (eg: in the case of biomass and biogas and other green energy plants)
- Inflation rates
- Interest rates for the invested capital
- Profit margins for investors. (Bustos, M. (2004)[4]

According to the expected amount of electricity generated and the estimated lifetime of the power plant, a level of the cost can be fixed.

Most countries that apply feed-in tariffs use the concept based on electricity generation costs to determine the tariff level.

Besides the electricity generation costs, other factors, such as the avoided external costs, can be considered when fixing the level of cost of the electrical energy. External costs arise *"when the social or economic activities of one group of persons have an impact on another group and when that impact is not fully accounted, or compensated for, by the first group"* (European Commission 2003,).

Electricity producers and distributors receive a monthly payment that is calculated by a special formula. The elements of the formula represent different factors that influence the costs avoided due to the electricity energy regulation commission. The following factors are included in the formula:

A fixed contribution on the plant capacity to reflect the investment for conventional power plants that would have to be built, variable contribution per kWh of electricity generated that corresponds to the power generation costs of those hypothetical conventional power plants

- An environmental parcel corresponding to the costs for CO2 emissions prevented due to electricity generation, multiplied by a technology-specific coefficient.
- Different tariff levels for electricity generated during day and night time
- Adjustment to inflation.

A factor that represents the avoided electrical losses in the grid. (Krewitt) the growing rural population. There is significant potential for solar energy to be exploited in most parts of Kenya which experience up to over 6 hours of direct sunlight a day. Substantial research has been done over the years on exploiting the huge solar energy resource.

In Kenya, only 1.2% of the households utilize individual solar P.V. panels for smaller loads, i.e. lighting and powering T.V sets and radios. But most of this are stand-alone P.V installations. Photo voltaic panels have shown its potential as a technology for decentralized rural electrification and as a means to improve access to electricity in rural areas of developing countries. Over the last 3 years, the number of home systems installed has grown at an average of 20,000 units per annum and demand projected to reach 22 GWh annually in the year 2020. [2]. Given that there are 4 million households in rural Kenya alone, the demand for power has grown tremendously by the day.

Photovoltaic (PV) systems are composed of interconnected components designed to accomplish specific goals, ranging from powering a small device to feeding electricity into the main distribution grid. More specifically, P.V devices convert sunlight into DC electricity. Such energy is transferred to the load or to the utility grid by means of a subsystem. [3]

There are two main classifications;

- Stand-alone systems
- Grid connected systems

The main distinguishing factor between these two categories is that in stand-alone systems the solar energy output is matched with the load demand. When a PV system is interconnected with the main grid, it might deliver excess energy to the grid or use the grid as a backup system, in case of insufficient photovoltaic generation. Stand-alone systems are mostly used in the cases of rural electrification. [4].

Currently Kenya generates a total of 1533 MW of power from various sources. The peak demand however stands at 1680 MW with numerous efforts being made to meet this rising demand. Core of these demands is the need for energy generation sources that are environmental friendly, reliable and efficient at the same time. This narrows down to solar and wind energy sources. This paper proposes a base study of Laikipia County precisely focusing on Nanyuki area. It experiences direct normal irradiance levels of 5KW/m2 and has a population density of about 35,000 people.

Solar mini-grids are an ideal alternative to grid electricity in remote villages that do not have grid connectivity. And because mini-grids are independent entities, they can also be controlled and managed without presenting threats to the conventional grid [5]. Such distributed energy systems also provide more reliable electricity, as any outages or interruptions to electricity supply can be quickly identified and corrected. Additionally, having the site of power generation closer to the load also reduces transmission and distribution losses.

Power transmission and distribution in rural areas of Kenya (arid and semi-arid) is currently constant but a slow growth rate, hence lagging economic and social development in such areas with regards to vision 2030

Generally this project work aims at helping the power generating and distributing companies have alternative options for power generation for rural electrification program (R.E.P) as they seek to increase the supply capacity and expand power connections to every household through both grid and off-grid systems hence proposal for a solar mini-grid development.

In the event of a needed back-up or an alternative supply to the region, a diesel generator is proposed to supply power to the region. This paper has three distinct objectives stated as follows;

1.2. Objectives

- Analysing the cost of capital investiment in generating, transmiting and distributing equipments.
- Establishing the actual cost of electrical energy and returns on investiments when the renewable energy sources are considered.
- Develop a formular which is used to calculate the cost of power for all consumers.

2. Modeling and Simulation

2.1. Calculating the Most Levelized Economical Electrical Cost

Calculation of electrical energy is done by considering the levelisation of electrical energy prices which is the price at which electricity must be generated from a specific source to break even over the lifetime of the project. It is an economic assessment of the cost of the energy-generating system including all the costs over its lifetime: initial investment, operations and maintenance, cost of fuel, cost of capital, and is very useful in calculating the costs of generation from different sources.

The formula used to calculate the most economical and levelised electrical energy cost is give by:

$$\text{LEC} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

Where

- LEC= Average lifetime levelised electricity generation cost
- I_t= Investment expenditures in the year t
- M_t= Operations and maintenance expenditures in the year t
- F_t= Fuel expenditures in the year t
- E_t= Electricity generation in the year t
- r= Discount rate this value is assumed to about 3.5% of the capital cost
- n= Life of the system

Table 1. *Costs for generating electrical energy*

Plant type	U.S. Average daily Levelized Cost for Plants Entering Service in 2013 (KSH/MWh)					
	Capacity factor	Levelised capital cost	Fixed cost	Variable cost of fuel	Transmission investments	Variable operating cost
Conventional Combustion Turbine	85	65.7	4.1	29.2	1.2	7.32
Hydro electric generators	52	78.1	4.1	6.1	2.1	3.20
Conventional Coal system	30	44.2	2.7	80.0	3.4	3.70
Nuclear generating stations	90	83.4	11.6	12.3	1.1	6.00
Biomass gene rating station	83	53.2	14.3	42.3	1.2	4.61
Geothermal generating stations	92	76.2	12.0	0	3.2	0
Wind turbine generating stations	34	70.3	13.1	0	3.2	6.45
Solar PV systems	25	130.5	9.9	0	4	0
Solar thermal systems	20	214.2	41.4	0	5.9	0
Wind (tidal) systems	37	193.1	22.4	0	5.7	21.18

Efficiency curve of integrated electrical generating plants

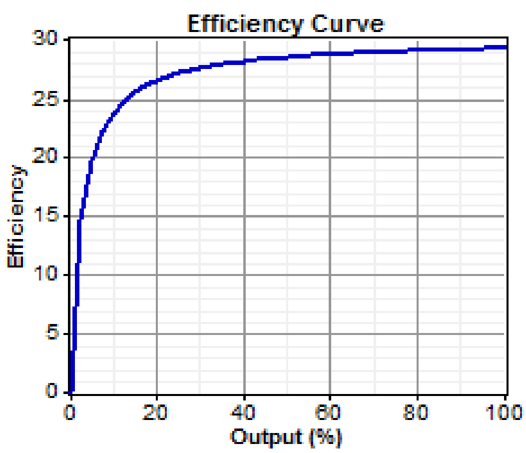

Figure 1. Efficiency Curve

3. Simulation Results

3.1. Cost Benefit Analysis for the Renewable Energies

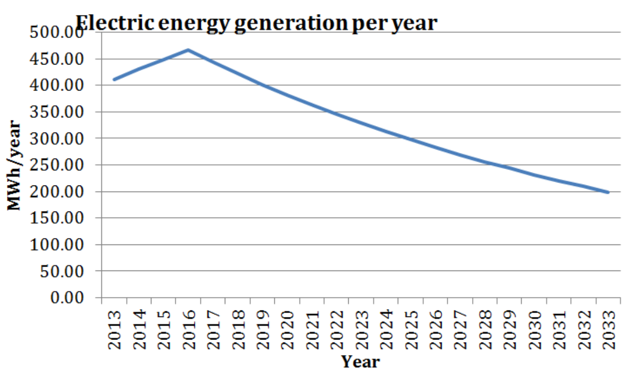

Figure 2. *Electricity generation from the renewable sources*

This section presents the results and analysis cost and the benefit of the using of the renewable sources of energies of simulations of the TRIST and the EXCEL. Initially the site can produce the 400MWh/year and then reaches a peak in the year 2017, all the costs is dollars.

3.2. Comparison of Renewable Energies Connected to the Grid

Both the optimized grid connected systems have two plant installed system which add up to 10MW installed capacity. In graph below the other parameters are compared. We see that the urban and the rural are very similar except the operation and maintenance cost. This is expected because of the distance this plant will be from any regular maintenance routes.

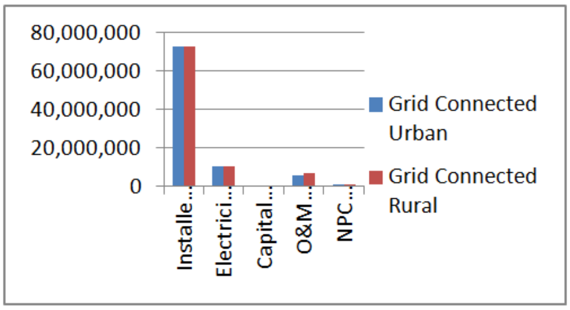

Figure 3. *Comparison between rural and urban networks.*

4. Conclusions

This Renewable energy sources have by far many advantages than the fossil fuels since they are naturally available. The study of electricity tariffs and the development of the best tariff which is affordable and one which elliminates electricity poverty, the biggest problem is on how the tariffs are structured and how they inco-oporate various elements like fuel prices, voltage levels and new staions addition was carried out successefully bringing out the salient features of electricity tariffs in Kenya.Where it was found that the electricity in Kenya is still high compared with countries like South Africa and Egypt.The government of Kenya should start encouraging the use of the renewable energy andcome up with policies which can lead toincoparation of the reneable energies in the national grid for the reduction of electricity costs in kenya.We can therefore conclude that the objective of the project in comparing the renewable energies and the convetional was met and it was established that the renewable sources are comparattively cheap.

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