Abstract

Title: Utility Investment Planning using Risk Analysis: A Case Study of Tanzania's Power Sector

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Background: Investments in infrastructure projects in developing countries are often seen as risky by private investors and local capital markets are not fully developed. Consequently, financial resources and guarantees are often to a large extent provided by financial institutions. Financial and economic analysis is important in assessing infrastructure investment proposals in order to assure that they are financially sustainable and make the best use of scarce resources. Investments in the energy sector are associated with some special risks, such as uncertainty about hydrology variations, volatile oil prices, future demand etc. Many traditional methods for assessing investment programs are not very well equipped to handle risk.

Tanzania is a development country, which is receiving support from different donor countries and agencies for the purpose of reforming the energy sector and for increasing the access to electricity within the country. At the same time, Tanzania's and its power sector has been affected by severe droughts, leading to shortage of productive capacity and load shedding.

Objective: The purpose of the thesis is to develop a method which combines quantitative risk analysis with traditional methods for power sector investment appraisal. The method shall be demonstrated by creating a financial model and adapting it to a real case. The model shall be able to consider identified, inherent risk factors and their conceivable impact on the power system.

Methodology: In order to fulfil the purpose of this master thesis, a quantitative case study has been conducted. The case studied is a capital investment program for Tanzania's power sector, including identification of inherent risk variables and their effects on the financial viability of the program. Three risk variables are identified as the most critical for the case; (i) the annual contribution of hydro-power to the system; (ii) the price of oil; and (iii) the specific demand for electricity.

The data required for the analysis of this thesis has been collected from multiple sources of information. The main source has been documentation, used for empirical data as well as for the theoretical framework. Further, archival records have been widely used for the study as well as open interviews and personal correspondence with employees at Tanzania's major power utility, TANESCO. Finally, the author has used direct observational sources of information during her two years of consulting assignment at TANESCO, working with related issues.

A financial Excel model has been developed for the case study and is used as a tool

to estimate the probability distribution of financial indicators. For the purpose of performing the quantitative analysis, a risk analysis tool, namely @Risk, has been combined with the financial model. The technique used by @Risk is Monte Carlo simulation.

Conclusion: In order to demonstrate the flexibility of the method for quantitative risk analysis, the case was analysed from various angles, i.e. base case analysis, stress analysis and variation of the investment program etc.

The overall advantages of the method can be summarised as follows. Firstly, calculating the probability distribution of the financial indicators enhances the basis for decision and quantifies the company's risk exposure due to the investment program. Further, as a result of the simulation, the full range of expected outcomes of the risk variables is analysed and the result is presented in a lucid way. For a decision maker, the combined influence of all risk variables can easily be observed. Moreover, the method can easily be extended to more than three risk variables as well as provide information on whether a risk variable is negligible or not. Stress analysis provides the decision maker with additional insight. Finally, risk assessment increases the opportunity of identifying effects of changes in investment plans and comparing them with the base case both in terms of expected benefits and in terms of associated risk exposure.

However, the method has some drawbacks as well. The method involves a difficulty in the identification of risk variables as well as estimating the distribution functions for the variables. Quantitative risk analysis also makes the basis for the investment decision more complex, as the decision is not based on a single net present value.

Case Study Results: The financial result of the investment plan analysed, based on a real discount rate of 7%, shows a negative net present value (NPV), calculated over a period of 20 years. The negative NPV amounts to almost USD 1 billion for an investment program in the amount of USD 4.7 billion, indicating that the assumed tariffs do not cover all costs, which is essential for an investment program to be financially viable. An analysis of the required tariff level to attain a positive net present value indicates that a 37% tariff increase in the first year of analysis would be needed. There is a significant variation in the NPV as a result of the simulations performed, indicating that the three risk variables, oil price, hydrology and future demand do have a strong effect on the financial outcome of the investment plan.

With regard to unserved energy, the analysis shows that the investments in generation are fully appropriate, and even somewhat excessive, during the first 7 years of analysis, showing virtually no risk for unserved energy during this period. With the assumption of an annual growth in demand of 10% with a variation of 4 % the last years, the demand will most likely not be served after year 2015. For the entire 20 year period of analysis, the proposed investment plan indicates a mean amount of total unserved energy of 28 TWh. This effect appears at the end of the period, with an unserved demand reaching a mean of 25% of the total energy demand in the last year. It can be concluded that there is an unbalance between future demand and generation capacity by the end of the period. The reason for this may be that the assumptions regarding future demand may be too optimistic, however, if this demand is to be met investment in generation need to be

substantially larger at the end of the period.

As a result of this observation, an analysis was performed of an expanded investment plan including its effects on both unserved demand and the net present value. The extended investment plan includes a postponement of the Kinyerezi gas plant, and additional investment in both hydro power and coal fired power plants. With these assumptions, the net present value increases substantially at the same time as the amount of unserved demand is significantly reduced. However, even assuming an additional capacity of a total 1600 MW after year 2015, the generating capacity of the system is still not sufficient to meet an increase of demand of 10% annually over the next 20 years.

Key Words: Quantitative risk analysis, power sector, investment planning, investment decision, financial analysis, uncertainties, discounted cash flow, net present value, probability distribution, Monte Carlo simulations.

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Abbreviations

ADB	Asian Development Bank
AGO	Automotive Gas Oil
AREED	African Rural Energy Enterprise Development
DCF	Discounted Cash Flow
ESMAP	Energy Sector Management Assistance Programme
EWURA	Energy and Water Utilities Regulatory Authority
FRP	Financial Recovery Plan
GDP	Gross Domestic Product
GJ	Gigajoule
GoT	Government of Tanzania
GWh	Gigawatthours
HFO	Heavy Fuel Oil
IDO	Industrial Diesel Oil
IEA	International Energy Agency
IMF	International Monetary Fund
IPP	Independent Power Producers
IPTL	Independent Power Tanzania Limited
IRR	Internal Rate of Return
kWh	Kilowatt hours
LNG	Liquefied Natural Gas
MEM	Ministry of Energy and Minerals
MW	Megawatt
NBS	Net Basin Supply
NBS	National Bureau of Statistics
NPV	Net Present Value
NSGRP	National Strategy for Growth and Reduction of Poverty
O&M	Operating and Maintenance
PSMP	Power System Master Plan
PV	Present Value
TANESCO	Tanzania Electric Supply Company Limited
TSH	Tanzanian Shilling
UNDP	United Nations Development Program
USD	United States Dollars

1. Introduction

This chapter provides the reader with the background and a problem description as well as the objective of the thesis and the overall approach to the problem. The chapter further delimitates the study and proposes anticipated target audience.

1.1 Background and Problem

The situation for infrastructure investment projects is often different in developing countries from what it is in an industrialised country. The local capital market is small and may be unable to provide long term credits. Investments are often seen as highly risky by foreign private investors. Reasons for this may be of political nature or be related to an uncertain market or the absence of a regulator. For this reason, support and guarantees from multilateral donors or bilateral donors may be required in order to obtain financing. This requires a careful analysis of the investment program to demonstrate that the proposed investment program is financially sustainable under varying assumptions, and represents the best overall economic value to the country.

When assessing an investment program, financial and economic analyses are important; the financial analysis in order to guarantee that the investment program is sustainable, i.e. that the new assets produce a revenue sufficient to cover the full operation and maintenance cost as well as capital costs; the economic analysis in order to verify that the investments makes good sense with regard to the national economy, for example contributing to economic growth and supporting the country's poverty reduction strategy. The financial and economic analysis should also show that the best alternative has been chosen, i.e. avoiding too expensive and too risky investments.

Investments in the energy sector are associated with special risks such as uncertainty about hydrological variations, volatile oil prices and may also be associated with climate change effects and future costs of emitting greenhouse gases. These uncertainties contribute to high risks in energy sector investments. Moreover the fact that electricity is an irreversibly produced product makes the accuracy of the investment decision more essential[1]. Investment and investment appraisal in the energy sector worldwide are faced with a major problem; how to handle such uncertainties.

Many traditional methods of assessing investment programs are not very well equipped to handle risk. Risk analysis is usually applied in the form of sensitivity analysis or scenario development. Neither of these methods, which look at one uncertainty factor, or set of uncertainty factors at a time, provides a good picture of the combined risk. Enhanced methods for project appraisal are therefore essential to guarantee long term performance and profitability of the investment.[2]

During many years following independence, numerous African countries, including Tanzania, invested heavily in hydropower, which is very cheap to operate as long as there is enough water in the rivers. The risk of adverse hydrology and higher variability of rainfalls was not properly taken into account. Tanzania is such a country, which has run out of productive capacity several times. On these occasions, the country has realized how vulnerable the power system is to drought. To compensate for this the country is now investing more in thermal generation, both gas fired power plants fuelled by gas from own resources, and diesel fuelled power plants using imported fuel. This means an increased likelihood that the system will be able to satisfy the demand, although at a higher cost. Performing a risk analysis using Tanzania as a case study is therefore considered highly relevant.

[1] Yang and Blyth (2007), p.3
[2] Asian Development Bank (2002), p.31

In a development country, it is essential to make the best use of scarce investment resources, at the same time as uncertainty about future development is high. This master thesis shall demonstrate how quantitative risk analysis, based on probabilistic methods, combined with the traditional tool of net present value calculation, based on the discounted cash flow method, can assist decision makers in making the right decisions.

1.2 Objective

The purpose of the thesis is to develop a method which combines quantitative risk analysis with traditional methods for power sector investment appraisal. The method shall be demonstrated by creating a financial model and adapting it to a real case. The model shall be able to consider identified, inherent risk factors and their conceivable impact on the power system.

1.3 Target Audience

This thesis is targeted to students and professionals in the fields of engineering and management. Moreover, the results of the analysis are intended to demonstrate the possibility of applying risk analysis when assessing investment projects at TANESCO, which is also applicable to other power utilities. Finally, it is anticipated that the model developed as part of this thesis work and the method used could be developed into a useful tool for other decision makers such as borrowing governments and financial institutions.

2. Methodology

The chapter explains and defines the methodology used for conducting the research. The procedure of the thesis is linked to scientific frameworks, including research methods and strategies, methods for data acquisition and verification of the thesis' authenticity

2.1 General Approach

In order to develop a method, which combines quantitative risk analysis with traditional methods for power sector investment appraisal, various research strategies and methods have been investigated. It is clear that neither an inductive nor a deductive approach is fully appropriate. The work will have to rely on combination of and interaction between both approaches. For example an inductive method is needed to define the distribution function for the identified risk variables, while a deductive approach produces the final model results. Therefore the general approach can be referred to as an abductive approach. This applies also to the development of the financial model. The practical approach to the research is further elaborated and illustrated in chapter 2.6.

2.2 Research Strategies

There are several research strategies to consider before conducting a research in order to fulfil the research's purpose. Each strategy has its advantages and disadvantages depending on the type of problem to analyse, the control the researcher has over certain events and the research's focus on historical, present or future occurrences. In the following, commonly used research strategies are described as well as selection of strategy for the thesis.

2.2.1 Description of Research Strategies[3, 4]

Survey – A survey research comprises a wide and extensive coverage of data compiled and embraces usually more than one case. The research is focusing on one single point in time. The survey strategy includes empirical research where required data is sought in the field. Generally multiple variables are examined to find related patterns.

Case Study – Case study research is characterised by its concentration on one research object, a single case, in order to conduct an intensive and detailed survey. The aim is to illuminate the general facts while investigating particular facts. The research is concerned with the complexity and particular nature of the case. The study is focusing on relations and processes and their connection to each other.

Experiment – The purpose of en experimental research is to scrutinise empirical relations and properties or to verify existing theories. The researcher holds a high level of control in terms of adjusting independent variables in order to observe certain effects on dependent variables. An experiment most commonly uses a quantitative research method based on observations and measurements. The experimental research focuses on the causality of situations.

Action Research – Action research involves a real problem or situation and is distinguished by its practical implications with development of solution. The strategy emphasises involvement of members of an organisation. The research includes feedback of results.

[3] Denscombe (1998), p. 12-71
[4] Bryman and Bell (2007), p.44, 54, 57, 62, 427

Evaluation Research – An evaluation research focuses on evaluation of such occurrence as organisational programs, policies, regulations or interventions. The research examines whether an initiative has achieved its anticipated goal.

2.2.2 Selection of Research Strategy

The purpose of this master thesis is to develop a method for power utility investment appraisal in development countries. In order to meet this objective, the case study research strategy has been selected as the most appropriate. The case to be studied will be investment in Tanzania's power sector over a period of 20 years focussing on identification of inherent risk variables, not controlled by the power utility, and their effects on the financial viability of the investment. The actual case was selected for several reasons. Tanzania power system has for many years been based on mostly hydropower generation. Hydropower is cheap to operate but also very dependent on adequate rainfalls. When rainfalls become unreliable, the country has to compensate for this, and is now investing more in thermal generation, both gas fired power plants fuelled by gas from own resources, and diesel fuelled power plants using imported fuel. This means an increased likelihood that the system will be able to satisfy the demand, although at a higher cost. Therefore, performing a risk analysis, considering these uncertainties is considered relevant and appropriate in order to demonstrate the benefits of the method.

Various power sector expansion options and assumed investment levels for Tanzania's future investment in the power sector will be assessed in the case study. In order to prepare a well founded investment plan, appropriate risk factors associated with the various investment alternatives will be considered. The investment choice can best be described as; how much should the utility invest, and how should the allocation be made between (i) hydro-power generation; (ii) thermal generation; and (iii) transmission and distribution system expansion.

2.3 Research Methods

Research methods can be distinguished between quantitative or qualitative research. These methods differentiate in general terms of the type of data gathered and the type of analysis of data performed. The diversification of the methods does however not only imply if the data is quantifiable or not. Other issues such as the extent of the research, the focus on a holistic or specific perspective, the involvement of the researcher etc., do differentiate the methods as well.

2.3.1 Description of Research Methods[5, 6]

Quantitative Research – The definition of a quantitative research is entailed with collection of numerical data and exhibiting a view of relationship between theory and research as deductive. The method tends to be of a larger scale with a specific focus. The researcher conducting this type of study commonly takes a neutral position where the comprised data is already existing independent of the researcher.

Qualitative Research – A qualitative research is characterised of the words as central analytic tool rather than numbers. The method has an inductive view of the relationship between theory and research, whereby the former is generated out of the latter[7]. Mainly the study is of a smaller scale with a holistic perspective i.e. contemplating the relations in their context. The researcher is regarded as the central tool while conducting the study.

[5] Denscombe (1998), p. 203-207
[6] Bryman and Bell (2007), p.28
[7] Bryman and Bell (2007), p.402

2.3.2 Selection of Research Method

In order to demonstrate the advantages of incorporating risk variables in the traditional method of investment appraisal in the power sector, a quantitative research method has been chosen. The data used is numerical and existing from the Tanzanian power sector as well as analysed with statistical models. Further, two analytic tools, in form of a computer model and a software program, are used, generating quantifiable results. The research is deductive i.e. the defined method of risk assessment is tested on investment in Tanzania's power sector in order to exhibit the benefits of the method.

2.4 Data Acquisition

Methods for collection of research data generally differ depending on which research strategy and method is applied on the study. Therefore this section will focus on sources and techniques which are applicable when conducting a quantitative case study. It should however be pointed out that for other research strategies similar sources of information in addition to others may be applied.

2.4.1 Sources of Information[8,9]

There are several sources of information to use during a research, whereof a few are described here. None of the sources has a complete advantage of the other and it is anticipated to use multiple sources since they can in fact be complementary.

***Documentation* –** This type of information can take many forms, e.g. books, formal studies and evaluation, proposals, letters, newspapers, internet etc. The most important use of documentation is to verify other sources of information. The use of documentation as a source of information is essential for all research strategies. Not only is it important for the researcher to be aware of already compiled studies of the research topic, it also identifies gaps in existing knowledge in the field. Documents have high accessibility, a broad coverage, they are exact in terms of names references and detail of events and they can be reviewed repeatedly. They may however be influenced by the author or have biased selectivity.

***Archival Records* –** Examples of archival records are computer files and records containing service records, organisational records, maps and charts, lists, survey data etc. This source is mostly highly relevant when performing quantitative analyses, since these require a large input of numerical data. Archival records have the same strengths and weaknesses as documentation sources although they may have a lower accessibility

***Interviews* –** Interviews are also an essential and insightful source of case study information. They make it possible to attain a deeper understanding for the subject, since the questions can be targeted to specific topics. In a case study the interviews rather appears to be guided conversations rather than structured queries. To make the interviews as efficient as possible, they can be structured with already formulated questions. This source does not require any specific technical equipment. There are several kinds of interview techniques depending on the information anticipated to obtain and depending on number of persons to be interviewed. The interview can be performed through personal meetings, telephone calls or by email correspondents. Interviews require certain skills from the researcher. The strengths of an interview include the focus on the case study topic although it is important to address the bias the responses may contain and the researchers affect on the answers.

[8] Yin (2003), p. 85-96,
[9] Denscombe (1998), p. 106-202

Direct Observations – Observational sources of information are often useful in providing additional information about the topic being studied. It focuses on collecting data from real situations, which would have occurred whether the researcher's presence or not. The direct observation is mostly associated with quantitative data and statistical analysis whereas the participative observation, described below, is of a qualitative nature. When using observation as a source of the observer's perception plays an extensive role. It can be useful to have more than one observer to increase the reliability of a research. The advantages of this source of information are its ability to cover real time events and the context of them. Direct observations are however time consuming, selective and costly.

Participant Observations – In a participant observation the observer is no longer passive, instead it plays a role within the case study situation. The technique has mostly been used in observations of cultural and social groups, but is also applicable in observations of organisations of groups. The risk with this kind of observation is the observer's chance to manipulate events.

2.4.2 Principles of Data Collection[10]

When collecting data for a case study research, there are three principles which are favourable to follow in order to increase the reliability of the study.

Using Multiple Sources of Evidence – As mentioned earlier it is essential to use more than one source of information. The use of multiple sources of information allows the researcher to address a wider range of issues. Further, using more than one source of information increases the reliability of the data.

Creating a Case Study Database – A practical tool for analysing different data is to set up a database where the collected data is organised and documented. The data base should be distinguished from the actual case study report. The database shall be arranged in the manners that a secondary analysis could be performed without and reports by the original researcher. In this way a second investigator can review the evidence directly and not be restricted to the written report. The database increases the reliability of the case study.

Maintaining a Chain of Evidence – The principle of a chain of evidence is to allow the reader of the report to follow the origin of the information compiled, ranging from the initial problem and purpose to the case studies conclusion. The steps should be traceable in either direction and incorporates also the organised database.

2.4.3 Utilised Sources of Information

The data collected for the analysis of this thesis derive from multiple sources of information. The main source has been documentation for both empirical data as well as the theoretical framework. The documentation includes TANESCO's internal reports on the power system and reports on similar projects in other countries. Further, archival records have been widely used for the study, these concerns comprehensively the accessibility to TANESCO's data files on generation, demand, and costs material. The author has also performed open interviews and personal correspondents with employees at TANESCO, in order to collect data. Finally, the author has used direct observational sources of information during her two years of consulting assignment at TANESCO working with related issues. The principles of data collection have been applied in the research work.

[10] Yin (2003), p. 97-106

2.5 Authenticity

A vital part of an empirical research is to verify the authenticity of the data used and its sources of information. The relevance and correctness of the data collected is important, therefore the quality of the research should be tested. Concepts used as tools in order to determine the authenticity are outlined in the following.

2.5.1 Concepts for Authenticity[11, 12]

***Validity* –** Validity concerns the amount of systematic errors during data collection and data analyses. The concept of validity is the question whether the study really measures the indicators it intended to. Validity can be distinguished by internal and external validity. Internal validity refers to causal relation and whether they might have underlying influences not identified, whereas external validity concerns generalisations of a study result.

***Reliability* –** The reliability of a research refers to the accuracy of the method. In a reliable research, errors and biases are minimised. Reliability includes that measures should be stable over time, factors indicating the result should be coherent and the subjectivity in the researcher's decision shall be diminished. In other terms, reliability means that if the case study were conducted all over by another researcher he or she will arrive at the same result. The principles of data collection described earlier in this chapter are used to achieve augmented reliability of a research.

***Objectivity* –** Objectivity regards the transparency in the method of a research so that the researcher's personal biases intrude as little as possible in the process[13].

2.5.2 Authenticity of the Thesis

The overall validity of the performed research in this thesis is high since the purpose was determined in the initial phase of the study. Subsequently, the collection and analysis of data is conducted in order to attain the anticipated goal of the study. Although the causal method of identifying risk variables might lead to a lower internal validity, since all risk variables could not possibly have been incorporated in this specific case study. A generalisation of the demonstrated method for risk assessment in investment project for other investments than in the power sector of Tanzania is essential in the thesis, but does however not include the result of the actual case study which is specific for the case analysed.

The data collected for the case study is historical data received from TANESCO's internal archive and internal reports as well as a number of other similar studies. Yet, in many situations, the same data from different sources diverge significantly. Data has to the most possible extent been confirmed across a range of written sources and personal meetings. However, some assumptions made by the author have been unavoidable. The author has followed the three principles of data collection described earlier in order to increase the overall reliability and transparency of the research and therefore it should be possible for another investigator to conduct the same research and end up at the same result. It should however be addressed that the development of the Tanzanian power sector is progressing rapidly resulting in a low stability of data over time.

The objectivity of the thesis is considered to be high as a quantitative approach was chosen. Numerical empirics and results minimises the effects of subjection by the author. The author is however aware

[11] Bryman and Bell (2007), p.162-165
[12] Yin (2003), p. 33-39
[13] Bryman and Bell (2007), p.302

that her experiences and actions may influence the identification of problem and the proposal for solution in the initial stage of the research. As it was necessary for the author to make some assumptions where data was ambiguous, as discussed above, this may be considered to have an affect on the thesis' objectivity.

Any personal misunderstanding, interpreting of written sources or other errors and omissions are the responsibility of the author.

2.6 Practical Research Approach

The practical approach to conducting the research, starting with the problem identification up to the final results and conclusions is described in the following section. In the initial stage of the research, the problem of how to incorporate uncertainty into traditional financial investment appraisal of energy projects is identified and described. Subsequently, different methods to solve the problem are reviewed and the quantitative risk analysis approach is chosen as the most appropriate for solving the problem. As a first result, the objective of the thesis can be defined.

In order to meet the objective, a case study research strategy is chosen. The case to analyse, investments in Tanzania's power sector, is proposed based on both the relevance of the case to attain the objectives of the thesis as well as on the author's present location and sphere of interest. The objective and research method is presented to and fully supported by TANESCO.

The practical approach is illustrated in Figure 1, which describes the interrelationship between the different chapters of the thesis.

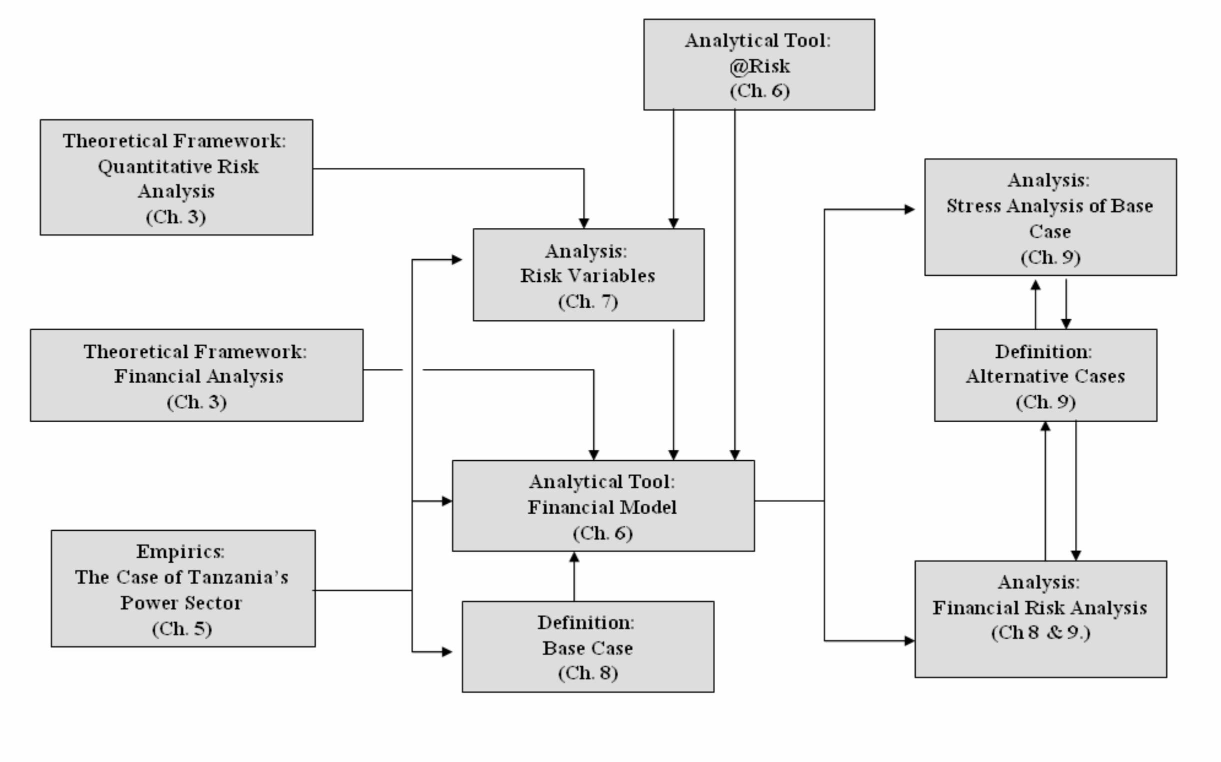

Figure 1: Schematic of the Practical Approach

Relevant academic literature, reports and articles on financial analysis, and quantitative risk analysis are studied in order to define the theoretical framework as well as the appropriate methodology. The theoretical framework is presented in chapter 3.

Thereafter, the overall structure of the power system is investigated and empirical data for the case study collected. Data derives mainly from TANESCO system reports, data bases and similar studies. Three reports in particular form the basis for the technical as well as the financial empirical information, namely Tanzania Power System Master Plan, PSMP (2003) (update from 1999), East African Power Master Plan Study, EAPMP (2005) and TANESCO Financial Recovery Plan, FRP (2006). The studies are performed by TANESCO or, in the case of the EAPMP, based on information provided by TANESCO. Project reports, studies and similar research conducted by consultants; donor agencies etc. are also examined for supplementary information as well as to verify various sources. The empirical data and its sources are described in chapter 5.

The financial theoretical framework combined with system structure and the empirical data provides the basis for the development of the financial model. It is based on standard financial and technical concepts, adapted for the selected case and implemented as an Excel spreadsheet model. The second analytical tool used for the different analyses is the computer program @Risk, which can be integrated into the Excel program, which gives the financial model the ability to simulate the influence of a set of key variables. These tools are explained in chapter 6.

Three risk variables are identified from the empirical data and analysed following the suggested theoretical method for quantitative risk analysis. The key variables initially chosen are: (i) the annual contribution of hydro-power to the system; (ii) the world market price of oil; and (iii) the specific demand for electricity. The analytical tool @Risk is used to match the data for the risk variables to a suitable distribution function which then is applied in the Monte Carlo simulations performed in the financial model. In chapter 7 the three risk variables are evaluated.

Further, a base case for the analysis is defined based on the empirical data and general assumptions made. Base case data is incorporated in the financial model and the analysis is performed with the statistical variation of the risk variables taken into consideration. The result is presented in chapter 8.

With the base case result available, alternative cases may be defined and analysed in an iterative fashion, including e.g. stressing the risk variables and reformulating the investment plan. This is described in chapter 9, where also some additional results are presented.

3. Theoretical Framework

The theoretical framework, described in this chapter, forms the basis for the study. Initially the essential elements of traditional methods for financial analysis of investments are described. Thereafter, benefits of the extended method of quantifying risk are discussed. Finally the theoretical approach for this method is described. Moreover general probability theory is explained for an enhanced understanding of the theoretical problem analysis.

3.1 Financial Analysis of Investments

In order to assess the financial viability of an investment project from the viewpoint of the operating utility, a financial analysis of the project shall be carried out. A financial analysis is different from an economic analysis, which evaluates a project from the viewpoint of the national economy, however, the methodology for performing these kind of analyses are alike and therefore bibliography studied also include academic books on economic analysis.

The financial analysis is best performed by determining the project's Net Present Value (NPV) using Discounted Cash Flow (DCF) analysis. This analysis involves essentially identification of all relevant cash flows of the project and discounting them to a certain point in time. The financial analysis can be made on a project level, by calculating the incremental cash flow associated with a certain project, or for the firm as a whole, determining what investment program will give the highest net present value. A calculation of the net present value and the internal rate of return (IRR) are commonly included in the analysis. The DCF approach is a widely used method when it comes to financial investment appraisal.

3.1.1 Discounted Cash Flow Method

A project's revenues arise from selling a product or providing a service. In order to receive these revenues there are also several costs involved such as payment of investments, salaries, operating and maintenance costs etc. The remaining net earnings, after the payment of costs, constitute the yearly payoff. To calculate present value, the expected future payoffs should be discounted by the rate of return offered by comparable investment alternative[14]. This rate of return is often referred to as the discount rate or the opportunity cost of capital. It is similar to an interest rate adjusting for the time value of money. The present value (PV) of the cash flow is calculated by summing the discounted annual cash flow over the financial time period.

The statement of cash flow reports cash receipts and payments in the period of their occurrence, classified as to operation, investing, and financing activities. It also provides supplementary disclosures about non-cash investing and financing activities. Cash flow data also help explain changes in consecutive balance sheets and supplements the information provided by the income statement.[15]

3.1.2 Investment Profitability Measures

Net Present Value

There are several common criteria, which may be applied in assessing what investments a utility should undertake. In this work and in the model developed, the criteria will be the net present value,

[14] Brealey and Myers (1996), p. 12
[15] White, Sondhi and Fried (2003), p. 17

based on discounted cash flow. Using discounted cash flow to calculate net present values has several attractive characteristics for investment decisions: (i) it takes into account the time value of money, i.e. that a dollar today is worth more than a dollar tomorrow; (ii) it depends only on the forecasted cash flow from the proposed investment program and the chosen discount rate; and (iii) you can easily compare alternative investment programs by the difference in net present value. The criteria for accepting an investment is that the NPV is positive. When choosing between alternative (but mutually exclusive) investments, the investment with the highest NPV should be chosen. However, calculating an NPV requires a discount rate, which level has a considerable effect on the result. The method is described in detail below:

Calculating NPV – The net present value (NPV) is calculated by adding the project's initial investment to the present value of future revenues and costs. However, calculating an NPV requires a discount rate, which level has a considerable effect on the result.

Definition[16]:

$$NPV = C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_t}{(1+r)^t},$$

Where:

C_0 = Cash Flow for time period 0 (usually a negative value, representing the investment), C_1 = Cash Flow for time period 1, r = rate of return/discount rate

Discount Rate[17] – If the discount rate is stated in nominal terms, it is required to calculate the cash flow in nominal terms as well. If the cash flow is in real terms, the nominal discount rate should be restated to real term using the following formula:

$1 + r_{nominal} = (1 + r_{real})(1 + \alpha_i)$, Where: α_i =inflation rate

Salvage Value[18] – When an investment has not been fully utilized at the end of the modelling period, meaning that it can be used to generate cash flow also beyond the final year, a salvage value or terminal value for that investment has to be determined. This is particularly important if there are large investments coming in at the end of the period, as otherwise their entire investment cost will be taken into account when calculating the net present value, although the contribution to cash flow is only for a few years. In the analysis performed here, the salvage value is calculated as the depreciated value of the investment, based on linear depreciation over the assumed economic lifetime of the investment. The salvage value, which represents an estimate of future cash flows, is treated as a positive cash flow at the end of the calculation period. This is applied to the net present value with the following calculation.

$$NPV = C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_t}{(1+r)^t} + \frac{C_{Salvage}}{(1+r)^t}$$

[16] Brealey and Myers (1996), p. 100
[17] Brealey and Myers (1996), p. 117
[18] Brealey and Myers (1996), p. 118-121

Financing Decisions[19] **–** In *Brealey and Myers (1996),* the importance of separating the investment from the financing decision, is addressed. It is suggested to initially treat a project as is was equity financed, treating all cash outflows as coming from the stockholders and all cash inflows as going to them. After the NPV has been calculated, a separate analysis of financing can be undertaken.

***Income Statements* –** The purpose of the cash flow analysis is to analyse and compare alternative investments. Depreciation, which is an accounting entity and not associated with any cash flow, must be calculated in order to determine the corporate profit tax, which does affect cash flow, and the salvage values of various investments. For this purpose annual income statements need to be produced. However, these income statements should be seen only as a means for considering taxes as part of the cash flow analysis when comparing different investment programs, and are not calculated with an accuracy that makes it useful to an accountant.

Other Profitability measures[20]

The most popular alternatives to net present value are: (i) payback; (ii) return on book value; and (iii) internal rate of return. These methods have certain weaknesses:

- The payback method simply calculates how many years it takes before the sum of yearly cash flows match the initial investment. The investment with the shortest payback is preferred. The method, for example, does not take into account what happens after the payback period. It may prefer short term small investment, rather than the combination of investments that will maximize the value of the firm in the long term.

- The rate of return on book value compares average forecasted profits (after depreciation and taxes) with the average book value of the investment. If the return on book value is higher than the company's average cost of capital, the investment can be accepted. A weakness of this method is, as for the simple payback period, that it does not take into account the time value of money, and, contrary to the payback period, tends to give too much weight to distant cash flows.

- The internal rate of return (IRR) method, which is a much more used and accepted tool, is defined as the discount rate at which the net present value is zero. If the IRR is higher than the company's average cost of capital, the investment can be accepted. However, some difficulties in using the method properly are described in *Brealey and Myers (1996).* The most important for this analysis is that the IRR may be misleading when choosing from mutually exclusive projects, i.e. it may choose a smaller investment with a very high return, rather than a larger investment with an acceptable rate of return and a higher net present value (i.e. choosing to sell to the most profitable customers rather than trying to expand to as many customers as possible, which meet the set profitability criteria). Properly applied, however, it will give the same answer as the net present value.

3.1.3 Financial Modelling

Financial analysis can be performed in many ways; one way is by using a financial model that simulates the project company accounts. A financial model facilitates the analysis of the project in

[19] Brealey and Myers (1996), p. 120
[20] Brealey and Myers (1996), ch. 5

order to set up a financial structure that meets the requirements of the investor as well as forms a baseline plan for the risk assessment.

The financial analysis hence shows the pattern of cash flow, which the project parts provide over its financial lifetime. It also determines the ability to pay the debt service, operating and maintenance cost streams and brings out any cash flow deficits, which may arise. Ideally the net cash flow should be positive; otherwise other short-term loans have to be used to cover these deficits during the project operation. In evaluating the cash flow, all expenditures such as debt service, operation and maintenance, depreciation, income from sale of electricity are lumped into end of year payments.

3.2 Benefits of a Risk Assessment

The conventional DCF method as described above is the one most commonly used when assessing power investment projects, although it has some drawbacks. The DCF method major weakness is that the approach does not consider uncertainties in future returns, except in the choice of the discount factor. Every investment carries its own risks and it is important that they are known and evaluated. It is therefore not enough to only model the desired behaviour but also the unwanted behaviour. Assumptions on future energy demand, prices and generation output tend to be very hard to predict. In this context, a comprehensive risk assessment appears highly relevant for investment analysis in the power sector.

A risk analysis assesses how uncertainty in the forecast of input parameters affects the outcome of the project as well as gives an indication of the probability of a project failure. By including risks and uncertainties in the financial analysis, the project operators are given an enhanced foundation when choosing between different project alternatives and information on how the project may or may not affect the total business. For project financiers, other than the operating utility, the concept of risk in investment is important in determining terms and conditions of loans and in the structure of the financing plan to optimize the financing resources.

Cash flow uncertainties could be justified by changes of the discount rate with the capital asset pricing model (CAPM)[21], however this will not incorporate the real fluctuations in input variables. Further, the CAPM method is reliant on an established and well functioning capital market, and therefore not as relevant for development countries.

Sensitivity analysis is another common approach to deal with uncertainties. The method involves identification of the variables that most influence the project's net benefits and quantifies the extent of their influence, which consists of testing how percentage increases and decreases in uncertain variables affects the projects financial outputs such as the NPV. Typical variables in analysis of power utility investment programs are: (i) high and low demand growth; (ii) fuel costs; (iii) capital costs of projects; (iv) project timing; and (v) discount rate. This method does not consider the probability of different variations and hence neither the probability of different outcomes of the project. Further, variables usually do not change one at a time[22].

Scenario analysis is another method, which tries to capture the interrelationship between uncertain variable. Scenario analysis looks at a limited number of combinations of variables. Further, neither of these methods identifies the correlation between uncertain variables i.e. how their variation is dependent on each other.

[21] White, Sondhi, Fried (2003), p. 668
[22] Brealey and Myers (1996), Ch. 5

Monte Carlo simulation, which is the basis for the quantitative risk analysis, gives the added advantage of looking at a large number of combinations of variables, and of obtaining a full distribution of cash flows. The additional work associated with this approach is that, supplementary to the financial model, distribution functions for the risk variables need to be modelled and incorporated. The benefit of this approach, in addition to being able to handle combinations of variables, each with its specific probability distribution and relation to other variables, is that it may increase the understanding of the investment process and the risks involved.

Even more ambitious theoretical approaches for modelling investment decisions exist, using for example decision trees, as well mathematical tools as linear programming. However, this is out of the scope for this work. Most of the professional analyses made on power utility investments for African countries are still limited to sensitivity analysis and scenario analysis to cope with uncertainty and risk. Risk analysis based on Monte Carlo simulation as applied in this thesis, therefore adds to the tools currently applied, and is intended to provide new insight into utility investment planning.

3.3 Quantitative Risk Analysis

Quantitative risk analysis involves consideration of a range of possible values for key variables (either singly, or in combination), which then results in the derivation of a probability distribution of a project's expected NPV or IRR or other relevant project measures[23]. In order to perform a quantitative risk analysis, a risk simulation program has been used, @Risk, which is further described in section 6.3.

3.3.1 Probability Theory

Certain knowledge of probability theory is required, in order to perform a risk analysis. General concepts and definitions are described below.

Probability Distribution

When quantifying risk variables, possible outcomes and probabilities of their occurrence shall be considered. The risk is thereafter summarised using a probability distribution. In A*sian Development Bank (2002)* an example of creating a probability distribution is illustrated. In the example the number of passenger bus trips on a specific route was evaluated. The number of passenger expected on a particular route per week is shown in Table 1.

Table 1: Number of bus trips and their probability of occurrence.

Number of bus trips ('000)	10	20	30	40	50	60	70	80	90
Probability of occurence	2,5%	5,0%	10,0%	20,0%	25,0%	20,0%	10,0%	5,0%	2,5%

The probability density function, PDF bases on frequency of observation falling within particular class intervals, for the number of passenger, deriving from the data above is shown in Figure 2. The probability density function are most often also referred to the probability distribution function.

[23] Asian Development Bank (2002), p.4

The PDF can be described as a statistical function that shows how the density of possible observations in a population is distributed. Definition[24]: A function with values *f(x)*, defined over the set of all real numbers, is called a probability density function (PDF) of the continuous random variable X if and only if :

$$P(a \le X \le b) = \int_a^b f(x)dx$$

for any real constants a and b with $a \le b$.

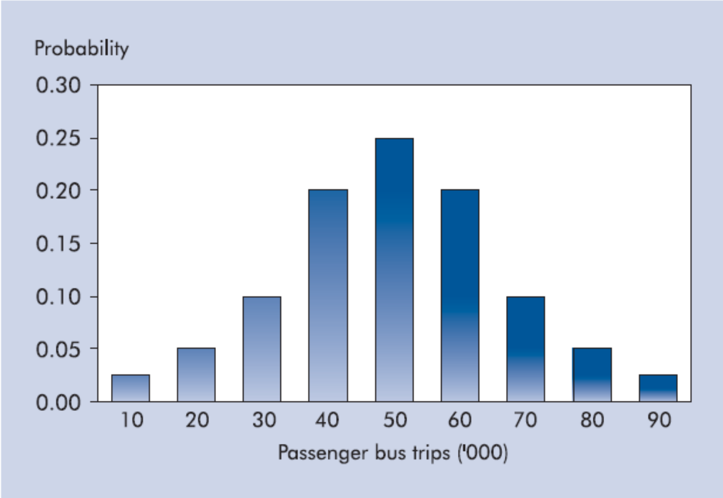

Figure 2: Probability Density Function of Number of Bus Trips[25]

There are many forms and types of probability distributions, each of which describes a range of possible values and their likelihood of occurrence.

Cumulative Distribution Function

The cumulative distribution function, CDF, plots the probability that the actual outcome will be below a certain level. An example of a cumulative distribution function is shown in Figure 3. It can be observed from the figure that the likelihood of the NPV to fall under zero is 30%.

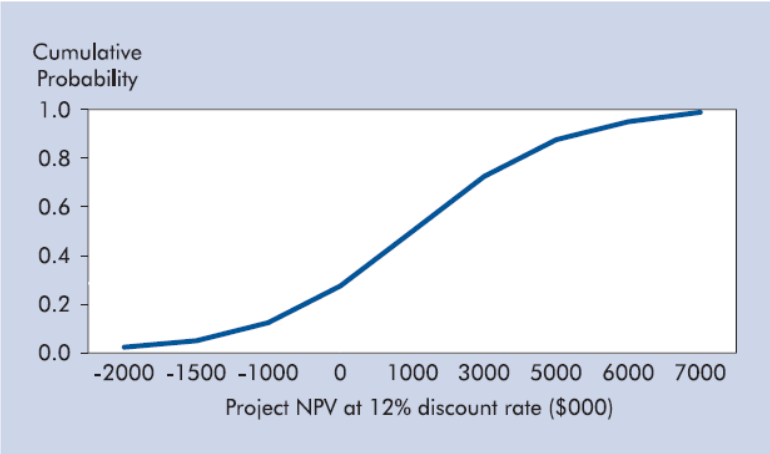

Figure 3: Cumulative Probability Distribution of Number of Bus Trips[26]

[24] Blom (1984), p.63
[25] Asian Development Bank (2002), p.17
[26] Asian Development Bank (2002), p.18

Distribution Function Parameters

Distribution parameters can include mean and standard deviation, whereby the mean is the average number of the measured variables and the standard deviation is the average difference between all observations and the mean.

There are different methods for calculating these parameters. @Risk uses the maximum likelihood estimator (MLEs). The MLEs are the parameters of that function that maximize the probability of obtaining the given data set.

Definition[27]: For any density distribution $f(x,\theta)$ with one parameter θ and a corresponding set of sampled values x_i, the likelihood function as follows can be defined:

$$L(\theta) = \prod_{i=1}^{n} f(x_i, \theta)$$

To find the MLE, L shall be maximized with respect to θ.

$$\frac{dL}{d\theta} = 0,$$

and solved for θ.

Fit Statistics

Fit statistics measure how good the distribution fits the input data and how confident you can be that the data was produced by the distribution functions. The smaller the value of these statistics, the better the fit. One fit statistic that @Risk makes use of is the Chi-squared Statistic. The Chi-squared statistic is the best known goodness-of-fit statistic[28].

Definition: To calculate the Chi-squared statistic, the x-axis domain is broken up in several "bins".

$$\chi^2 = \sum_{i=1}^{K} \frac{(N_i - E_i)^2}{E_i}$$

where,

K = the number of bins

N_i = the observed number of samples in the ith bin

E_i = the expected number of samples in the ith bin.

A weakness of the Chi-squared statistic is that there are no clear guidelines for selecting the number and location of the bins.

[27] Blom and Holmquist (1970), p.62
[28] Palisade (2005), p.147

3.3.2 Evaluation of Risk Variables

The procedure of identifying and defining the risk variables of the project is explained in A*sian Development Bank (2002)* [29] and *Grey (1995)*[30]. Detailed methods for different kind of "distribution fitting" is described in *Palisade (2005)*[31]

Identifying Key Risk Variables

The key risk variables are the variables that have an unknown future outcome but are expected to affect the project return. Risk variables are defined as variables, of which the likelihoods of outcomes are known, based on historical data or forecast data and for which a probability distribution can be constructed. If distribution functions can not be estimated the variables are defined as uncertainties. Risk variables are most commonly variables over which the investing utility has no influence.

The method for sensitivity analysis as described earlier can also be used to determine which key variables the risk analysis should be based upon.

Assembling Data

After the key risk variables have been identified, data regarding each variable should be collected or estimated. If a historical data set exists, which shows the natural pattern of the variable in the past, the future expected probability distribution can be modelled. If no such data occurs, future expected values have to be estimated, although in this case the estimator should have some sense for in which range the variable is expected to fall.

It shall also be considered which underlying factor the specific risk variable is dependent of and correlated to. This is described more in detail further down.

Modelling Risk Variables

Well tried empirical methods exist for developing probability distributions[32];

- Visual impact techniques, Identifies the frequency of value occurrence based on historical data.

- Structured questions to identify key points in a distribution, Identifies the median, quartiles, etc of the data set.

- The application of "smoothing" techniques in situation where a few real data point may be available.

Techniques applied to develop definitions and derivations of probability distributions for individual variables in most cases are likely to depend upon some subjective judgement by an appraisal team.[33]

[29] Asian Development Bank (2002), p. 22
[30] Grey (1995), ch. 3
[31] Palisade (2005), ch. 6
[32] Asian Development Bank (2002), p.22
[33] Asian Development Bank (2002), p.21

Goodness of the Fit

If the distribution has been fitted to the sampled data, it is essential to evaluate the goodness of the fit. @Risk measures the deviation of the fitted distribution form the input data. The smaller the fit statistic is, the better the fit. The observed significance of the test is called the p-value of the fit and defines the deviation of the fitted distribution from the input data. The P-value is used as hypothesis test if a new set of samples drawn from the fitted distribution would generate the same fit statistic. The closer the P-value is to zero the less it can be trusted that the fitted distribution could generate the original data set. Conversely, when the P-value approaches 1, there is no basis to reject the hypothesis.

Correlation

Correlation between any of the risk variables shall be identified. Correlation is in statistics a measure of strength of the relationship between two variables. It may be used to predict one variable given the value of the other. For example a generated high value of one variable may imply a high value of another variable since these two are positive correlated, i.e. they are depending on the same fluctuation.

Applying the Distribution to the Financial Analysis

Once the result of the fit has been analysed, the fit can be used in the financial model as an input key variable.

3.3.3 Scenario Generator

Generating the underlying distribution and calculating the expected NPV through mathematical analysis is generally impossible. The analyst must rely on computer generated simulation.[34] The following step will be the incorporation of the risk analysis in project financial analysis, were a scenario generator (e.g. software program such as @Risk), will be a helpful tool.

The scenario generator comprises models of the PDFs for the identified risk factors affecting the project. The output of the scenario generator is a large number of Monte Carlo paths of all modelled risk factors over the projects financial lifetime. The generator takes into account dependencies among the risk factors and dependencies over time i.e. correlation between the factors. The scenarios reproduce the behaviour of the risk factors to sufficiently account for any extreme individual and joint outcomes.

3.3.4 Output of Analysis

The output of the model will be a detailed quantitative analysis, which provides both statistical and visual information regarding the simulated paths and their distributions. The result will be the simulated distribution function of the project financial indicators and will assess and design the optimal investment program for the project.

3.4 Risk Measurement and Risk Aversion

Through quantitative risk analysis, the investment project's risk exposure is quantified and measured by appropriate risk measures. These measures include not only the expected return of the project but also the variability of the return and the likelihood that the NPV or IRR falls out of an acceptable

[34] Belli (2001), p.152

range. Although, risk measurements themselves do not give any information on weather a certain project or project alternative should be implemented or not, since these decisions are strictly dependent on the decision makers risk aversion. Risk aversion is the amount of risk that the decision makers are prepared to accept as the trade off for a higher project return.

4. Tanzania's Power Sector - Overview

The objective of the following chapter is to provide the reader with an overall picture of Tanzania and its energy sector. It gives a brief introduction to Tanzania's history, economy and politics. Further, the chapter presents the current energy situation and introduces Tanzania's major power utility, TANESCO. Finally, Tanzania's present energy resources are described.

4.1 The United Republic of Tanzania

Tanzania is located on the East coast of Africa just below the equator. Mainland Tanzania, previously Tanganyika, became independent in 1961 and was joined by the Zanzibar in 1964. Tanzania has a population of 38 million, growing at about 2% per year[35]. Tanzania bounds in the North to Kenya, Uganda, Burundi and Rwanda, in the West to Democratic Republic of Congo and Zambia, in the South to Malawi and Mozambique, and the whole eastern boarder consist of the Indian Ocean coast line. The major city is Dar es Salaam (Port of Peace) on the East coast with more than 3 million inhabitants. The country covers an area of about 945,000 square kilometres, i.e. double the size of Sweden. Tanzania is famous for its national parks, including the Ngorogoro crater and the Serengeti, Africa's highest mountain Kilimanjaro, still with snow on the top, and the island of Zanzibar.

Tanzania's economy is still very much reliant on agriculture, which sector contributes to about 50% of the gross domestic product (GDP) and provides employment for 85% of the population[36]. Other important sectors are manufacturing, mining and tourism. The economy has progressed steadily since the implementation of macroeconomic stabilization and structural reform in the mid-nineties. GDP is now growing at a rate of about 6-7% per year with inflation contained at less than 6% per year. With a per capita GDP of 319 USD, Tanzania ranks as a low income country[37].

Tanzania is highly dependent on foreign aid, which accounts for about 40% of the state budget of about 5 billion USD. The budget is intended to support the implementation of the National Strategy for Poverty Eradication (the MKUKUTA in Swahili) and the achievement of the Millennium Development Goals[38].

Under its first president, Julius Nyerere, Tanzania's ruling party was Chama Cha Mapinduzi or the Revolutionary Party, and Tanzania was in fact a one party state. With political reforms undertaken in the nineties, moving away from the socialist economic policies of Nyerere, the constitution was amended and the multi-party system that exists today, although weak, was created. Market economy has been introduced and there is some progress with privatization.

4.2 Present Energy Situation[39]

Tanzania still relies heavily on wood fuels for cooking and heating. It is estimated that 93% of the total energy consumption in the country comes from different biomass energy resources such as fuel-wood and charcoal. The electricity sector is small; the average per capita consumption of electricity is

[35] The World Bank, 10.08.2007
[36] Tanzania's National Website, 09.07.2007
[37] The National Bureau of Statistics, 23.08.2007
[38] International Monetary Fund, 23.08.2007
[39] TANESCO, 14.03.2007

only about 75 kWh[40] per year, compared to Sweden's 17,000 kWh[41] per capita and year. Electricity is also available only to a small part of the population.

Less then 11% of the population in Tanzania have access to electricity and at present, outside the major cities and towns, only the majority of regional headquarters, some district township and a limited number of villages are supplied with electricity, as can be seen in Figure 4.

Only 2% of rural households have access to grid electricity. The lack of basic modern energy services in most rural areas is perceived as being a bottleneck in social and economic development. In Tanzania's poverty reduction strategy (the MKUKUTA)[42], energy is considered as an important component. Increased proportion of the population having access to electricity is one of the main conditions to achieve the millennium goals.

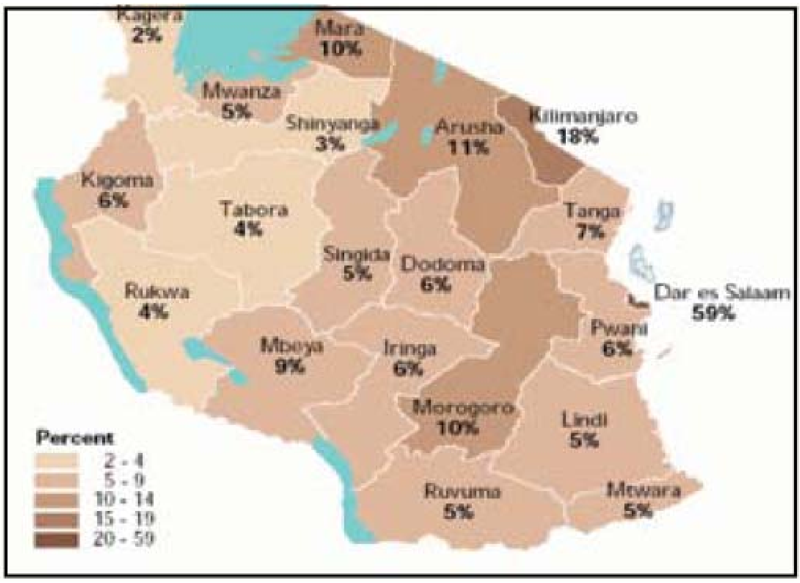

Figure 4: Electricity Access in Tanzania

The demand for electricity in Tanzania is expected to grow at a rate exceeding 10% per year, which would require a heavy investment program in generation, transmission and distribution. In the state budget for 2007/2008, TANESCO's investment needs, only in order to rehabilitate transmission and distribution lines, over a five-year period are indicated as USD 1 300 million[43].

4.3 Tanzania Electric Supply Company Limited (TANESCO)

Tanzania's major actor in the power sector is the Tanzania Electric Supply Company Limited (TANESCO), which was established in 1964 when the government bought all the shares of two private utilities. The company's core business is the generation, transmission, distribution and sale of electricity to the mainland and bulk supply to the island of Zanzibar.

The parastatal power company is directed by a Board of Directors. TANESCO is overseen by and reporting to the Ministry of Energy and Minerals (MEM). As the electricity sector regulator EWURA, which was created in 2002, has become operational, it has taken over MEM's role as power sector regulator, and is thus in charge of approving tariff increases put forward by TANESCO.

At present 98%[44] of the country's electricity supply is provided by TANESCO, who owns and operates the national grid and also owns the major hydro power plants.

[40] TANESCO, 23.08.2007
[41] Svenska Energimyndigheten, 23.08.2007
[42] Tanzania, NSGRP (2005), p.14
[43] TANESCO FRP (2006)
[44] African Rural Energy Enterprise Development, 10.07.2007

TANESCO's corporate vision is to be an efficient and commercially focused utility supporting the development of Tanzania, and to become a regional player in the East African power industry[45].

4.4 Development in the Energy Sector

As Tanzania emerged on market sector reforms in the beginning of the nineties, an energy policy was developed by the government and a privatization of the state power utility TANESCO was decided on. It was also decided to introduce a regulator to oversee the power market, and an agency that would provide subsidies for rural electrification, the Rural Energy Agency. However, due to the weak global market for foreign investments in the energy sector in developing countries, the decision to privatize TANESCO was reversed and it was decided that TANESCO should remain a fully state owned utility. The policy although has progressed the development of independent power producers, IPPs.

Performance was improved by engaging a management consultant to manage TANESCO during a period of about 5 years. However, the draught experienced in 2003-2006 has caused much damage to TANESCO, which is currently in a weak financial position. To some extent, TANESCO still suffers from a number of problems: overstaffing, poor reliability of supply, low coverage, low financial performance, a minimally diverse generation base and a tariff which does not cover all of the costs of the service.

4.5 Energy Resources[46]

Tanzania is a country with abundant resources for energy generation, these includes hydro power, natural gas, coal as well as renewable sources such as wind and solar.

4.5.1 Hydropower

The total hydropower potential in Tanzania is estimated at about 4,000MW, which could provide 20,000 GWh of electricity annually, or about six times the electricity consumed today. The two major hydropower plants, Kidatu and Kihansi, are located on the Greater Ruaha River and the Kihansi River in Southern Tanzania. The Greater Ruaha River feeds into the Mtera dam, from which water runs to the Kidatu plant. Downstream of the Kidatu plant the Kihansi and other rivers feed into the Rufidji River, which flows through its delta into the Indian Ocean. See Figure 5 below. Two smaller hydro power plants, Pangani and Hale, are located on the Pangani River in Northern Tanzania. There are several smaller river systems in the Northwest of Tanzania also providing potential for hydro power generation.

[45]TANESCO, 23.08.2007
[46] TANESCO PSMP (2005)

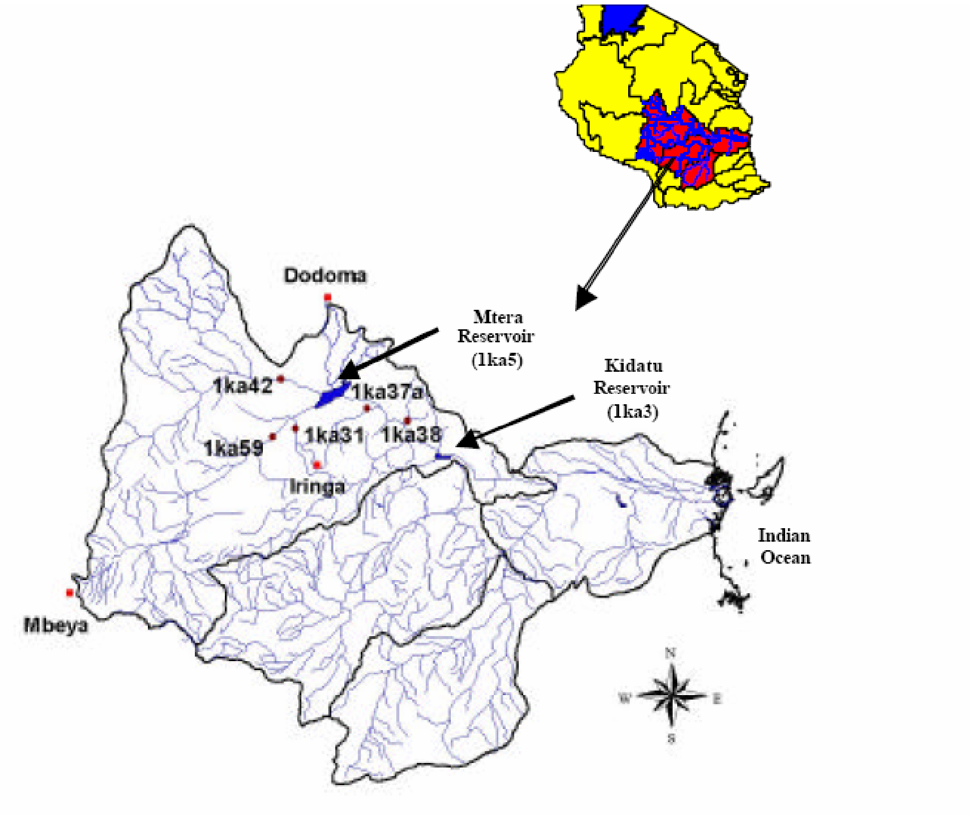

Figure 5: Hydro Power Resources[47]

At the same time, Tanzania as well as several other sub-Saharan countries has during recent years experienced a number of severe droughts, which has lead to a shortage of water for hydropower generation. There have been difficulties in refilling the reservoirs, which in its turn is a threat to reliability of electricity supply. In Tanzania the extended drought eventually led to power rationing during part of 2006. At the end of 2006, the whole Northern network was threatened due to insufficient generation capacity.

4.5.2 Natural Gas

Gas was discovered in Tanzania in 1974 at the Songo Songo island. The initial plan was to utilize the gas for fertilizer production. At that time, the idea to use gas for power was considered by the ministry of energy, MEM, but there were insufficient public funds and private investment was not forthcoming[48]. By 1991, it had been determined that gas-based power generation was the next least-cost option to hydropower and quicker to develop than other sources, this became a corner stone of the Power System Master Plan (of the same year).

Figure 6: Gas Well at Songo Songo[49]

[47] Yawson, Kashaigili, Kachroo & Mtalo (2003)
[48] Gratwick, Ghanadan & Eberhard (2006), p.10
[49] Songas, 30.08.2007

The total proven reserves of natural gas at Songo Songo range from 0.8 to 1.0 Tcf[50]. The quantity 0.8 Tcf of natural gas is sufficient to fuel 500 MW of combined cycle generation for about 33 years. Natural gas has been found also in the Mnazi Bay. However, the reserves are uncertain and as the field is located too far from the main electric grid there are plans for development of a 15 MW plant to supply a local mini-grid in the Lindi and Mtwara regions.

4.5.3 Coal

Proven coal reserves in Tanzania are estimated to be about 159 million tonnes with a potential reserve as high as 1,200 million tonnes. The coal sites include Kiwira, Northwest of Lake Malawi and Mchuchuma/Katewaka southeast of the lake. The Mchuchuma/Katewaka coal field is located about 750 km inland in the southwestern part of Tanzania. The proven reserves at Mchuchuma are reported to be sufficient to fuel a power plant of up to 400 MW capacity for a period of 35 to 50 years.

4.5.4 Oil

Tanzania has no discovered commercially viable oil resources and is hence an oil-importing country with the nearest source of petroleum fuel available is in the Arabian Gulf.

4.5.5 Renewable Resources

In addition to major hydroelectric, thermal stations and geothermal generation projects, all three countries studied in the *EAPMP*, have the potential to generate power from renewable sources:

- Wind Energy
- Solar Energy
- Biomass (e.g. Bagasse/Peat)
- Mini Hydro

In the *EAPMP*, the use of the above renewable energy resources are considered in the first instance to be more appropriate to non grid connected rural electrification schemes.

The map below shows the location of Tanzania's main energy resources:

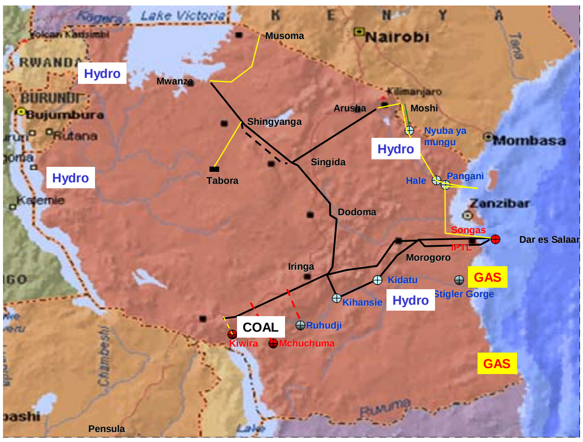

Figure 7: Geographical Location of Tanzania's Energy Resources

[50] *Tcf- Trillion cubic feet - SI unit used to measure quantity of gas at atmospheric pressure*

5. Tanzania's Power Sector - Empirics

The following chapter comprises the collected data from TANESCO and other relevant sources, which will form the main assumptions and input variables in the analysis. Initially, historic development at TANESCO is discussed, covering electricity sales, tariffs and revenues as well as existing transmission and distribution network and generation facilities used to produce electricity to meet the current demand. Further, data on future energy demand and forecasting methods are presented, as well as investment requirements in order to meet future demand. Moreover, TANESCO's financial situation, including its recent approved financial recovery plan and financing options are described. The purpose of the chapter is to give the reader insight in Tanzania's power sector and TANESCO operations as well as in similar studies performed in the field. The chapter also provides with the technical background for the analytical framework.

5.1 Historic Electricity Consumption and Generation Mix

5.1.1 Electricity Consumption

At present 98% of the country's electricity supply is provided by TANESCO, who owns and operates the national grid. In total about 3 400 GWh of electricity was generated in 2006.

The electricity consumption in Tanzania has grown steadily over the last decade, although the last two years show a decrease caused by supply constraints due to the droughts. The total number of customers supplied by TANESCO by the end of December 2006 is estimated at 580 000, divided on residential, industrial and commercial. The average growth of the customer base since 2000 has been between 6 to 12% annually[51].

Tanzania has experienced drought for several years, causing a large loss of hydro power generation. As not sufficient thermal generation was available to compensate, this caused an energy crisis with significant load shedding in 2006. [52] Improved rain falls in late 2006 and early 2007 restored full hydro capacity, and since then generation shortfalls have been avoided. Additional thermal capacity has also been added, so that no load shedding should be expected over the medium term. The energy crisis is estimated to account for at least 2% GDP drop in 2006[53].

The following table presents TANESCO's historical sales data by consumer category for the year 2002 to 2006. It can be observed from the sales data, that the share of electricity supplied to general use consumers decreased over the years 2003, 2005 and 2006, which is a result of the capacity shortage due to the drought, while the high voltage consumers, i.e. industrial consumers were less affected.

[51] TANESCO Database
[52] *During peak hours only part of the customers could be supplied, and there was even a high risk of TANESCO not being able to supply the Northwest part of Tanzania with electricity.*
[53] The World Bank (2007), I

Table 2: Historical Electricity Sales by consumer Category[54]

	Electricity Sales (GWh)				
Category	**2002**	**2003**	**2004**	**2005**	**2006**
General Use	1 108	1 029	1 131	900	871
Low Voltage	295	335	375	400	398
High Voltage	528	639	681	779	830
Zanzibar	133	145	161	186	204
Miines	129	138	201	155	160
Total Sales	**2 193**	**2 286**	**2 550**	**2 418**	**2 464**
Annual Growth Rate (%)		4%	12%	-5%	2%
Number of Customers (No)	427 970	485 669	504 371	541 413	580 565

The following figures show the development of sales over the period (left), as well as the share of each consumer category for 2006 (right):

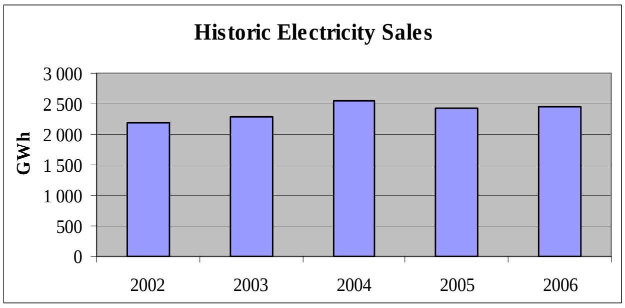

Figure 8: Historical Electricity Sales

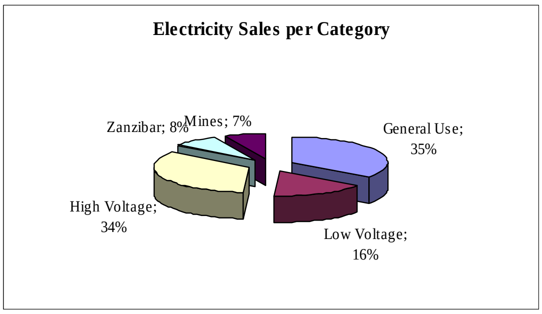

Figure 9: Share of Electricity Sales on Consumer Category

Consumption of electricity has a daily variation and also a seasonal variation. Figure 10 below shows typical daily load variations. The maximum load occurs in the evening around 20 hours, and is mainly due to residential demand. The maximum load is about 30% higher than the load in the middle of the day, and about 80% higher than in the middle of the night. From the daily load curves it is possible to construct also a yearly load curve (Figure 11), covering all 8 760 hours of the year. While electricity consumption is measured by an energy unit in GWh, the load is measured as capacity in MW. The ratio between the average load and the maximum load is referred to as the load factor. The load factor is about 0.74 for the daily load curve and about 0.64 for an annual load curve. The maximum load on TANESCO's network reached 618 MW in February 2007. Applying the above load factor of 64%, this corresponds to about 3 500 GWh energy consumption. In the annual load diagram below, the peak represents the maximum load (MW) and the area under the curve by the energy consumed (GWh).

[54] TANESCO database

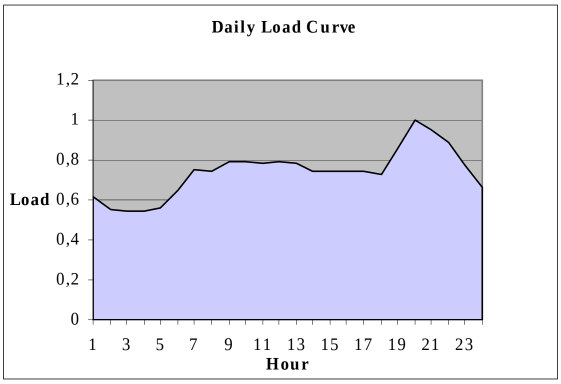

Figure 10: Typical Daily Load Variations[55]

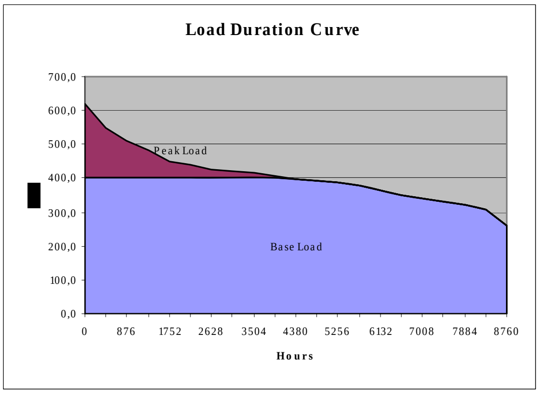

Figure 11: Load Curve Diagram

5.1.2 Revenue Generation and Tariff Structure

TANESCO is paid for the electricity that it delivers to its customers according to the prevailing tariff and based on the metered energy consumption. Industrial customers also pay a capacity charge depending on their maximum connected load. The collection rate, i.e. the ratio of amount collected to amount billed, has been consistently improving in recent years and is now about 96%[56], a level which can not be much improved. However, TANESCO currently has about 10% of non-technical losses, which is due to non-functioning meters, illegal connections and theft.

The non-technical losses, as well as the technical losses, which exist on the transmission and distribution system (section 5.1.3) have to be taken into account when determining the required energy generation.

In order to become connected to the network, a new customer has to pay a connection fee. The sale of energy and the corresponding average revenue per kWh is shown in Table 3.

Table 3: TANESCO Energy Sales[57]

	2006
Energy sold (GWh)	2 900
Revenue (million TSh)	225 259
Exchange rate (TSh/USD)	1 174
Revenue (million USD)	191,8
Average tariff USc/kWh	6,6

Increasing the tariff to compensate for increased costs has always been a politically very sensitive issue. Tariffs are set in Tanzanian shillings, while many costs of TANESCO i.e. IPP capacity charges, fuel, main part of investments etc. are incurred in US dollars. An increasing exchange rate between TSh and USD, i.e. more TSh required to buy a USD, will therefore also affect TANESCO's finances in a negative way. The current procedure for setting the tariff is that TANESCO has to apply to the energy and water regulator (EWURA) for a tariff increase.

The historical development of the average tariff (calculated as revenue from sales per sold kWh) in USD is shown in Figure 12 below, together with the exchange rate TSh/USD. As can be seen from the

[55] TANESCO EAPMP (2004), p.6-7
[56] Personal Correspondence
[57] FRP (2006), p .6

figure, the tariff, when expressed in USD, has eroded over time, due to the unstable exchange rate. This is problematic, since oil as well as many major investments incurs costs in foreign currency.

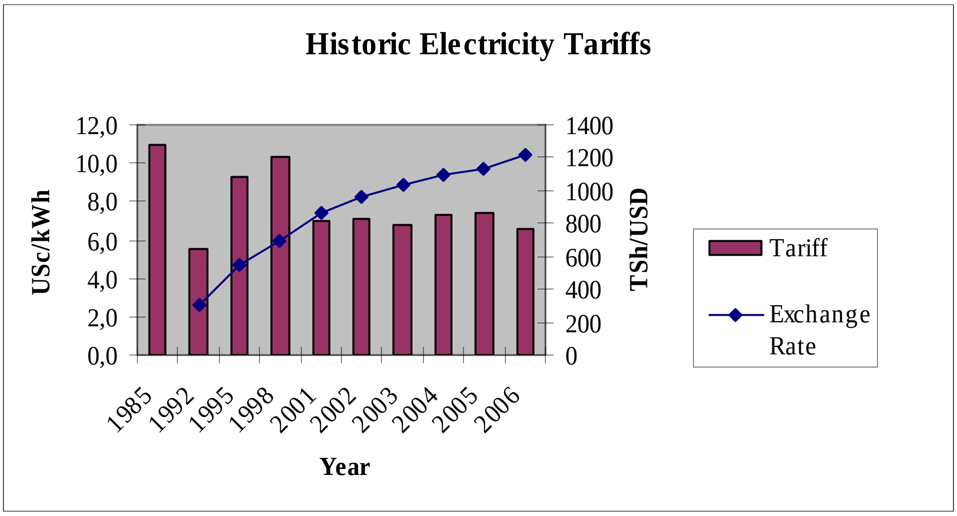

Figure 12: TANESCO's historical Electricity Tariff and Tanzania's Exchange Rate[58, 59, 60]

Recent tariff increases have been 4.3% in May 2005, 5% in June 2006, and 6% in January 2007. In total about 16% over a two year period. This has not been sufficient to compensate for the increased costs of thermal generation during 2005 and 2006. According to the current tariff (January 2007) a general consumer pays TSh 128 per kWh, an industrial customer TSh 65-70 per kWh plus a capacity charge of TSH 6 400 - 6 900 per kW and month. Very small consumers (who use less than 50 kWh per month) pay a "life-line rate" of TSh 40 per kWh. On top of the tariff is added 20% value added tax (VAT).

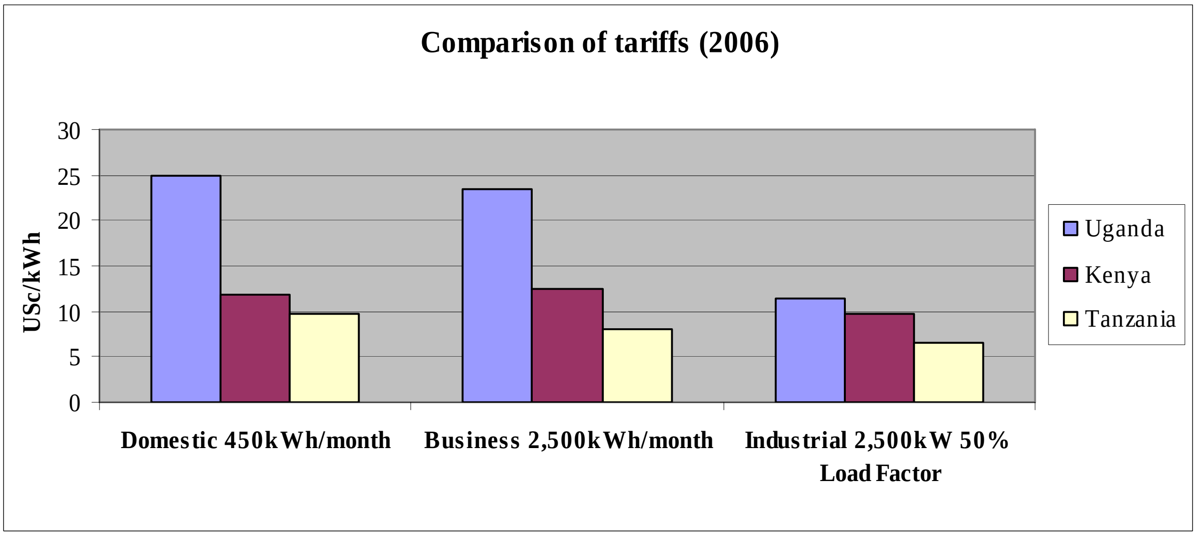

Figure 13: Tanzania average Electricity Tariff 2006 in Comparison with other African states[61, 62, 63]

[58] Gratwick, Ghanadan & Eberhard (2006), p.8
[59] The World Bank (2007), III, p. 25
[60] TANESCO FRP (2006), p. 15
[61] TANESCO FRP (2006), p.15

5.1.3 Transmission and Distribution System

Electricity generated in a power plant is transmitted to the final consumer through a series of transmission lines, switchyards, distribution lines and transformer stations. The voltage level varies from 132kV and above on the transmission system, allowing transmission over long distances, down to 11kV and 400V on the local distribution systems. Residential end users are connected by a single phase 220V line, or a three phase line. Large industrial customers may be connected directly to a high voltage (11kV) line. Electricity consumption is metered at the customers' premises. In Tanzania, pre-paid meters are being used increasingly.

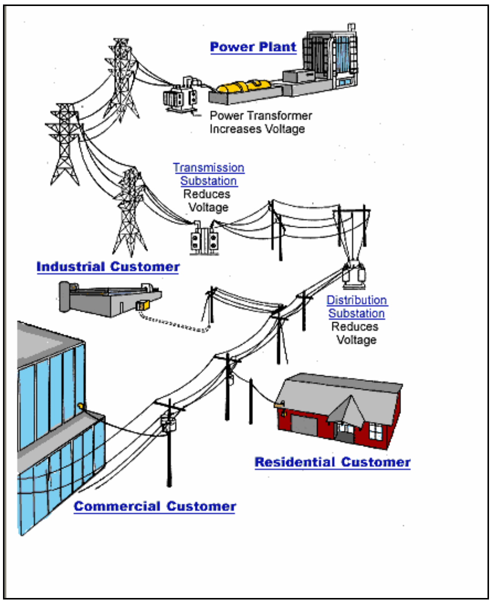

Figure 14: Example of an electricity network[64]

Transmission System

The transmission system is used for the regional distribution of electricity from the major generating stations across the country to various distribution areas. It operates at high voltage levels (currently up to 220 kV) and connects to the distribution networks through transformer substations at main supply points. Usually the power lines are mounted in steel towers. TANESCO's transmission system is extended across the country as shown in the map below. One can observe that it does not yet cover the whole territory of the country, nor are there any major cross border connections to Kenya, Uganda and Zambia.

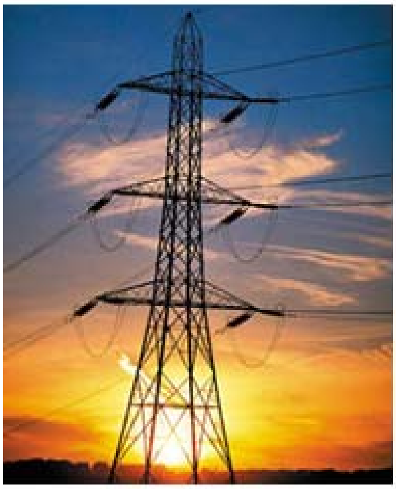

Figure 15: Transmission Tower[65]

[62] Umeme, 27.08.2007
[63] The Kenya Power and Lighting Company, 27.08.2007
[64] Mayfield, 30.08.2007
[65] Hydro One, 31.08.2007

Figure 16: TANESCO's Transmission System

Distribution System

The distribution network extends from the transformer substations of the transmission network to individual customer connections. On the way, there may be several changes in voltage level accomplished through distribution transformers. The historic development of TANESCO's transmission and distribution system is shown in the following table:

Voltage level	Electricity Grid Length (km)			
	1980	1990	2000	2006
220kV	300	1 847	2 658	2 624
132kV	821	1 160	1 420	1 442
66kV	136	136	378	459
33kV	-	3 136	5 500	8 700
11kV	-	2 720	3 218	4 100

Table 4: TANESCO's Transmission and Distribution System[66],[67]

Total System Losses

Total system losses consist of technical losses in transmission and distribution as well as non-technical distribution losses (commercial losses). Non-technical distribution losses result from poor customer management, non-payment, billing issues, or theft. Illegal connections also play a role[68].

Historic system losses for the period 1996 – 2005 are shown in the left figure below. In the period 2002-2005, transmission losses increased from 3.5% to 5% and distribution losses from 10% to 15%. The reason for this is the increased load, without corresponding investment in transmission and distribution reinforcement. The composition of system losses for the period 2002 to 2005 is shown to the right.

[66] TANESCO Presentation (March 2007)
[67] ESI Africa (2002)
[68] Ghanadan and Eberhard (2007), p. 24-25

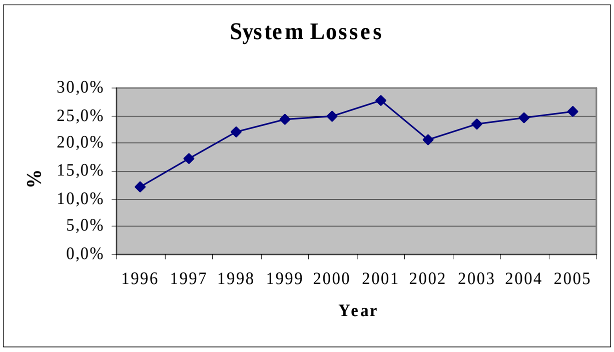

Figure 17: Historical System Losses

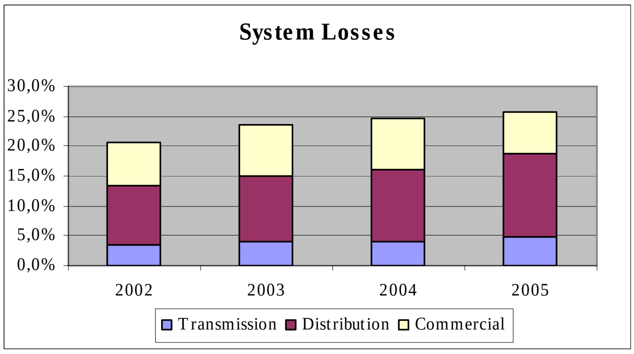

Figure 18: System Losses

5.1.4 TANESCO's Generation Plants

The national power system operated by TANESCO has an installed capacity of 1 028 MW, of which 55% hydropower and 45% thermal power. [69] TANESCO owns all the major hydro power plants, a small amount of thermal plants and has also rented a number of thermal power plants.

TANESCO is currently running six hydro power plants at Mtera, Kidatu in the Grate Ruaha river system; Nyumba ya Mungu, Hale, Pangani Falls in the Pangani river system and Kiahansi in Kilombero drainage basin. The total installed hydro capacity is 561 MW and is shown in the table below.

TANESCO's own thermal generation connected to the grid is limited to 85 MW diesel plant. The unreliable situation with regard to hydro power generation has led to the need for rapid increase of thermal power capacity on the network. TANESCO buys power from two independent power producers (IPPs), IPTL and Songas, operating diesel power plants and gas turbines in Dar es Salaam. The fuel is imported oil (IPTL) and natural gas from the Songo Songo gas field (Songas).TANESCO further imports about 65 GWh from Uganda and Zambia in order to supply some districts close to the border. The total installed thermal capacity is 467 MW.

Moreover, there are a few districts that are supplied with isolated diesel generators, thus not connected to the national grid, their installed capacity amounts to 31 MW and effectively contribute with 15 MW. These diesel generators are fuelled by imported oil.

Table 5: Existing Generation Plants (January 2007)

Hydro Power Plants		Thermal Power Plants		
Plant (TANESCO)	**Installed Capacity (MW)**	**Owner**	**Installed Capacity(MW)**	**Type of fuel**
Mtera	80	TANESCO	85	Diesel
Kidatu	204	IPTL	100	Diesel
Nyumbu ya Mungu	8	SonGas	182	Gas (internal Tanz)
Hale	21	Alstom (rented)	40	Diesel
Pangani Falls	68	Aggreko (rented)	40	Gas
Kihansi	180	Dowans (rented)	20	Gas
Total Hydro Capacity	**561**	**Total Thermal Capacity**	**467**	

[69] TANESCO Presentation (March 2007)

5.1.5 Independent Power Producers

The option of Independent Power Producers (IPPs) was first considered in Tanzania during its energy sector reform in the beginning of the nineties. IPPs are intended to relieve state utilities of the burden of financing new plants, bring quick, quality power and reduce costs for end-users[70].

Tanzania has developed two main IPPs over the last decade: Songas and IPTL. Together, they have an installed capacity of almost 300 MW, which is about one third of the country's present generation capacity. The IPPs are hence contributing greatly to Tanzania's electricity generation, but they have also turned out to be very costly. TANESCO currently pays more than 50% of its revenue towards combined fuel and capacity charges for the IPPs[71].

Independent Power Tanzania

Independent Power Tanzania Limited (IPTL) was the first IPP to begin selling electricity to TANESCO under a 20 years Power Purchase Agreement (PPA). The project consists of a 100 MW diesel generator plant, which presently runs on imported heavy fuel oil (HFO).

Discussions are currently under-way for a buy-out arrangement of the power plant by the Government of Tanzania (GoT). Meanwhile, plans are to convert the plant from oil usage to a domestic gas operated facility. Costs for eventual conversion are estimated to be about USD 21.7 million[72].

According to the PPA with IPTL, TANESCO has to pay a capacity charge of USD 42.6 million per year as well as fuel costs for the generated electricity.

Songas

Songas, Tanzania's second IPP, commenced operations in July 2004 and consist of a 190 MW natural gas-fired plant at Ubungo, Dar es Salaam, which is run on natural gas sourced from the domestic off-shore Songo-Songo gas field. TANESCO has a 20 year PPA arrangement with Songas. The PPA consists of a capacity charge averaging USD 4.4 million per month, depending on the available capacity in one particular month, and an energy charge of US cent 4.9 per kWh.

Figure 19: Gas Turbines at Ubungo[73]

[70] Gratwick, Ghanadan & Eberhard (2006), p.8
[71] Gratwick, Ghanadan & Eberhard (2006), p.8
[72] Correspondence with TANESCO
[73] Songas, 30.08.2007

5.2 Future Demand and Investment Options

5.2.1 Future Electricity Demand

Tanzania is a country where only a small portion of the population is connected to the electricity network. Overall, the connection rate is less than 10%, and in rural areas less than 2%. In some of TANESCO's distribution areas, which are supplied only by costly diesel generators, the cost of production is higher than the revenue from sales, which makes it unattractive for TANESCO to connect more customers. In summary, there are a large number of potential customers which would like to be connected to the network. It is the task of TANESCO to find means to expand the network and add generation facilities in order to provide these services.

In the following, two scenarios for future electricity demand are presented. The first one, used in the *PSMP*, is the more traditional method of applying statistical methods to growth, assuming more or less "business as usual". The second one, represented by TANESCO's financial recovery plan of 2006, takes a much more ambitious approach, assuming that the actual demand would allow TANESCO to expand much more rapidly, provided that adequate resources in the form of financing and technical resources are made available.

For the preparation of its *PSMP (2003)*, TANESCO uses a forecast model which utilizes historical data on electricity sales, tariff levels, electricity generation, system losses and Gross Domestic Product (GDP) to perform regression analysis to establish the relationship between the electricity consumption and changes in electricity prices and GDP growth. The forecasts are broken down on the main consumer categories i.e. general use (residential, light industrial and light commercial), industrial sales, public lighting and bulk sales to Zanzibar. Special consideration is taken to the mining sector, as in recent years, the mining sector has recorded high growth. Much of the mining load is currently met by isolated diesel units.

In the preparation of the *EAPMP (2004)*, three demand forecasts (low, reference, and high) were developed by TANESCO. They were based on an annual GDP growth of 3.5%, 5% and 5.9% respectively. All scenarios assumed a 5% annual growth in number of customers, but differed in the growth of specific energy consumption by customer and by industrial development, in particular the connection of mines.

The three scenarios for the load development in Tanzania over the period 2001 to 2024, according to the *EAPMP* are shown in the figure below. In all cases exports to Kenya have been excluded. The forecasted energy consumption in 2025 ranges between 6 300 GWh and 11 300 GWh, corresponding to a maximum load of about 1 100 MW to 2 000 MW. Over the period technical losses are assumed to be reduced to 7.5% and non-technical losses to 6.5% of electricity generated.

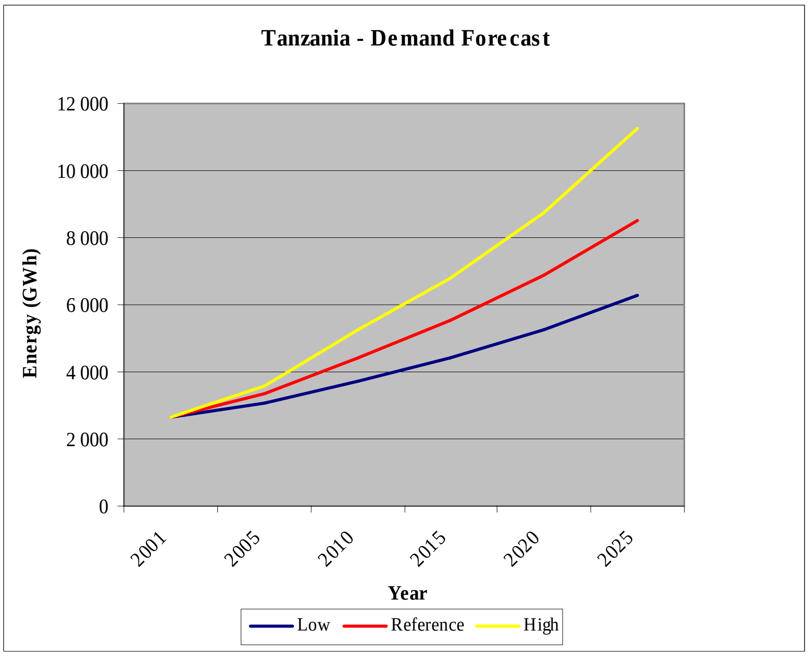

Figure 20: Demand Forecast – 3 Scenarios of *EAPMP*

In TANESCO's *FRP (2006)*[74], a significant higher demand forecast has been assumed with total annual growth averaging 15% and a connection of 100 000 new customers yearly. Historically, because of limited resources, TANESCO has only been able to connect about 30 000 new customers per year. During the years 2002 to 2005, TANESCO received about 17 000 service line applications per month, but was only able to connect about 2 500 customers per month[75]. Consequently there is a substantial back-log.

The assumed sale for the period 2007 to 2010, according to the *FRP*, is shown in the following table. The year 2006 is included for comparison:

Table 6: Expected Future Energy Sales

	2006	2007	2008	2009	2010
Sale of energy MTsh	225 259	313 595	444 471	572 774	666 162
Exchange rate TSh/USD	1 174	1 303	1 334	1 366	1 400
Sale of energy MUSD	191,8	240,7	333,2	419,3	475,8
Sales (GWh)	2 900	3 217	4 220	4 982	5 404
Growth	8,00%	10,90%	31,20%	18,10%	8,50%
Average tariff USc/kWh	6,6	7,5	7,9	8,4	8,8

The energy consumption forecasts have to be converted to energy generation requirements on the basis of projected losses in the transmission and distribution systems. It is foreseen both in the *EAPMP* and the *FRP* that total system losses should eventually be reduced to a level of about 14%.

[74] TANESCO FRP (2006)
[75] Ghanadan & Eberhard (2007), p.33

5.2.2 Candidate Plants for Increased Generation

The current mix of generation facilities was described in section 5.1.4. This subsection provides a brief description of generation projects available to meet the future net energy generation requirements. The candidate plants are described based on available sources with their assumed capital and operating costs and characteristics.

Hydro Power Plants

Hydro power plants are characterized by high capital cost and low operating costs. They have no associated fuel cost, and is therefore insensitive to oil price fluctuations. Fully utilized they provide electricity at a low cost. The weakness of a hydro power plant is in the variability of the hydrology. Forecasted hydrology in the study area has a significant effect on the forecasted generation output from hydro power.

A number of candidate hydro-power schemes are described in the *EAPMP*. They were, at the time of preparation of the *EAPMP* at various stages of development ranging from outline concepts to completed designs. Other projects were deemed to be either too small for inclusion in the study or unlikely to proceed due to environmental constraints. The projects considered are listed in Table 7 below along with the capital costs in 2004 values and annual energy generation as well as an estimate of the number of months required to reach commissioning of the project following a decision to proceed.

Construction costs are based on the estimated values of the implementation contracts at the time of award. No allowance has been included for interest during construction or for any other financing costs. Taxes and duties are excluded. Cost escalation during the construction period has also been excluded. The foreign cost component is estimated at 80%.

Estimated environmental mitigation costs are also shown in the table. The *EAPMP* study concludes that "these cost estimates may be expected to be on the low side owing to either increasingly stringent requirement of funding agencies since studies were originally done, or because of greater attention now being given to these practices".

Table 7 Candidate Hydro Projects

Project	Installed Capacity MW	Average Annual Energy GWh	Lead Time Years	Capital Costs MUSD	Environmental Costs MUSD
Upper Kihansi			6	81,2	4,2
Mpanga	144	1 028	8	190,8	7,2
Masigira	118	695	7	157,0	4,9
Ruhudji	358	1 930	8	384,0	5,3
Rumakali	222	1 141	10	351,3	10,1
Mandera	21	149	5	42,1	1,4
Stiegler's Gorge	1 200	6 203	23	1 068	Not recomm-ended

In the *EAPMP* it is also indicated that the Ruhudji project and the Rumakali project were the most attractive. These were then studied to feasibility level. The Ruhudji hydropower scheme would be located on the Ruhudji River some 75 km south-east of Njombe. The project was studied to feasibility level and was reported in May 1998. The proposed design included the Zanziberi storage dam. The

Rumakali hydroelectric project would be located on the Rumakali River some 85 km west of Njombe in the Iringa Region, and some 20 km to the north of Lake Malawi. These two plants are the ones included in TANESCO's current capital investment plan.

Thermal Plants

A thermal plant is based on a combustible fuel, such as coal, biomass, oil or natural gas. A significant influence on the choice of any specific thermal power plant is the reliability, the capital cost, the fuel price and the efficiency. Due consideration should be taken of both the indirect and direct environmental effects and, where appropriate, suitable mitigation measures should be put in place.

Base-load plants are plants with high investment cost and low fuel costs, which operate at high load factors. A coal fired plant, which drives a steam turbine for the generation of electricity, is a typical base-load plant. Two examples of such plants are Kiwira and Mchuchuma.

- For the Kiwira coal fired plant, very limited information is available. It currently delivers about 6 MW of power. Capital costs for a 200 MW plant have been indicated as USD 272 million. TANESCO is assumed to buy power under a power purchase agreement (signed in 2006) with monthly capacity charges of USD 6 million per month[76]. 50 MW would be available in 2007, and an additional 150 MW in 2009.

- The proposed Mchuchuma coal fired plant is discussed in *Kömnevik*[77] and *EAPMP*. The project is proposed as a 400 MW mine-mouth plant, with pulverized coal firing, fed from an opencast mine. The capital cost, including desulphurization but excluding transmission line, upgrading of roads and mine development, was reported in EAPMP as USD 452 million in 2004, figure based on supplier information. Additional costs would be transmission USD 110 million, mine development USD 100 million, and access roads USD 75 million. The plant would be developed in two stages of 200 MW each. The price of coal from Mchuchuma has been estimated at USD 1.27 per GJ[78].

Plants for peak load and reserve, which operate at low load factors, are usually characterized by low investment cost and higher fuel costs. Typical examples are diesel generators (a diesel engine and an electric generator) using oil or natural gas as fuel, or gas turbines, which use natural gas or very light petroleum fuels (e.g. JET fuel). Examples of diesel generators are Aggreko plant, and Ubungo, Mwanza and Tegeta rented diesels. Examples of gas turbine plants are Songas and Dowans. Basically, the only plants suitable for emergency situations are diesel plants and gas turbines, as they can be quickly transported to the site.

[76] This Day, 10.08.2007
[77] Kömnevik (2004), p.28
[78] EAPMP (2004)

Emergency diesel plant which is containerized and capable of being readily shipped is generally only available as high speed diesels. These plants have lower efficiencies and lower specific capital costs than low or medium speed diesel plants, and also have a shorter operating life. Emergency plants provided by Aggreko is of this type, see Figure 21 for a typical installation. As the unit sizes are normally in the order of 1-2 MW, a large number of individual plants need to be installed to allow a firm delivery of 50 or 100 MW.

Figure 21: Aggreko Diesel Plant

Medium or low speed diesel plats are normally installed on a more permanent basis. The IPTL installation consists of 10 x 10 MW of diesel plants able to operate on heavy fuel oil. However, as indigenous natural gas is less expensive fuel than oil, TANESCO is interested in converting the plant to run on gas, a conversion that is estimated to cost about USD 22 million.

Aero derivative gas turbines, which are used in Tanzania, are based on jet engine technology, with a light construction, high efficiency and frequent service intervals. Unit sizes up to 20 MW are available in containerized form, suitable for emergency plant. The rented Dowans plant and Songas use simple cycle gas turbine technology. In a combined cycle gas turbine, the exhaust gas from the gas turbine drives a steam turbine, which increases the efficiency. Although there have been discussions in Tanzania to introduce this technology, it is not reflected in any of the plans reviewed.

The characteristics of thermal plant, shown in Table 8 below, are based on the *EAPMP*. Only plants of the type interesting for Tanzania are included below. Capital costs have been updated, based on *PPA (2006)*, to reflect 2006 price level.

Table 8 Thermal Plant Types and Characteristics (average values)

Plant Type	Fuel Type	Heat rate (kJ/kWh)	Capital Cost $/kW	O&M cost $/kW	O&M cost $/kWh	Emissions TonneCO$_2$/ GWh
Diesel generator (medium speed)	IDO	8 450	1 300	35	0.013	690
Coal Fired/ Steam Turbine	COAL	11 100	2 300	45	0.0066	1 100
Gas Turbine/ Simple Cycle	GAS	11 600	930	12	0.006	675
Gas Turbine/ Combined Cycle	GAS	8 000	1 600	6.5	0.006	450

Notes:

1. Fuel Type: IDO= industrial diesel oil, HFO= heavy fuel oil. Oil prices are discussed in section 0. The financial cost of natural gas to be delivered to Dar-es-Salaam has been estimated at USD 3 per GJ;
2. Heat rates (kJ of fuel per kWh of electricity generated) are based on the higher (calorimetric) heating value (HHF) of the fuel.
3. Operating and maintenance costs (excluding fuel) are generic in nature. Fixed costs are costs attributable to each plant regardless of the energy produced. The variable costs are those cost (excluding fuel) directly associated with the energy produced.
4. Carbon Oxide Emission. Under the Kyoto protocol, which aims to limit and reduce the levels of CO_2 emissions to the atmosphere, there are provisions for developing countries to monetize CO_2 credits. A value of USD 10 per tonne was used in the *EAPMP*.

The *PSMP (2003)* indicates the following plants, and their intended date of commissioning. The following table summarizes the plants included in TANESCO's capital investment plan, *CIP (2006)*[79]:

Table 9 Total Generation Investment Plan

Plant	Capacity (MW)	Type	Estimated Project Cost (MUSD)	Expected date of commissioning
Mwanza, ALSTOM (rented)	40		150	June 2007
Ubungo, Dowans (rented)	80		133 (173 bn Tsh)	June 2007
Ubungo, Wärtsilä	100		83 (58 M€)	September 2007
Tegeta, Wärtsilä	45		44 (31 M€)	December 2007
Kiwira I	50	Coal	63	December 2007
Kiwira II	150	Coal	187	2009
Kinyerezi	200	Gas	146 (190 bn Tsh)	2009
Zambia-Tanzania	200	Interconnector	168	2010
Ruhudji	358	Hydro Power	401	2012
Mchuchuma I	200	Coal	202	2018
Mchuchuma II	200	Coal	177	2022
Rumakali	222	Hydro Power	338	2022
Total Increase in Capacity	**1 845**		**2 092**	

1 USD = 1,300 TSh, 1USD = 0.7€

5.2.3 Expansion of Transmission and Distribution Systems

In the *EAPMP (2004)*, three main scenarios were developed, which differ in terms of interconnection and trade with neighboring countries, in particular Zambia, Kenya and Uganda. The three scenarios are:

- The reference scenario, which assumes that the three systems develop independently and that there will be no additional trade amongst the three member countries;

- The trade scenario[80], which considers that there would be bilateral or trilateral trade amongst Tanzania, Kenya and Uganda and with Zambia.

- Integrated operation scenario, which a further step of mutual assistance to be taken in system operations, eventually leading to sharing arrangements and integrated planning and operations.

The following table, based on *PSMP*, shows major planned transmission lines, their timing, and estimated investment cost.

[79] TANESCO Database

[80] *The trade scenario could include sending hydro based generation produced in Uganda to Kenya or Tanzania, sending generation from Tanzania into Kenya, importing of power from Zambia to supply Tanzania and/or Kenya.*

Table 10: Investment Plan in Transmission System

Transmission System Additions	Year	Distance (KM)	Cost (MUSD)
132 kV Kinyerezi – Factory Zone III	2005	22	5,45
220kV Mtera – Dodoma -Singida – Shinyanga (Line II)	2007	669	82,14
220 kV Shinyanga – Mwanza	2010	139	17,5
330 kV Mbeya– Singida	2010	487	82,79
330 kV Singida – Arusha	2012	316	53,72
220 kV Iringa – Mtera	2017		17,5
220 kV Ruhudji – Mufindi – Kihansi	2016	200	28,85
220 kV Ruhudji – Kihansi	2016	150	21,91
220 kV Kidatu – Morogoro – Ubungo	2010	310	76,88
220 kV Mchuchuma - Mufindi	2022	283	67,7
220 kV Mchuchuma - Mufindi 2nd circuit	2024	283	45,1
220 kV Rumakali – Mbeya	2027	85	11,86
220 kV Rumakali – Mufindi	2027	2 x 134	33,91

The estimated investment costs related to additional transmission were estimated at USD 490 million, excluding the 330kV line Arusha – Embakasi needed for the trade scenario.

The *EAPMP* did not look at distribution, as this was not considered necessary for making conclusion about the most favorable generation and transmission system for the three countries involved. Commonly the investment required in distribution is compliant with the number of new customers to be connected.

In 2005, TANESCO estimated the investments necessary to sustain a 5-year program for increasing the number of customers from 560 000 to 1 030 000 as follows[81]:

Transmission: USD 280 million or USD 600 per new customer
Distribution: USD 240 million or USD 500 per new customer

In *TANESCO's FRP*, the following investment plan for transmission and distribution is indicated for the years 2007 to 2010. Many of these investments are for reinforcement of the existing system, which is in a poor state due to several years of underinvestment:

Table 11: Capital Investment Plan in *FRP*

TANESCO Capital Investment Plan (All Values in USD)	**YTD**	**2007**	**2008**	**2009**	**2010**
Transmission	29 927 244	181 267 475	206 940 525	76 771 496	8 471 122
Distribution	24 960 540	64 783 819	88 800 634	88 244 679	59 633 264
Rural Electrification	0	61 999 708	85 591 169	83 346 060	57 485 350

[81] TANESCO Presentation (May 2005)

5.2.4 Economic Life Time of Investments

Due to degrading etc. of equipment it is necessary to account for depreciation on investment. In *EAPMP* the economic life of the different plant types considered as generation resources are assumed as in Table 12.

Table 12: Economic Life for Capital Investment

Plant Type	Economic Life (Years)
Hydro	50
Coal Steam	25
Gas Turbine	20
Oil Steam	25
Low Speed Diesel	25
Transmission	30
Distribution	30

5.2.5 Plans to Interconnect Zambia and Tanzania[82]

A power interconnection from Zambia to Tanzania has been considered many times over the last 10-15 years. Previously, Zambia experienced a considerable energy surplus which was exported to Zimbabwe. With the interconnection of the Zimbabwean grid to South Africa via Botswana, a regional power market was established, the Southern African Power Pool (SAPP). This system is now experiencing a power deficit; therefore, tapping into the Zambian system may not be such an attractive option any more. TANESCO and the other utilities in the region are still pursuing the project though, with a possible interconnection to Kenya as well as Zambia.

Any significant power exchanges between Zambia, Tanzania and Kenya, i.e. exchanges in the range of a few hundred MW, would require not only the construction of a long transmission lines from country to country, but also substantial investments within Tanzania. The timing of such projects is therefore naturally uncertain. In a feasibility study, the investment cost for the first phase, a 200MW power transfer, was estimated at USD 326 million[83]. The second stage, increasing the capacity to 400MW was estimated at 240 million USD.

5.3 TANESCO's Financial Situation

Increasing generation costs, supply shortfalls and load shedding have put TANESCO in an extremely weak financial position. The current cost of supply to final consumers for TANESCO is TSh 118 per kWh,[84] and the average tariffs charged are around TSh 80 per kWh. Consequently, TANESCO looses, on average, about TSh 38 on every kWh sold[85]. Hence the tariffs are not cost reflective.

5.3.1 TANESCO's Financial Recovery Plan

On February 3, 2007, the Cabinet approved the TANESCO Financial Recovery Plan, which has the objective to restore complete financial sustainability of TANESCO. The first 6% tariff increase has been implemented. The government has also committed that over the next 9 months, TANESCO will improve its power sales revenues by at least 15%. It is expected that TANESCO will file for a tariff increase in the range of 15-20% to EWURA in July 2007. For the long-term, once financial recovery level is achieved, it is expected that a reliable mechanism for tariff adjustment, such as multiyear tariffs, will be put in place to ensure sustainability of TANESCO's financial recovery.

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[82] SWECO & Norconsult (2007)
[83] Scott Wilson Piésold (2003)
[84] *Exchange rate: 1251 TSH/USD, August 9, 2007*
[85] The World Bank (2007), II, p. 19

5.3.2 Financial Statement

Profit and loss statements for the years 2006 to 2010 included in the *FRP* is shown below:

Table 13: Profit and Loss Statement[86]

Profit And Loss Statement (Million TSh, Current Prices)

	2006	2007	2008	2009	2010
Revenue					
Sale of Energy	225,259	313,595	444,471	571,774	666,162
Government Subsidies	5,250	102,694	77,436	-	-
Other Income	10,220	6,061	6,061	6,061	6,061
Total Operating Income	240,729	422,350	527,968	577,835	672,223
Operating Costs					
Power Purchases & Imports					
IPP Energy	104,748	22,076	33,564	38,537	39,967
IPP Capacity	104,544	67,619	58,919	56,885	54,704
Imports	4,853	5,607	6,478	7,485	8,648
Fuel	27,433	31,987	37,297	43,488	50,708
Thermal Plants New	14,521	209,121	189,088	124,053	156,926
Payroll	54,720	62,928	71,738	81,064	91,602
Repairs and Maintenance	15,500	16,500	17,325	18,191	19,101
Transport and Travel	8,171	8,580	9,009	9,459	9,932
Administration and Overheads	20,411	21,281	22,195	23,155	24,163
Efficiency Improvements	7,680	15,980	17,030	14,780	11,030
Depreciation	31,437	37,230	66,979	84,633	75,203
Bad Debts	7,686	12,258	13,350	16,387	16,754
Obsolete Stock	478	457	568	653	688
Total Operating Costs	402,183	511,623	543,540	518,771	559,425
Surplus Operating Income	-161,454	-89,273	-15,572	59,064	112,798
Finance Charges					
Interest on O/D's	5,664	580	-	-	-
Interest on loans	2,363	27,664	17,468	4,792	10,831
Total Finance Charges	8,027	28,243	17,468	4,792	10,831
Non Operating Income	-	-	-	-	-
Profit Before Tax	-169,481	-117,516	-33,039	54,271	101,967
Corporate tax	-	-	-	-	-
Profit After Tax	-169,481	-117,516	-33,039	54,271	101,967

In the table, figures from 2006 are real values, while the next years are an estimate.

5.3.3 Financing of Investments[87]

In the state budget for 2007/2008, TANESCO's investment needs, only in order to rehabilitate transmission and distribution lines over a five-year period, is indicated as USD 1 300 million. USD 100 million is expected from the World Bank in order to upgrade the distribution network in three main urban areas – Dar es Salaam, Arusha and Kilimanjaro, which account for the majority of TANESCO's revenues.The planed investment in generation, transmission and distribution facilities though need to be funded. Funds available consists of public, private, bilateral, donor and own funds.

The *FRP* allows for funding of investment (contributed as equity) by the government of Tanzania (GoT) for year 2007, 2008 and 2009. The rest is assumed to be financed through donor funding, customer contributions, new loans and operational surpluses. The *FRP* assumes that the contribution from GoT will be a grant and therefore treated as equity. The same applies for all donor funding, as well as funds from the World Bank. There is therefore no on-lending to TANESCO in these cases.

The FRP also assumes loans for investments with repayment periods of 15 years, interest rates of 7.5%, and no grace periods.

[86] TANESCO FRP (2006), p. 13
[87] TANESCO FRP (2006)

For cash deficits, financial assistance can be provided in the form of bridging finance by the GoT, a bank overdraft guaranteed by the GoT, or a short/medium term (6 year) loan from commercial institutions.

6. Analytical Tools

This chapter describes the analytical tools used to perform the analysis. These include a financial Excel model, created by the author and a software program called @Risk, which is combined with the financial Excel model. The chapter briefly describes characteristics and logics of these tools.

6.1 Introduction

In order to perform the analysis, a financial risk analysis model will be developed and used, a model which has the ability to simulate the influence of a set of key variables, over which the system owner has no influence, but whose variability can somehow be estimated statistically. The financial risk analysis model is a combination of the two analytical tools described further in this chapter.

For a given investment program, the model will calculate the probability distribution of some financial indicators, e.g. the net present value (NPV). The NPV will be calculated based on the firms discounted cash flow. The risk analysis will be applied on the power system operated by the major power utility in Tanzania, the parastatal company TANESCO. The model is also able to indicate e.g. what tariff level is required to fully cover capital and operating costs.

6.2 Financial Excel Model

For the analysis of the selected case, a financial model has been developed with Microsoft Excel, and is used as a tool to calculate financial indicators, taking the variation of a number of risk variables into consideration. Based on general assumptions and data derived from the empirical research, the financial viability of the proposed investment program can be determined. The model structure follows closely the logistics of TANESCO's Business Planning Framework, which is described more in detail below. The result is presented in the form of key financial indicators as well as the project's cash flow statement.

In the following section, the concept, as well as steps of the process using the Excel-model is described. The purpose of the model is to provide the user with a tool, which incorporates the results of the research, is easy to use, and which presents the resulting output in an uniformed way.

6.2.1 Business Planning Framework of TANESCO

The economic planning framework, which is used by TANESCO, is shown in Figure 22 below. The planning starts with assumptions about the future demand for electricity services, which is known to have grown at a high rate in recent years. In order to meet this growing demand, TANESCO must invest in new generation as well as new transmission lines (TX) and distribution lines (DX). TANESCO may also need to reinvest in order to maintain its existing assets in good shape. These investments can be financed by TANESCO in different ways, from its own funds, by equity contributions or by lending.

For new generation, an alternative is to buy power from an independent power producer. Total expenditures include operating costs such as staff costs, maintenance costs, fuel costs, and costs for buying power. Revenues are generated mainly from selling electricity at an agreed and approved tariff but there is also some income from charges applied for connecting customers. An important result of the economic analysis is the cash flow statement, which can be used for determining how profitable the company and its investments are, whether tariffs applied are sufficient, etc. This is usually summarised by using various indicators such as net present value, internal financial rate of return, and others.

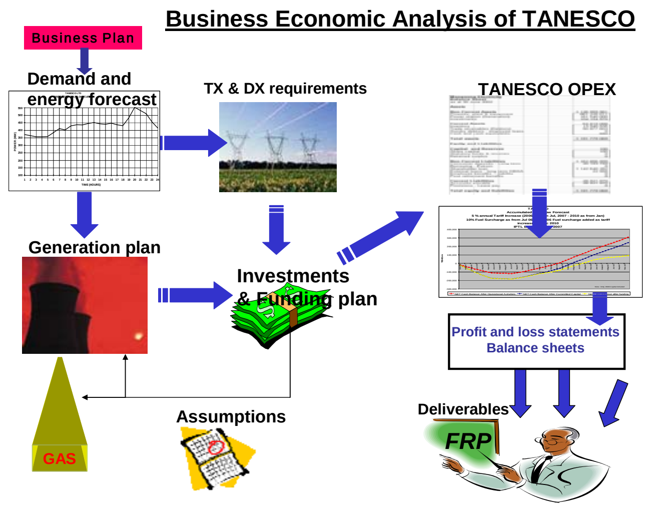


Figure 22: TANESCO's Business Planning Framework

6.2.2 General Model Characteristics

The model consists of three main parts for different types of data namely input, calculation and output. All calculations are made in real terms over a period of 20 years.

Input data and assumptions are entered in the input sheets. The input sheets are structured to correspond to the planning framework described above and include input such as future demand and losses, tariffs, existing generation facilities, investment plan for new generation plant including costs, fuel prices and heat rates for each category of generation plant. Further, proposed funding plans for the investments can be entered, i.e. allocation to loans or internal funds.

These input sheets are followed by several sheets performing different types of calculations:

- ***Demand –*** The starting point for the demand forecast is the number of customers and the demand for the year 2006, and an assumed annual increase of consumption as well as a growth factor for the number of customers. Thereafter, the future demand is calculated for each year of analysis. This is the amount energy that needs to be supplied in order to meet the demand of the customers. However, both technical and non-technical losses have to be considered. After adding losses to the demand, the model arrives at the required energy to be supplied. This is the energy that should be met by the energy generated.

- ***Investment –*** Proposed new investment in generation units; transmission and distribution are defined in the input sheets. The investment chosen to be integrated in the financial analysis can be selected and are easily changed so that the investment plan matches the required demand. Additional investment in the transmission and distribution system depends on expected number of new connections each year. Investment expenses are summarised to an annual cash flow amount. Depreciation, although not a cash flow item, is calculated to produce investment salvage value at the end of the calculation, and is also necessary if corporate taxes are to be calculated. Straight line depreciation is considered, using the number of years for depreciation period as specified for each investment.

- ***Capacity –*** The total capacity of the proposed as well as existing generation plants is calculated. Plant capacity is also calculated for each category of generation units, i.e. hydro power, coal, diesel generators fuelled with natural gas, gas turbines, diesel generators fuelled with imported oil, for each year of analysis. Interconnection to other countries is included as one category.

- ***Generation –*** In order to arrive at the actual energy generated from each category of generation plant, an annual load curve is used as shown in the figure below. This step is essential since the load is not evenly distributed over a year. Therefore, full capacity is not required every hour. For each year of analysis, the generated energy of each generation category is adjusted to fit the load curve in order to meet the expected demand. It should be pointed out that the expected amount of hydro power output for each year will form the basis for the calculation. The order of merit is the categories with least generation costs, with hydro power in the bottom. It might occur that the proposed generation plan does not fulfil the expected demand of electricity, leaving a part of required demand as unserved.

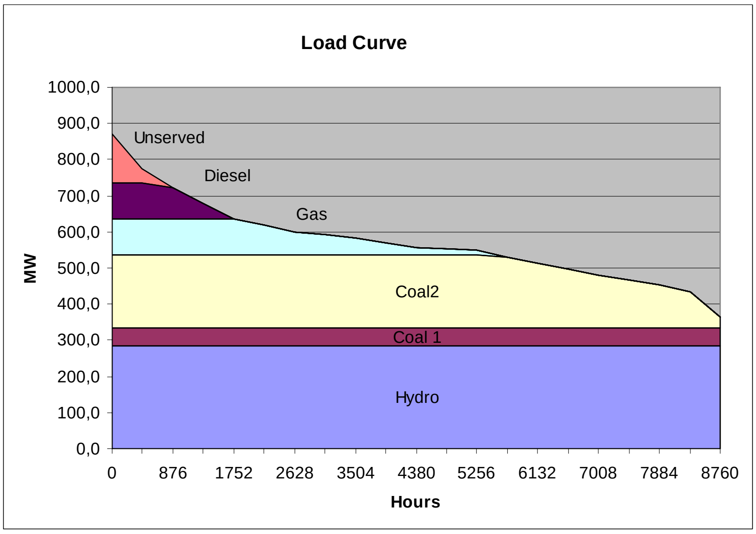


Figure 23: Example of a Load Curve for Tanzania's Power System

- ***Operating Costs –*** Based on the determined generation for each generation category and the fuel price specified for each type as well as a heat rate, indicating the required fuel per energy unit generated, fuel costs are calculated. Moreover, a fixed capacity cost and a variable operating cost for each generation category are assumed. These costs, in addition to possible leasing costs as well as TANESCO administration costs and operating and maintenance cost for existing plants, represent the total operating costs.

- ***Revenues –*** Following the determined generation, the revenue of electricity sales can be calculated. However, revenues will only be accounted for actual served demand. The demand may be split into several tariff categories, i.e. general usage, low voltage, high voltage and public lighting. Additional revenues arise from connection charges as well as monthly service charges. The collection rate is defined as the percentage of revenue actually collected for the energy supplied, excluding bills that were not paid.

- ***Financing –*** In the model, the financing of the investment cost can be allocated to loans, own funds and grants. The financing is assumed to cover all investment costs related to the planned extension of the system. The own funds will be the balance assumed to be financed by the Government of Tanzania at a long-term sovereign risk rate. As for the borrowed capital, different loan conditions may apply.

6.2.3 General Model Outputs

The financial model generates both the income statement and the cash flow statement and several financial indicators, in order to describe the expected financial performance of the investments.

- ***Income Statement –*** The income statement presents the annual profit over the period of analysis and includes depreciation, financing costs and taxes.

- ***Cash Flow Statement –*** This statement shows the cash flow, which includes the quantified costs and revenues over the period of analysis. The cash flow statement consists of tree main parts: the cash flow from operating activities, from investment activities and from financing activities. The cash flow statement determines the ability to pay the debt service, operating and maintenance cost streams and brings out any cash flow deficits which may arise. In evaluating the cash flow, all expenditures such as debt service operation and maintenance, income from sale of electricity are lumped into end of year's payments. Ideally the net cash flow should be positive; otherwise short-term loans may have to be used to cover these deficits.

- ***Financial Indicators –*** The financial model generates the Present Value (PV) for operating activities, investment activities and financing activities and the total NPV of the Investments. The NPV summarises the discounted cash flow both before and after financing.

- ***Unserved Energy –*** The model determines the amount of unserved energy for each year, based on the assumed demand growth and output from the generation facilities. The unserved energy is summarised for the total period of analysis. A fictive cost for the unserved energy is defined as output in the model as well.

6.3 @ Risk 4.5 for Excel

In order to apply a quantitative risk analysis to the financial model, a risk analysis tool has been used. @Risk is a risk analysis and simulation add-in for Microsoft Excel, consequently integrated in the Excel spreadsheet via a new toolbar. The @Risk techniques allow for analysing spreadsheets for risk. Risk analysis identifies the range of possible outcomes that can be expected for a spreadsheet result and their relative likelihood for occurrence. In this specific case the spreadsheet will consist of the financial model described above. Following the theoretical framework for performing risk analysis the @Risk program is used as a tool for certain steps in the process.

@Risk has been chosen for the following reasons:

- It provides the required techniques in order to perform the risk analysis in this thesis
- It is applicable to Excel, which is of advantage since the financial model consists of excel spreadsheets
- It is simple
- It costs less than comparable tools for quantitative risk analyses

Define Probability Distribution

When certain risk variables in an Excel model are identified, the variation of each variable can be represented by a probability distribution, which quantifies the risk of each variable. These probability distributions can be defined using @Risk which offers a selection of 30 different types. The variety of distribution types range from uniform and triangular distributions to more complex forms such as gamma and weibull. All distribution types use a set of arguments to specify a range of actual values and distribution of probabilities; these define the shape and range for the distribution. The normal distribution, for example, uses a mean and standard deviation as its arguments. The @Risk Define Distribution window presents a graphically preview of the distributions in order to assign them to uncertain values, an example is shown in Figure 24.

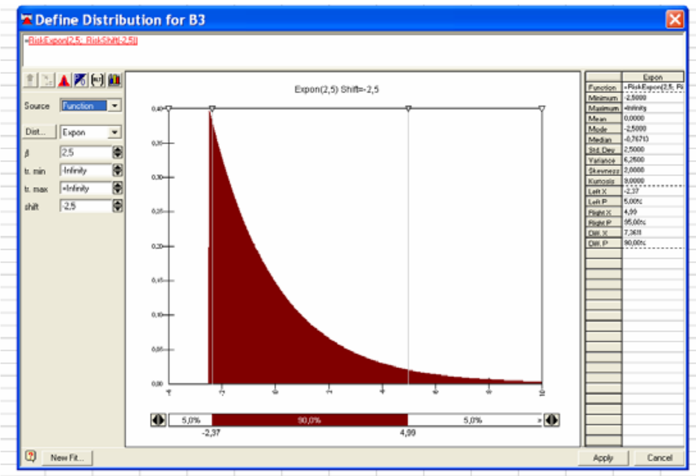


Figure 24: Example of defining an exponential distribution with @Risk

Distribution Fitting

With help of @Risk it is possible to fit probability distributions to historical data. Fitting is done with a set of collected data that will be used as the basis for an input distribution in the spreadsheet. Three kinds of data can be used for distribution fitting: sample, density and cumulative. Further the data can be both continuous and discrete. For each of the distribution specified in @Risk, the program will try to find the set of parameters that make the closet match between the distribution function and the collected data set.

@Risk uses two methods to calculate the best distribution for the collected data. For sample data, distribution parameters are estimated using Maximum Likelihood Estimators (MLEs). For density and cumulative used to minimise the root-mean square error between the curve points and the theoretical points. This analysis is restricted to sample data of risk variable and therefore only the former technique is described in chapter 3.

Several techniques are use to interpret the results. These are described in chapter 3 as well.

Correlation

Correlation between input variables is specified through correlation matrices. @Risk takes the correlation into account during a simulation. If a negative correlation is specified between two variables, the second variable will receive a high value if the first variable receives a low value.

Defining Simulations Outputs

Before starting a simulation, one or several output cell shall be defined. These will be the variables that present the result of the model. In this case, for example the NPV and the cash flow. These output values are best described graphically. @Risk also performs sensitivity and scenario analysis reports, which identifies the input distributions most critical to the results.

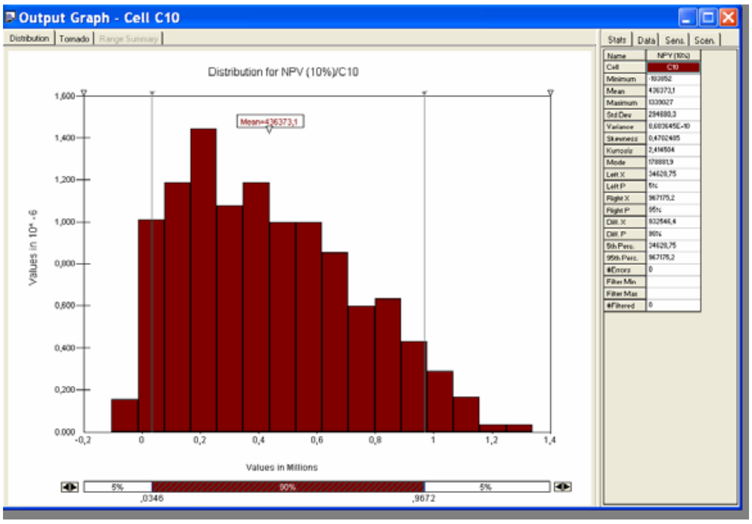


Figure 25: Example of Distribution of an Output Cell

Simulation Technique

@Risk uses a technique known as Monte Carlo Simulation. Simulation in this sense refers to a method whereby the distribution of possible outcomes is generated by letting a computer recalculate the spreadsheet over and over again, each time using different randomly selected sets of values for the probability distributions in the cell values and formulas. In effect, the computer is trying all valid combinations of the values of input variables to simulate all possible outcomes.

Stress Analysis

In order to analyse and interpret the result of the risk analysis, @Risk provides a technique of stressing risk variables. The technique states different criteria for the risk variables, such as testing the effects of applying extreme values of the distribution function etc. Multiple risk variables can be tested simultaneously.

6.4 Model Delimitations

Considering the complexity of making a complete analysis of the investment program of a major power utility, this study has many limitations with regard to the details that a utility may require.

On the technical side, some of the data has been aggregated to simplify the model. Demand is not broken down on customer categories, but treated as one variable. The various plants that generate electricity on the system have been aggregated into generic categories (hydro, gas fired turbines, oil fired diesel generators etc.) and are not treated as individual plants. There is a simplified allocation of generating plants to satisfy the load under the daily and annual load curves. However, since the objective of the master thesis is to demonstrate the financial risk analysis model, these simplifications on the technical side should be fully acceptable.

The financial calculations are limited to work on the cash flow before financing, with NPV calculated based on an assumed discount rate. Although this is the recommended first step of an investment analysis, it would also have been interesting, as a second step, to calculate NPV with a realistic financing alternative included. Because of the weak financial situation of the firm, as described in the report and without a realistic financial recovery plan at the time of writing this thesis, this was not considered meaningful. As the company will not be making a profit with the assumed tariff, corporate taxes have not been considered when determining the cash flow. There was also some uncertainty regarding the balance sheet for the first year, detailed conditions of the power purchase agreements and the exact conditions that apply to loans taken by the company, which should be clarified before realistic financial statements can be produced. For this reason, the results should be taken as indicative only.

The analysis further does not consider the possibility of carbon financing or carbon emission taxes, as this is not yet well developed in Africa. This is otherwise a factor that should be considered in energy sector investment analysis.

7. Analysis and Results – Evaluation of Risk Variables

The analysis and results are separated into three chapters. The following chapter comprises the analysis of the identified risk variables, based on the theoretical framework, supported by the analytical tool @Risk. In the analysis a distribution function for each risk variable is defined and evaluated. The chapter further includes a description of how the variables are implemented in the financial model.

7.1 Identification of Risk Variables

When compiling the empirical data for the case study, all input variables were evaluated in terms of uncertainty, and three key risk variables were identified as being the most crucial for the case i.e. (i) the future crude oil price, (ii) the hydrology of major river basins and (iii) the expected annual increase in electricity demand. These variables are considered to have an unknown future outcome but are expected to affect the investment program's return greatly. It should be pointed out that the case involves many other uncertainties, however, in order to keep the analysis simple; the valuated risk variables are limited to three. Examples of other risk variables that might have been relevant for the case studied are capital costs, foreign exchange rate, inflation rates etc.

7.2 Fuel prices

7.2.1 Characteristics

Tanzania has not yet any commercially exploited oil resources and is hence an oil-importing country with the nearest source of petroleum fuel available is in the Arabian Gulf. As a low-income oil importer, Tanzania's economy is highly sensitive to sharp rises of oil prices. For the energy sector this will subsequently have several effects. Firstly, high oil prices will imply higher generation costs for thermal power plants that run on oil fuels. Secondly, high oil prices will have effects on the overall national economy, resulting in a decrease in GDP which might lead to a decrease in demand for electricity.

Crude oil prices behave much as any other commodity with wide price swings in times of shortage or oversupply. The crude oil price cycle may extend over several years responding to changes in demand as well as OPEC and non-OPEC supply.

Crude oil prices are defined as a risk variable in the risk assessment and are analysed in the following.

7.2.2 Assembling data

Data collected for historical oil prices derives from *"BP - Statistical Review of World Energy 2007"*. The following figure details oil prices in 2006 dollar terms from 1861-2006.

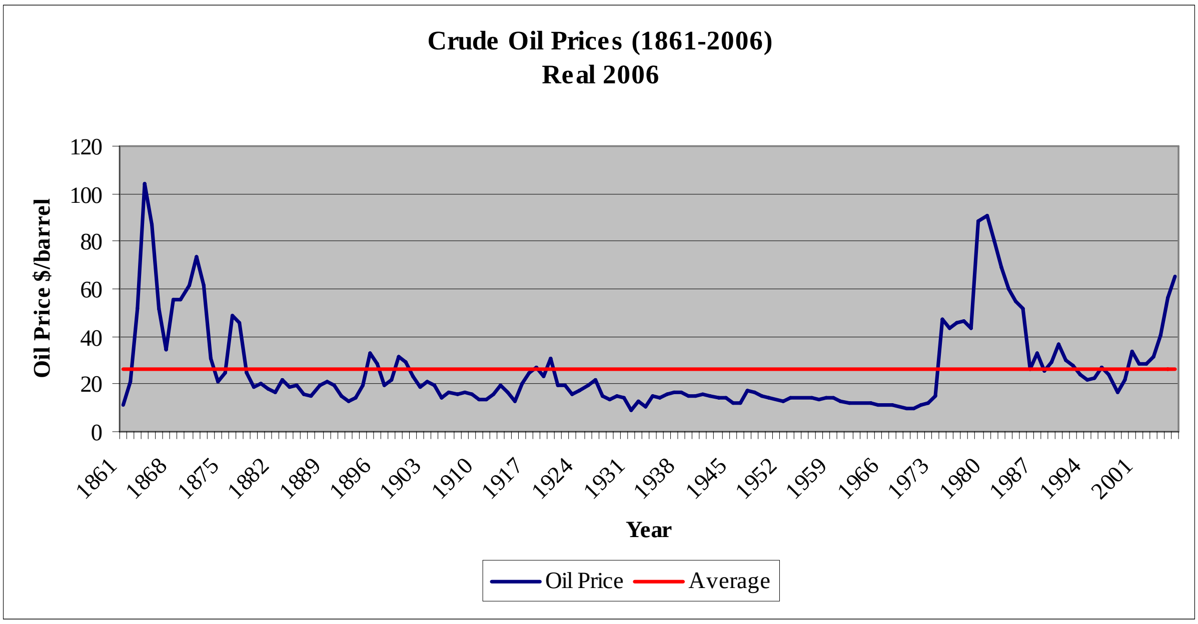


Figure 26: Oil Price History 1861-2006

It should be pointed out that the average price level over these years amounts to only USD 26 per barrel. The long-term view is however not representative for future oil price forecast and a shorter time period from 1970 to 2006 has been analysed and presented in Figure 27.

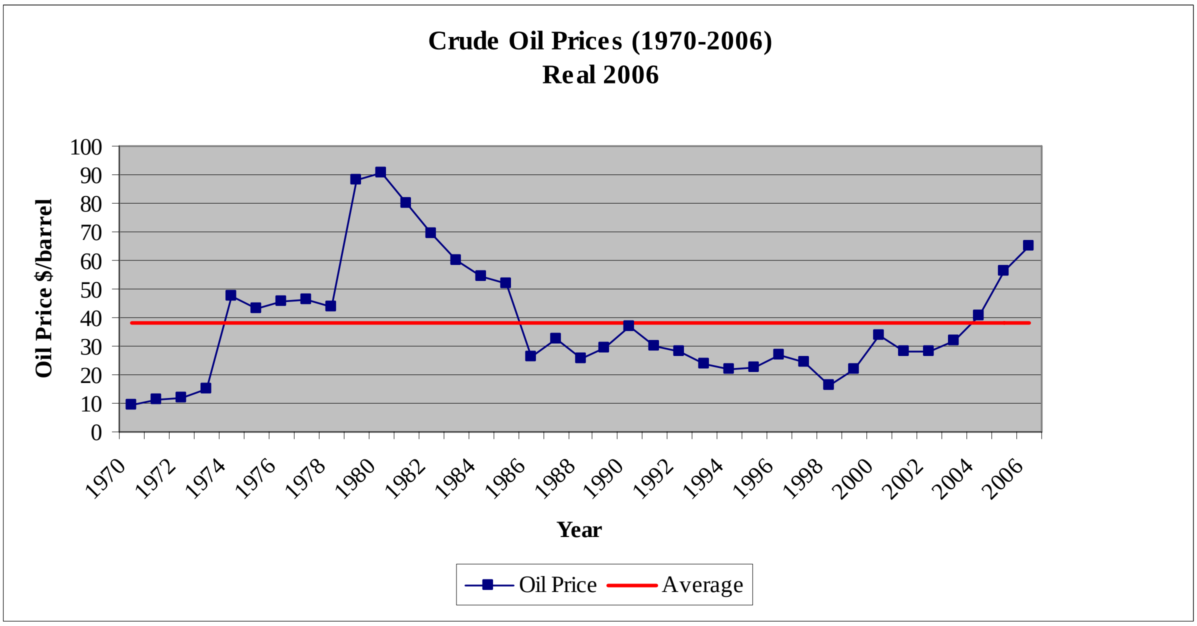


Figure 27: Oil Price History 1970-2006

Since OPEC took over the market, prices have been higher. For the period 1970 – 2006, the average price was USD 38 per barrel. However, these price levels were inordinately influenced by the high prices that prevailed from 1974 through 1985 that are associated with the two oil price shocks. For the period 1986 through 2006, the average price has been around USD 30 per barrel, only slightly above the top end of the historic band. The oil prices have nevertheless remained high over a longer period and oil futures prices indicate that prices may remain high. Overall, crude oil prices have been on-the-rise since 2001 and nothing is indicating a major persistent decline. [88]

However, debates concerning future oil prices seem to be a never ending story. In the article *"Dagens Nyheter – Sinande tillgångar driver upp oljepriset, 2005*[89]*"*, the ever decreasing oil resources are described as the reason for predicting high oil prices. The World Bank on the other hand is predicting a decline in oil price over the next years, explained by the fact that most increases are followed by a reversion towards a trend level[90]. The figure below addresses the difficulties raised in trying to forecast future oil prices, where both the World Banks outlook for future oil prices and three scenarios developed by the US Energy Information Administration (EIA) are presented for the next 8 years.

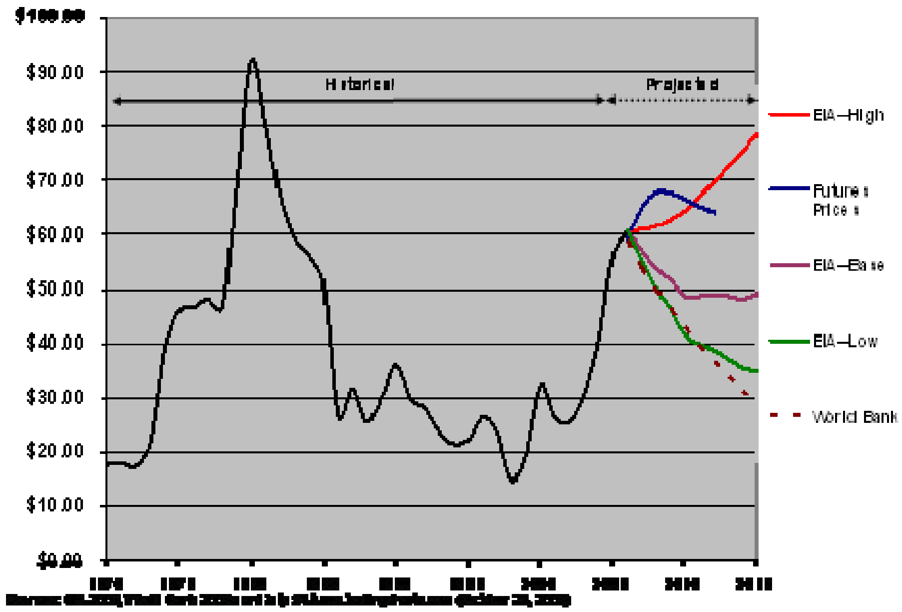


Figure 28: Oil Price Outlook[91]

Within the scope of the thesis, it is not intended to predict exact future oil prices. Instead a probability distribution function will be defined for the oil prices in terms of a risk variable. This function will later be used to simulate possible future values of the oil price for the time span of the analysis, incorporating both peaks and the variation around the average based on the historical figures from 1970-2006. In this way, the range of all possible outcomes will be analysed.

7.2.3 Distribution fitting

In order to fit probability distribution to the collected data, some properties where identified. The data consists of 37 sampled observations. Looking at the historical oil prices from the short term period in Figure 27, no specific trend can be identified other than the variation around the average over the time period. The sampled data is continuous, i.e. it can take on any value over a continuous range. The

[88] Hansson and Hedenström (2006), p.iii
[89] Schück (2005)
[90] UNDP/ESMAP (2005), p.10
[91] Ljung (2007), 127

sampled data should not be filtered, although it contains high peaks of oil prices it can not be eliminated that these peaks may occur in the future. It is not possible to predefine any distributions.

The @Risk distribution fitting simulation identified several distribution functions fitting the data for oil prices. The best fit described the sampled data with an Inverse Gaussian distribution function. The function has a mean of 43.7 with a standard deviation of 21.4 compared to a standard deviation of 21.8 for the real data. With a probability of 90%, the oil prices fall in the range of USD 10 barrel and USD 80 per barrel. The fitting of the distribution is presented in. Figure 29.

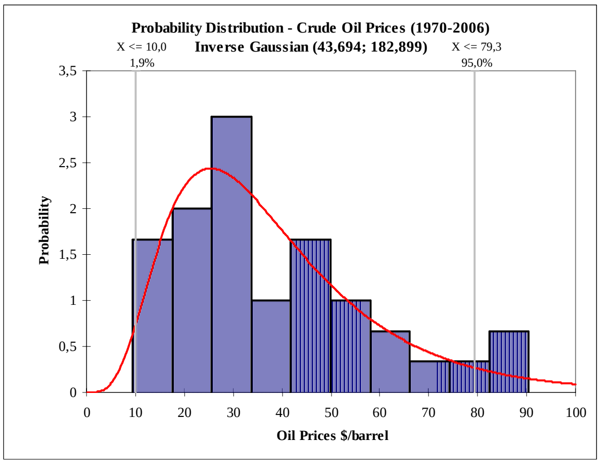


Figure 29: Probability distribution fitted to Oil Price data

7.2.4 Goodness of the Fit

After the distribution has been fitted to the sampled data, it is essential to evaluate the goodness of the fit. The distribution fitting of the oil price data was ranked by the Chi-Squared statistics. The observed significance of the test is called the p-value of the fit and defines the deviation of the fitted distribution from the input data. The distribution fitted generated a p-value of 0.904 which is close to one which indicates that there is no basis to reject the fit.

The Probability-Probability graph for the fit is shown in Figure 30. The graph is nearly linear, which as well signifies a "good fit".

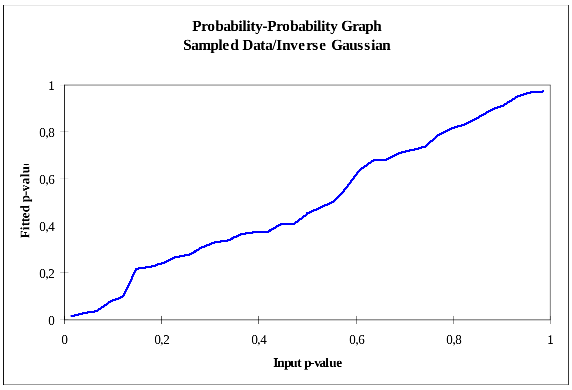


Figure 30: Probability-Probability Graph, Sampled data versus Fitted Distribution

7.2.5 Correlation

Net effects of oil price shocks are expected to lower world GDP because the reduced spending on all items by oil importers to balance higher oil import costs, will not be fully offset by increased demand for imports from oil exporters. Thus, most oil importing countries experience a further fall in GDP as their exports of other goods fall.[92] This implies that the demand for electricity might decrease with high oil prices, since the demand shows a correlation with the countries GDP. On the other hand, high oil prices might also entail a switch from diesel fuel to electricity by the private consumer, if TANESCO is able to keep its tariffs in an acceptable range.

[92] UNDP/ESMAP (2005), p.11

Quantifying certain correlation of crude oil prices and electricity demand in Tanzania will therefore be troublesome and is excluded from the analysis.

Further, looking at historical price development of oil, it can be observed that the price is not completely random. The price of one year is slightly correlated to the year before. This phenomenon is integrated in the oil price forecast.

7.2.6 Applying the Distribution to the Financial Analysis

The fitted distribution function for oil prices will be generated for each year of the financial analysis, adopting the range of possible values. The correlation from one year to the other has been assumed to be 0.5, i.e. the next years value will be a weighted average of this year's value and the generated value from the distribution function.

7.3 Hydrology

7.3.1 Characteristics

Energy generation plays an important role in deriving revenues for an energy project. Subsequently, for energy projects including hydro power generation, the forecasted hydrology in the study area has a significant effect on the forecasted generation costs. Characteristic of water resources is closely integrated with power scheduling. Reservoir inflow forecasts are part of the optimization for generation scheduling and unit commitments. As for Tanzania, hydro power generation is the least cost generation alternative leading to big jumps in supply costs depending on the hydrology.

An indication of the hydrology's influence on energy outputs in hydro-power dependent countries of East Africa is the effects of the recent years of droughts resulting in severe shortcuts of power generation. The loss of hydro generation is estimated to account for at least 2% GDP drop in 2006. Consequently, the output from Tanzania's hydro power stations, which is closely linked to predicted hydrology, is one of the identified risk variables in the risk assessment.

7.3.2 Assembling data

Hydrological forecast are made in a similar power project performed in Uganda, whereby the hydrology of Lake Victoria was assessed. Significantly contrasting values of Net Basin Inflows (NBI) have been observed between the periods 1900 to 1960 and 1961 to 2000, and the low inflow situation observed since 1999[93]. The data provided shows a 106-years sample and is shown in the following figure.

[93] PPA (2006), p.38

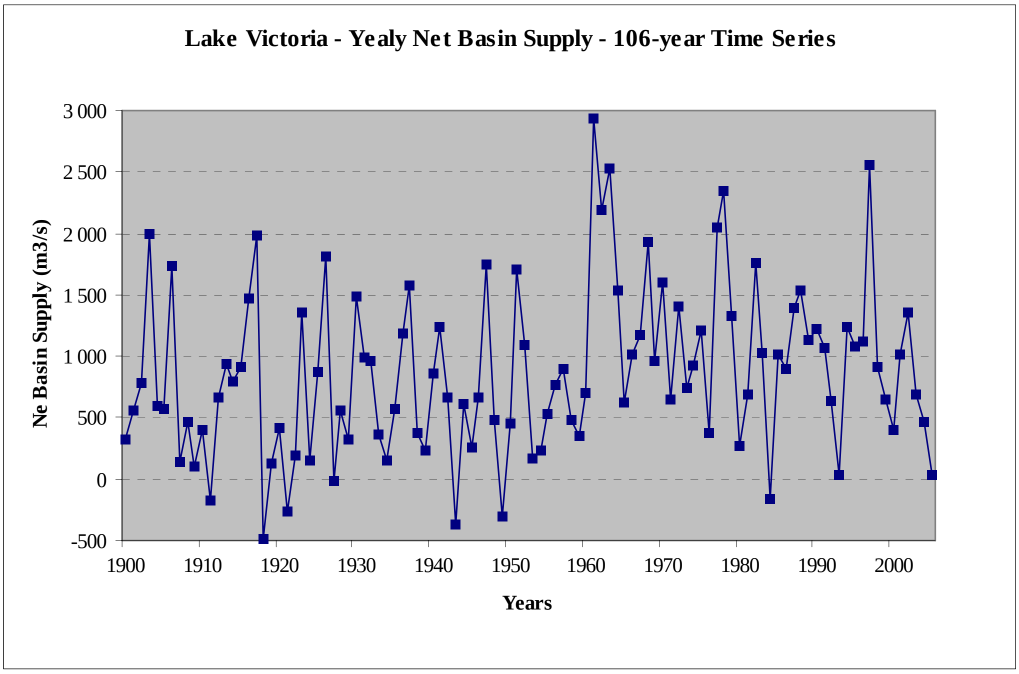


Figure 31: Net Yearly Basin Supply in Lake Victoria

Tanzania has currently six hydro power stations, with different basin supplies, which results in a more complex system. Hence the hydrology of the area of Lake Victoria is hard to apply on the Tanzanian hydro power stations. These data are only presented in order to illustrate the long term trends and volatility of the hydrology in the area which can be compared with Tanzania.

The forecast of future outputs from existing and new hydro power stations in Tanzania's are based on historical data from the existing generation units, described in section 5.1.4. The following figure shows the amount of energy which has been generated in each hydro power stations over the last two decades.

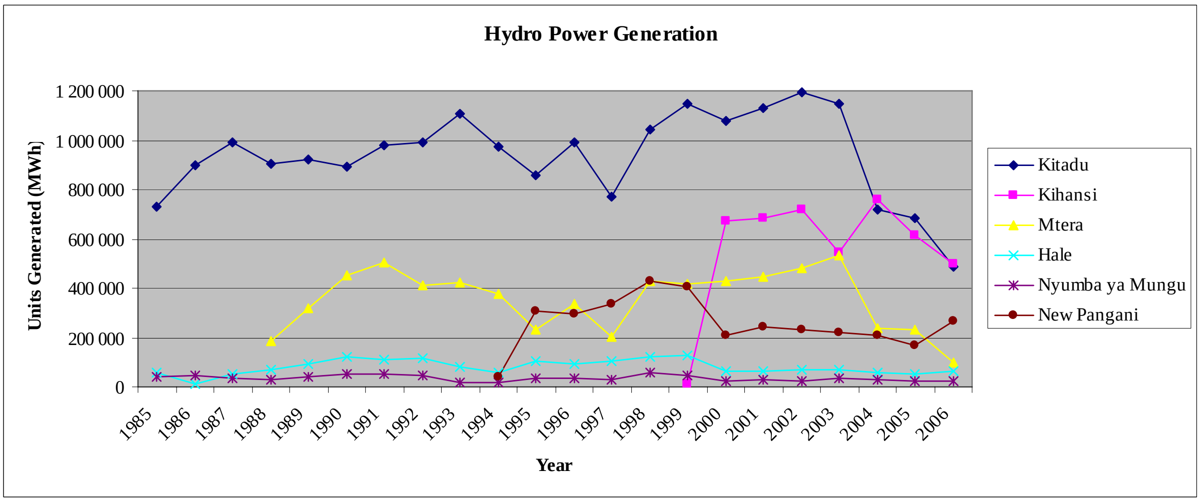


Figure 32: Generated units of Energy from TANESCO's Hydro Power Stations

The outputs from the hydro power stations are dependent on the capacity installed, and a more adequate variable to use in order to calculate future outputs from multiple stations will be the load factors over these years, i.e. the number of hours of generation / total number of hours. The load factor derives from the total generation of all stations per installed MW. The behaviour of the load factor from 1985 to 2006 is shown in Figure 33.

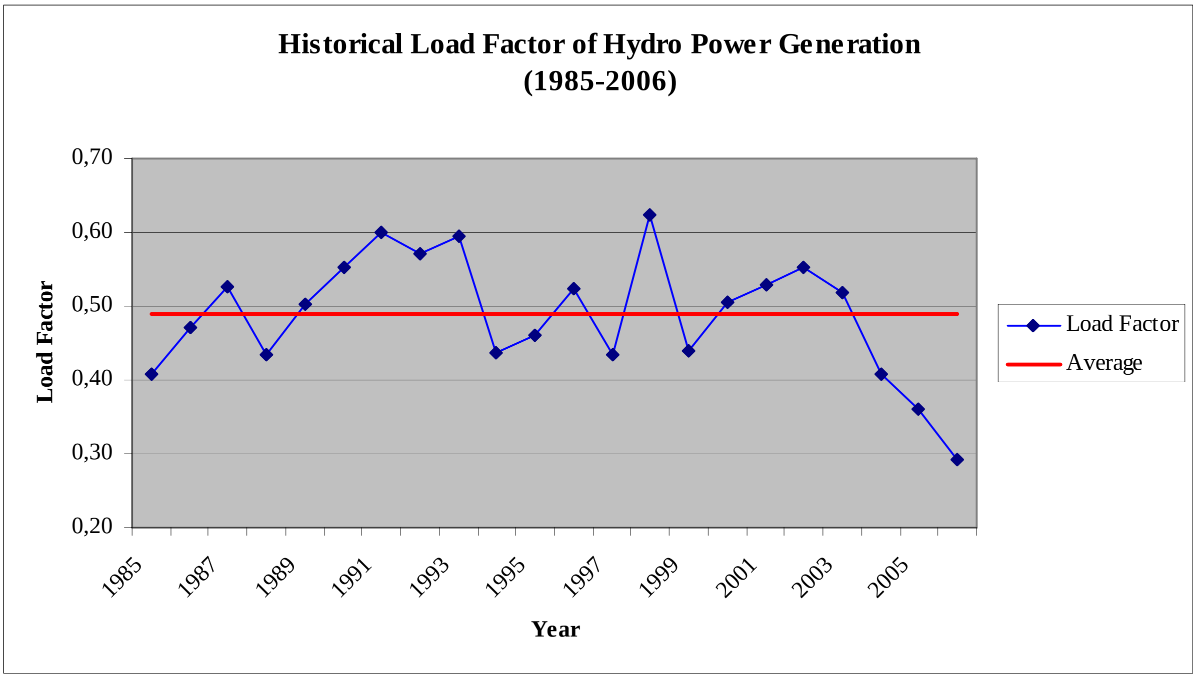


Figure 33: Historical Load Factor of Hydro Power Generation

It can be observed that the average load factor reaches 0.49, in comparison with a fulltime station utilisation, with inexhaustible water resources, and a load factor theoretically reaching 1. This data has been considered representative for the forecast of generation outputs for the coming years and will be the sampled data that will be used to define the probability distribution function.

7.3.3 Distribution fitting

In order to fit probability distribution to the collected data, some properties where identified. The data consists of 22 sampled observations. No trends could be identified in short term period of samples. The sampled data is continuous, i.e. it can take on any value over a continuous range. No filtering should be needed for the samples since even extreme values are expected to occur in the future. It is not possible to predefine any distributions.

The @Risk distribution fitting simulation identified several distribution functions fitting the data for hydro power generation load factors.

The best fit described the sampled data with a Normal distribution function. The function has a mean of 0.488 with a standard deviation of 0.082 which is the mean and standard deviation of the real data as well. With 90% probability the load factor falls in the range of 0.35 and 0.62 hours. The fitting of the distribution is presented in Figure 34.

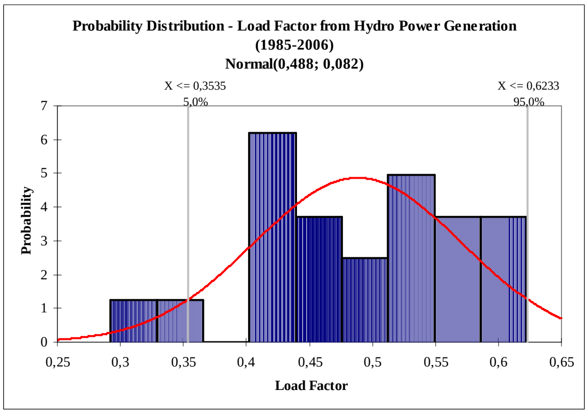


Figure 34: Probability Distribution fitted to Load Factor data

It can be observed that this fit is not quite as obvious as the one for historical oil prices. This is most likely a result of less sampled data. At the same time the right hand tail is a bit misleading since it will allow higher future values than the highest value of registered data. The goodness of the fit will nevertheless be tested further.

7.3.4 Goodness of the fit

The evaluation of the goodness of the fit for the hydro power load factor still shows strong evidence of a well fitted distribution function. The distribution fitting was ranked by the Chi-Squared statistics. The deviation of the fitted distribution compared to the distribution of the sampled data, namely the p-value, reaches a value of 0.91. This is also shown in Figure 35, where the Probability-Probability graph for the fit is close to linear. The goodness of the fit is accordingly significant.

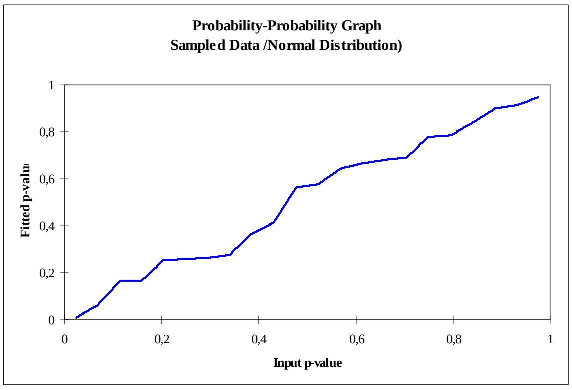


Figure 35: Probability -Probability Graph, Sampled data versus Fitted Distribution

7.3.5 Correlation

The correlation factor between the hydrology forecast and other identified risk variables is assumed to be zero, i.e. no correlation is expected.

7.3.6 Applying Distribution to the Financial Analysis

The distribution function fitted to the historical data of hydro power load factors is applied to the financial model. The output is expected to be completely random each year. The load factor is subsequently the annual load factor, multiplied with the total installed hydro power capacity for a relevant year.

7.4 Electricity Demand

7.4.1 Characteristics

Load forecasting is a critical element of electrical power utility planning[94]. The purpose of any form of load forecast is to estimate the most likely future level of demand to serve as the basis for generation planning. This includes the planning of distribution and transmission facilities, as well as the construction and operation of existing and new generation plants.

Generally, the demand for a certain commodity such as electricity depends on a number of factors: (i) the consumers relative preference for electricity over other energy sources; (ii) the income of the consumer (which may be represented by GDP); and (iii) the price of electricity. However, in order to be able to buy electricity from TANESCO, the consumer must also be connected to the network.

In the *PSMP*, a regression analysis has been performed to determine economic related relationships with the electricity demand in Tanzania. Theses relationships provide the long-term growth trends for each of the principal tariff categories. The regression analysis indicates that the level of economy is an important determinant of the level of electricity sales. The forecasted electricity demand consequently reflects the continuation of the GDP growth experienced over the past decade in Tanzania. In the years since 1999 the annual GDP growth has been in the range 4.7% - 6.7%[95].

Price elasticity of electricity consumption generally has a low impact on demand in countries where consumption per capita is low. In fact in Tanzania, in most cases it displayed a positive elasticity, thus sales increase rather than decrease as prices rise. For many consumers, electricity does not constitute a major portion of their expenses and the level of consumption may not be that responsive to price.

However, future electricity demand is regarded as a variable with a high uncertainty and has therefore been identified as a risk variable.

The annual growth in demand is governed by two factors: (i) the annual growth in new connected customers and (ii) the annual growth of specific demand, e.g. consumption per customer. The first factor is considered to be a variable that TANESCO actually will have an influence over and will therefore remain a fixed input item. The second factor is, as mentioned earlier, related to the annual growth of Tanzania's GDP and will therefore be assumed to fluctuate in accordance with variation in the annual growth in GDP. It is considered that the underlying GDP will reflect the most likely evolution of the specific power demand of customers.

7.4.2 Assembling data

For the *EAPMP* and the *PSMP* load forecasts have been performed which were described in section 5.2.1. This data will form the basis for the demand forecast in this report. However, a slightly different approach will be adopted. Instead of creating several different load scenarios over the period of analysis, one scenario with an uncertainty factor will be developed.

It should be noticed that in the FRP[96] a total annual growth of 15% is foreseen, with an annual increase of 100,000 customers. Looking at historical figures the total increase in demand the past 10 years has been in the range of 5% to 10%, and the annually increase in number of customers are in the

[94] TANESCO PSMP (2003)
[95] The Bank of Tanzania, 20.08.2007
[96] TANESCO FRP (2003), p.3

range of 30 000[97]. Consequently, a 15% increase in aggregate demand requires a substantially increased investment program with regard to new connections, network and generation facilities.

7.4.3 Defining Distribution

In contrast to the other two risk variables, historical data of the specific demand is not fitted to any probability distribution. Instead an appropriate distribution function is defined to describe the possible scenarios for annual growth of consumption per customer, reflecting the variation in growth of the GDP. In order to keep it simple and illustrative, a normal distribution function is selected for the annual growth with an expected value of 5% and a standard deviation of 2% for the first year of analysis. The defined distribution function is presented in the following figure.

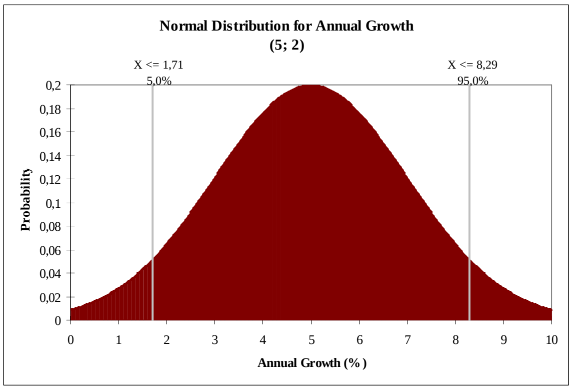


Figure 36: Probability distribution defined for annual growth in consumption of electricity per customer

Moreover, the uncertainty of annual growth of specific demand is expected to increase over time. This is taken into consideration by assuming an annual increase of the standard deviation of the normal distribution of 0.1%. The effect of the increase in variation over time on the growth of specific demand is presented in the following figure. One should note that the figure does not include the expected growth in the number of customers, and therefore does not represent total demand.

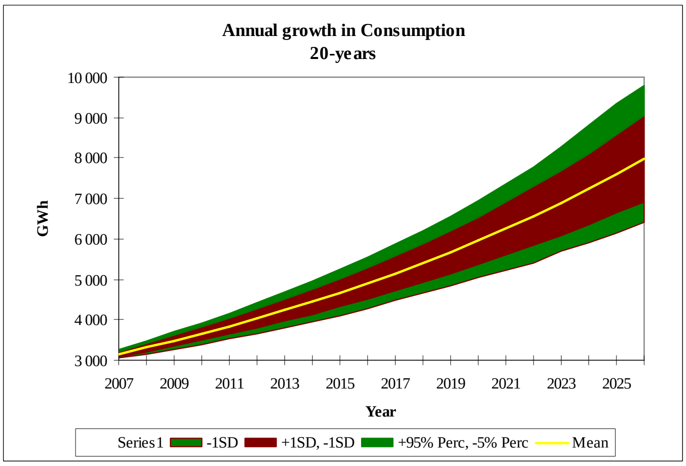


Figure 37: Annual Demand Growth

7.4.4 Correlation

The issues concerning correlation between forecasted oil prices and annual demand of electricity has already been discussed in Section 0 Any correlation between the annual demand and other risk variables is not assumed.

7.4.5 Applying the Distribution to the Financial Analysis

As mentioned earlier the demand growth can be separated in two parts. The growth in number of customers has been assumed to be 5% annually, since this is a variable the utility can influence the growth is held fixed. The start value is based on the number of customer year 2006. Consumption per customer is expected to rise on the basis of the growth rates determined. The start value is based on total consumption year 2006.

[97] TANESCO data base

8. Analysis and Results – Financial Risk Analysis of Base Case

The second chapter of analysis and results comprises the financial analysis of the base case, based on the discounted cash flow method supported by two analytical tools, the financial model and @Risk. The defined risk variables in chapter 7 are incorporated in the analysis. Initially, the assumptions and input variables for the base case used in the financial model are summarised. Thereafter, the results from the analysis are presented both as single expected values as well as distribution functions.

8.1 Definition of the Base Case

The following section will present general assumptions and input values that are used as a base case in the financial analysis of Tanzania's power system. In further analyses of alternative investment programs or stress analysis, the base case results are used as the reference. Inputs and basis for assumptions derive from data provided in chapter 5 or experiences from similar projects.

8.1.1 Demand

***Consumption* –** The inputs used for the demand forecast consist of 2006 year's customers of 580 000 and 2006 years energy consumption. However, the energy consumption has been interpolated from 2004 year's value since the recent years of droughts; resulting in a shortage of supply has lead to an inconsistent value of 2006 year's energy consumption. The number of customers is assumed to increase by 5% annually.

***Growth* –** The annual growth of electricity consumption is considered to be a risk variable in the risk analysis and assumptions made regarding the demand is described in chapter 7.4. The distribution function of the expected growth presented is implemented in the financial model assuming an increase in variation over the years of analysis. The base case assumes a normal distribution with an expected growth of 5% and a standard deviation of 2% with an annual increase of 0.1%.

***Losses* –** Technical and non-technical losses are assumed to be 10% each of the net generation required the first year of analysis. The total losses are further expected to decrease by 0.5% annually, until the minimum values of 7.5 % for technical, and 7% for non-technical losses, thereafter they are held fixed.

***Load variation* –** The financial analysis is made on yearly basis. The yearly load curve shown in Figure 11 is utilized in the analysis. The existing and new generation plants are categorised by type of plant. The categories are ranked in order after lowest variables generation costs.

8.1.2 Existing Generation

The capacity of all existing generation facilities which are presented in section 5.1.4 is included in the analysis.

8.1.3 Investment

Generation

The full list of investment to expand the generation possibilities has been applied for the base case in the financial analysis. The investment cost for each plant is assumed to be payable the start year of operation. To compensate for long term planning and construction periods for the large investment in hydro power plants and coal plants, where the capital costs normally are spread over several years, an additional 25% have been added to the original capital cost. The investment plan assumed for the base case includes the investments presented section 5.2.2 and amounts to a total amount of USD 2.2 billion.

Extension and Reinforcement of Existing Network

In order to connect the new generation plants to the existing network, investments in large transmission lines in accordance with Table 10 are assumed. The total amount of investment in transmission system addition is USD 500 million.

Further the investment proposed for reinforcement of the existing network, for transmission, distribution and rural electrification in the FRP are included as in Table 11. These cover the years from 2007 to 2010.

Thereafter, investment for extension of the transmission and distribution net are assumed to be proportionate to the number of annual new connected customer. For distribution a connection cost of USD 470 per new connected customer has been applied, resulting in average annual investment of 26 MUSD. As for transmission a connection costs of USD 550 per new connected customers.

For all investments a straight-line depreciation has been applied with an expected economic life time presented in section 5.2.4, ranging from 20-50 years, depending on type of plant. The depreciation does not affect the cash flow and is used only for the purpose of determining the assets salvage value at the end of the period of analysis.

8.1.4 Generation Costs

Each generation plant is associated with three cost items, the cost of fuel for energy generated, a fixed cost per installed capacity and a variable operating cost related to the energy generated. These costs derive from chapter 5.2.2 and are summarised in the following table.

Table 14: Expected cost of generation plants

	Type of Fuel	Fuel Price USD/GJ	Fixed Cost USD/kW*year	Variable Costs USD/kWh
Hydro Power		0,0	6	0
Coal Steam	Coal	1,2	45	0,0066
Diesel Generator	Gas	3,0	35	0,013
Gas Turbine	Gas	3,0	12	0,006
Diesel Generator	HFO	RV	20	0,012
Diesel Generator	IDO	RV	35	0,013

The price for IDO and HFO derives from the annual crude oil prices, which are regarded as a risk variable, RV, in the model. The fitted distribution function for oil prices will be incorporated in the financial analysis for each year. The correlation from one year to the other has been assumed to be 0.5, i.e. the next year's value will be a weighted average of this year's value and the value sampled from the distribution function, starting at 2006 year's oil price of USD 65.1 per barrel. Traditional ratios of products such as Diesel and HFO to crude oil prices were used to determine product prices. Cost of marine shipping, insurance and losses were added to obtain the landed cost in Dar es Salaam.

8.1.5 Leasing Costs for Rented Plants and IPPs

For the IPP's the following assumptions are made. The IPTL is assumed to be converted from oil usage to domestic gas in 2010 and at the same time a buy-out of the power plant by the Government of Tanzania is expected. This will lead to TANESCO paying the capacity charge of USD 42.6 million per month until 2010. An investment cost for the buy-out as well as the expected cost for the conversion is assumed in 2010, however resulting in the elimination of capacity charges after this year. The investment costs are assumed to be USD 21.7 million for the conversion and USD 127.5 million for the purchase of the plant. Thereafter, the IPTL plant will be operated as one of TANESCO's own assets.

As for Songas it is assumed that TANESCO will pay a capacity charge of USD 4.4 million per month and an energy charge of US cent 4.9 per kWh during the whole period of analysis for the energy generated by Songas.

As for the rented plants, i.e. Aggreko, Dowans and Mwanza Alstom, only figures for the Aggreko plant exist and which show a leasing cost of USD 200 000 per MW and year. This amount has been applied for all three rented plants.

8.1.6 Interconnection

A 200 MW interconnection line from Tanzania to Zambia is assumed to be constructed in 2010 with a capital cost of USD 168 million. The price for imported electricity is assumed to be US cent 7 per kWh. The possibility to collect revenue from export of electricity in case of surplus is not included in the analysis.

8.1.7 Other Operating Costs

TANESCO's administration and other costs of USD 60 million annual are applied, including payroll and administration of overhead. This figure derives however from the expected cost of 2006 and it is assumed the cost will increase along with the expansion of TANESCO operations with 5% real.

As for operation and maintenance of TANESCO's existing plants, a cost of USD 25 million is used in the analysis. This value includes repairs and maintenance, transport and travel and efficiency improvement.

8.1.8 Tariffs

TANESCO's average tariff for 2005 is interpolated with the realised real tariff increases of 11% up to 2007. Thereafter a further 5% increase in 2008 is assumed. Since the tariff should be in real values, no further increases after that are expected. The tariff and the annual consumption form the basis for the electricity sales calculation.

Additional revenues are assumed for collection customer connection fee. These are based on TANESCO's current tariff structure, i.e. USD 260 per general use customer, USD 800 per low voltage customer and USD 40 000 for high voltage customer.

8.1.9 Financing

In section 3.1.2 the importance of separating the financing decision from the investment in the initial state of the financial analysis is pointed out. Based on this theory and lack of reliable data, assumptions concerning the financing of the investment have not been made in the base case and are considered to fall outside the scope of the thesis. However, possible financing structure will be discussed in chapter 11 but not analysed.

8.1.10 Financial Planning Criteria

Time Period – A time horizon of 20 years for the financial analysis has been adopted with starting year of 2007. The time period is based on the investment plan and in order to capture a few years of each investment revenues. However, salvage values from investments made at the end of the modelling period will be considered and added to the financial results. The analysis is based on the calendar year.

Real Term – All calculations are made in real terms with year 2006 as reference year. Inputs of cost, estimated before year 2006 are updated to the common reference point, with a 5% inflation rate, reflecting the Tanzanian development.

Exchange Rate – The current exchange rate of TSh 1215 per USD is applied in the analysis.

Discount Rate – Based on experience from other TANESCO projects where a 12 % discount rate has been assumed, a 7% real discount rate for USD has been applied. All discounting is carried out to 2006.

Collection Rate – The collection rate is assumed to 96% based on TANESCO figures.

Taxes and Duties – Taxes and duties are not included in the analysis.

8.2 Financial Result

Based on the assumptions and inputs stated in the above section the financial result of the analysis is calculated using the financial model described in Section 6.2 .

8.2.1 Expected Values

All risk variables are specified with a distribution function and the mean of each distribution function representing the expected value of the outcome, i.e. the value with the highest likelihood to occur. When no risk simulations are run through the model, accordingly the financial result will be based on these expected values and will hence indicate the expected value of the result. This is comparable with the traditional discounted cash flow method without a quantitative risk analysis.

The expected result of the financial analysis of the base case is presented in the following table.

Table 15: Expected Result of the Base Case

Financial Result Base Case - Expected Values		Indicator Base Case
Investment		
Discount Rate	%	7%
Total Investment	000' USD	4 708 601
Net Present Value		
PV-Operating Activities	000' USD	1 224 271
PV-Investing Activities (incl. Salvage)	000' USD	-2 156 008
NPV	000' USD	-931 737
Unserved Energy		
Unserved Energy	GWh	26 762
NPV - Unserved Energy	000' USD	-4 002 621

Table 15 indicates that with a discount rate of 7%, the total net present value of operating and investing activities, including the salvage value of the investment at the end of the period of analysis, amounts to USD -930 million. It can also be observed that with the current assumption concerning demand growth and generation expansion, there is still an amount of 27 000 GWh over the 20-years period that will not be served, representing a total cost of USD 4 billion[98]. Keeping in mind that the risk variables are held fixed at their expected values, the year 2015 and onwards of analysis show an expected deficiency of supply.

8.2.2 Risk Analysis

Three risk variables: the future oil prices, the output from hydro power and the annual growth in demand, are incorporated in the financial model as described in chapter 7. When running a simulation through the model, for each iteration, a new value for each variable's distribution function is randomly sampled, calculating new financial indicators for every iteration. The result of a simulation with 1000 iterations of the base case is presented in the following. The statistics of two of the indicators are presented, the total net present value and the total unserved demand.

Table 16: Statistics of Indicators

Risk Analysis Base Case		Mean	Max	Min	Std Dev
Net Present Value	000' USD	-948 721	-656 951	-1 225 732	83 314
Unserved Demand	GWh	28 171	80 227	3 900	12 703

The net present value shows a mean of USD -950 million, with a minimum of USD -1230 million and a maximum USD -660 million and a standard deviation of USD 83 million. These figures shows the variation from the expected value calculated earlier, showing a distinct risk enhanced with the expected net present value. As for the total unserved demand, the statistics state a mean of 28 TWh, but there is a possibility that an unserved demand as high as 80 TWh might occur. In the last year of the analysis, the unserved energy reaches a mean of 25% of the total energy demand. Yet, these statistics do not reveal the likelihood of different outcomes.

[98] *Assuming a fictive cost of USD 0.5 per unserved kWh.*

Net Present Value and Unserved Energy

In the following figures the distribution of the net present value and the unserved energy demand over the 20-years of analysis is seen.

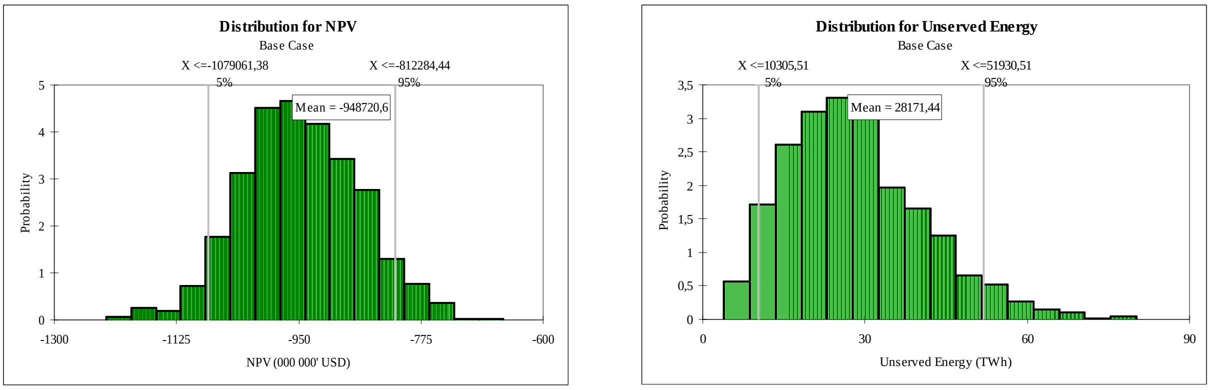


Figure 38: Distribution for Net Present Value and Unserved Energy in the Base Case

With 90% confidence, the net present value will fall in the range of USD -1100 million and USD -812 million. This is indicated by the grey delimiters to the left and right in the figure above. Although, in between these values the distribution of different outcomes is still high, with a peak at the estimated mean. With a likelihood of 28% the net present value will fall under the value of USD -1 billion. If the mean of the net present value would have been positive, the probability that the outcome of the net present value will be negative can be obtained similarly.

The distribution of the possible unserved energy in Figure 38 shows a different shape of the NPV. Its peak is at 28 TWh, but the function still shows values as high as almost 80 TWh over the 20 years of period. With the presented investment plan for the next 20 years there is probability of 89 % that the unserved energy will be less than 50 TWh and the risk that the unserved demand will be higher than 60 TWh is less than 2%.

Figure 39 summarises the changes in probability distribution of the unserved energy over the period of analysis. The figure shows distinctive peaks with wide variability for the years shortly before investments in new generation facilities. Such as 2017, i.e. the year before Mchuchuma I with a capacity of 200 MW is installed and year 2021 the year before the installation of Mchuchuma II and Rumakali, with another total capacity of 422 MW. At the same time there is a significant decrease in the risk of unserved demand in the years of and after new installations.

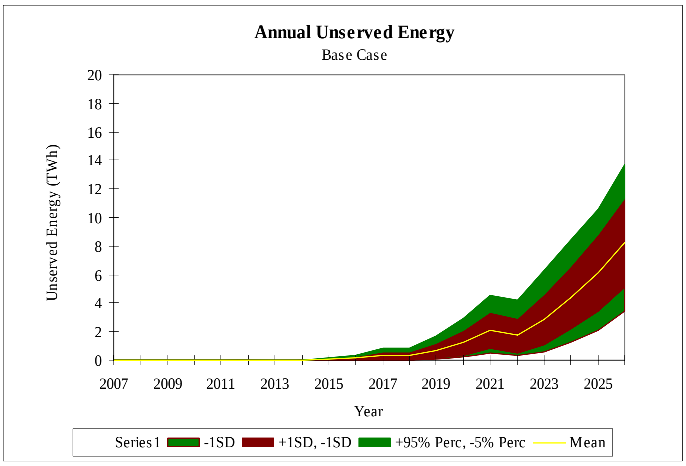


Figure 39: Annual Unserved Energy for Base Case

The yellow line presents the mean of the unserved demand. In Figure 39, values in the range of the red area define the mean plus/minus 1 standard deviation, and the green area is the values outside the 90% confidence interval, hence in this case the green area indicated the 95th percentile for each distribution. It is obvious from the figure that the expected demand will not be covered after year 2019 and with high probability not even after year 2017. At the same time the figure presents a non existing risk for unserved energy from year 2007 to year 2014.

8.3 Cost Covering Tariffs

For all cases, the resulting net present value certainly indicates that the initially assumed tariffs do not allow for fully cost recovery, even the "best cases" show a negative net present value. In order for the base case investment plan to show an expected net present value greater than zero a tariff increase the first year of analysis of 37% is required. However, this figure does not include for example financial cost occurring from possible financing structures and is therefore not entirely relevant. The probability distribution for the net present value for the base case investment with an assumed tariff increase of 40% the first year of analysis is presented in **Error! Reference source not found.**.

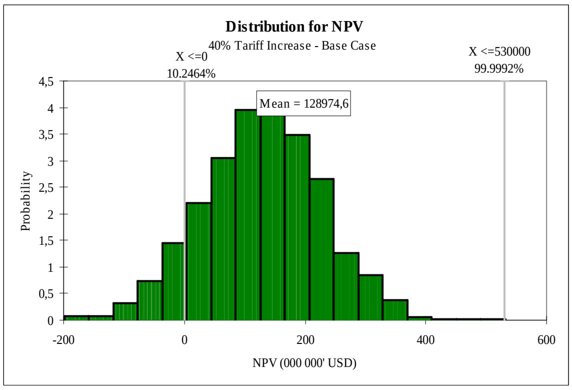


Figure 1: Distribution for NPV with a tariff increase of 40%

The table shows that with a probability of 90% the NPV will be higher than zero and hence indicating that with the assumed tariff increase, the base case would with a high probability be financially viable.

8.4 Summary

In summary, the results of the financial risk analysis of the base case show a net present value with a mean of USD -950 million and a standard deviation of USD 83 million. These figures show the variation from the expected value showing a distinct risk enhanced with the expected net present value.

The distribution of the unserved energy has a peak at 28 TWh, but there is a risk of values as high as almost 80 TWh over the 20 years of period. With the presented investment plan for the next 20 years there is probability of 89 % that the unserved energy will be less than 50 TWh and the risk that the unserved demand will be higher than 60 TWh is less than 2%. In the last year of the analysis, the unserved energy reaches a mean of 25% of the total energy demand.

In order for the base case investment plan to show an expected net NPV greater than zero a tariff increase the first year of analysis of 37% is required. With a probability of 90% the NPV will be higher than zero and hence indicating that with the assumed tariff increase, the base case would with a high probability be financially viable.

9. Analysis and Results – Stress Analysis of Base Case

The following chapter consists of the third part of the analysis and results. It reflects the effects of changes in risk variables or of general inputs of the model, on the financial output.

9.1 High Oil Prices

In the base case scenario, the probability distribution defined in Section 0, is used to sample values for the expected future oil prices, whereby all expected outcomes in the range of the probability distribution is analysed. It should also be studied what the outcome of the financial result would be if future oil prices would remain at today's high level. This can be done by stressing this particular risk variable in the model. As an example, stating that the oil prices only will accept values in the range of 85-100% of their highest values on the right hand scale of the distribution function i.e. the oil price will be USD 60 per barrel or more.

A comparison of the changes in the net present value between the base case and the stressed situation assuming consistently high oil prices for all years of analysis is performed and presented in the following.

Table 17: Comparison of NPV, Base Case versus High Oil Prices

Risk Analysis - Stressed Oil Prices					
Net Present Value		**Mean**	**Max**	**Min**	**Std Dev**
Base Case	000' USD	-949 424	-685 508	-1 183 994	78 265
Stressed Oil Prices	000' USD	-1 031 485	-769 882	-1 281 600	79 739
Difference	**000' USD**	**-82 061**	**-84 374**	**-97 605**	**1 474**

Table 17 indicates that the expected mean of the net present value is about USD 80 million less when high oil prices are assumed, compared to the base case, resulting in the possible minimum value of near USD 100 million lower comparing the base case to the stressed situation. However, the standard deviation does not change much in comparison; this is natural since the possible range of values for the oil price was substantially reduced in the stressed situation.

The figures below illustrate the same result. The left figure shows the cumulative distribution function of the both situations, demonstrating a difference of the functions. The results show that there is a difference of the outcome of the net present values.

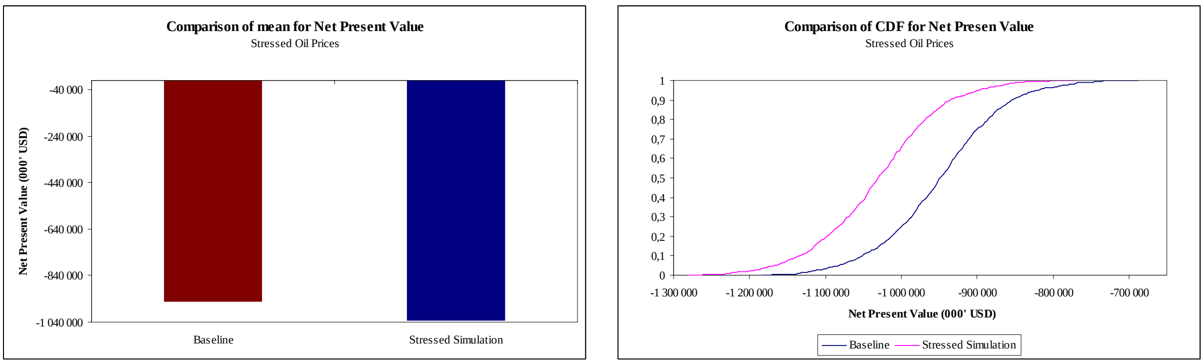


Figure 40: Comparison of outcomes from the base case and the high oil prices case.

It should be addressed that with the present investment plan, no big investments in diesel plants are expected. However, with the unserved demand in mind it might be necessary to invest more in short-term diesel plants in the future; this will change the result of stressing the oil prices significantly.

9.2 Rapid Annual Growth in Demand

As described in 7.4, a significant higher demand forecast assuming a 15 % growth has been adapted in the financial recovery plan. The distribution function assumed for the annual growth in demand for the base case, does reflect this value but with a considerably lower probability. In the base case the annual increase in customers is fixed to 5%, leaving that the variable annual growth needs to reach 10% in order to achieve the same total growth assumed in the financial recover plan. By stressing the annual growth variable in the risk analysis to only adapting values in the range of 90%, and higher the total annual growth falls in the range of 13 to 15% and hence reflecting the high demand assumptions. A stress analysis has been performed assuming the high annual growth of 90-100% of the distribution function for the first 5 years of analysis i.e. 2007-20011 and thereafter applying the variable growth from the base case.

Table 18: Comparison of Total Unserved Energy, Base Case versus High Demand Forecast

Risk Analysis- Stressed Demand					
Net Present Value		**Mean**	**Max**	**Min**	**Std Dev**
Base Case	GWh	-948 896	-676 738	-1 169 750	78 872
Stressed Annual Growth in Demand	GWh	-899 114	-609 685	-1 176 141	91 671
Difference	GWh	49 783	67 053	-6 391	12 799
Unserved Energy		**Mean**	**Max**	**Min**	**Std Dev**
Base Case	GWh	28 142	88 551	3 594	12 967
Stressed Annual Growth in Demand	GWh	52 334	123 270	13 177	17 001
Difference	GWh	24 192	34 719	9 583	4 033

Initially, when comparing the situations, the risk analysis presents an increase in net present value for a higher growth in demand. This is natural due to a distinctive increase in sales the first years of analysis when the demand still can be served.

However, at the same time, the risk analysis indicates that the high demand forecasts seem unrealistic with the current assumption of investment plan. Assuming a total annual growth of 13-15% annually the first 5 years of analysis implies an average amount of unserved energy of 52 TWh over the time period. The standard deviation of the mean also shows a very high figure, signifying a high variation of the outcome of unserved energy, resulting in very high risks. This is also to a great extent due to the assumed increase in variation of the future demand applied both in the base case as well as in the stressed situation. The changes in unserved energy in comparison of the two cases are presented in Figure 41.

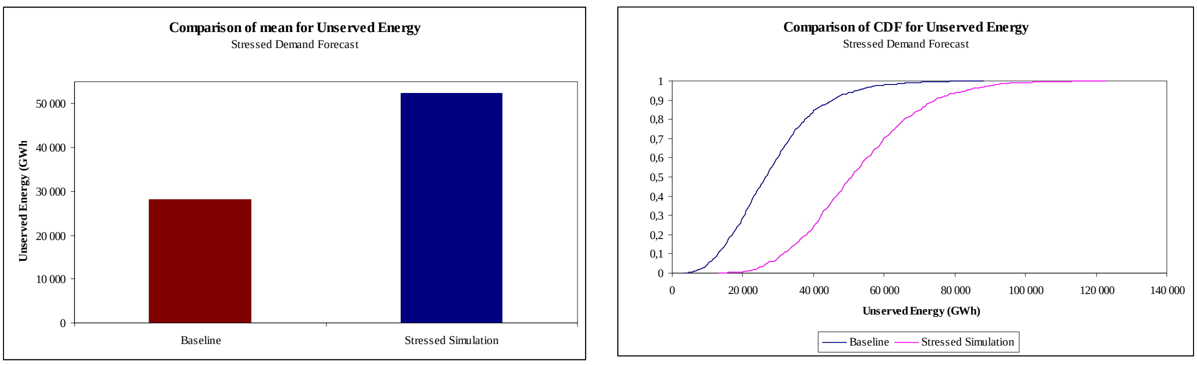


Figure 41: Comparison of outcomes from the base case and the high demand forecast.

It is however interesting to observe from Figure 42, that even when assuming a high annual growth in demand the first five years of analysis, the result does not show any tendency for risk involved with unserved demand until year 2012. Although, comparing with Figure 39 from the base case, a significant increase of the mean is seen in the stressed situation after year 2018.

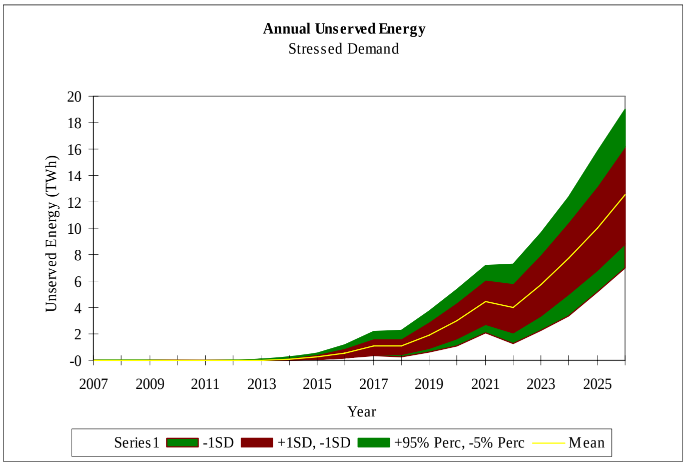


Figure 42: Annual Unserved Demand for high demand forecast

9.3 Extended Investment Plan

The result of the base case of investment plan evidently shows that the assumed investment plan does not cover future demand even with the more modest annual growth rate as for the base case. At the same time, from the start year and until year 2015 the base case investment plan show a surplus of generated energy. This may imply that TANESCO possibly could postpone plants that are expected to be implemented early to later years. At the same time, the large amount of unserved demand in the latter years of analysis indicates a need for additional generation possibilities after 2015. An extended investment plan is analysed, including the following changes from the base case: (i) a postponement of investment in Kinyerezi gas turbine from 2009 to 2012, (ii) an investment in additional hydro power in 2015 with a capacity of 1200MW, in the same size as Stiegler's George and a capital cost of USD 2 million per MW as for Rumakali (iii) an additional investment in a coal plant of 400 MW in 2020 with a capital cost of USD 500 million.

Table 19: Comparison of Financial Result of the Base Case versus the Extended Investment Plan

Financial Result Expected Values		Indicator Base Case	Indicator Extended Investment	Indicator Difference
Investment				
Discount Rate	%	7%	7%	
Total Investment	000' USD	4 708 601	7 608 601	2 900 000
Net Present Value				
NPV-Operating Activities	000' USD	1 224 271	2 448 130	1 223 859
NPV-Investing Activities (incl. Salvage)	000' USD	-2 156 008	-3 050 625	-894 617
NPV	000' USD	-931 737	-602 495	329 243
Unserved Energy				
Unserved Energy	GWh	26 762	3 178	-23 584
NPV - Unserved Energy	000' USD	-4 002 621	-433 662	3 568 959

Assuming the expansion of the generation facilities and a postponement of Kinyerezi gas turbine, will indeed imply a lower amount of unserved energy with 88%. Simultaneously, the investment plan will as expected also affect the net present value, leading to an increase of 35%. The following figure shows the distribution function for the net present value for the case where the additional generation plant and the postponement is included.

The distribution function shows a similar distribution as for the base case but with the mean displaced USD 330 million to the left. However, it also shows an increase in variation compared to Figure 38. This indicates that there is an increased sensibility in the proposed investment plan, probably dependent on the defined risk variable for hydro power output. The result is strengthened by the comparison in Table 20, showing an increase in standard deviation of USD 100 million, resulting in a lower minimum value than the base case. In this context, the extended investment plan involves a higher risk than the base case.

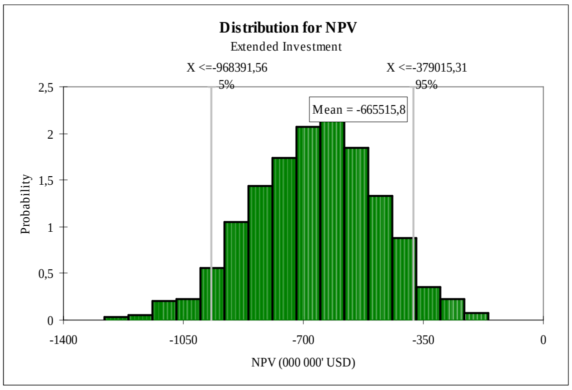
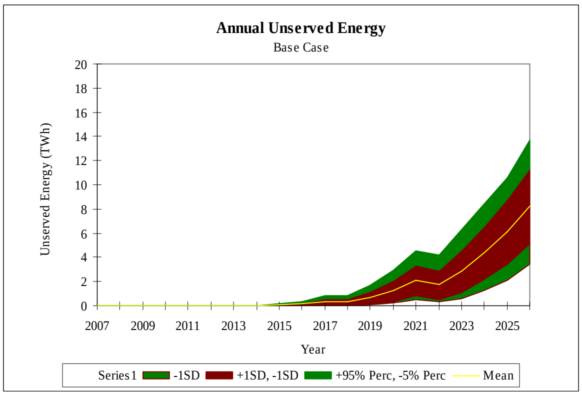


Figure 43: Distribution for Net Present Value with the Extended Investment plan.

Table 20: Comparison of NPV, Base Case versus Extended Investment Plan

Risk Analysis					
Net Present Value		**Mean**	**Max**	**Min**	**Std Dev**
Base Case	000' USD	-948 721	-656 951	-1 225 732	83 314
Extended Investment Plan	000' USD	-665 516	-159 621	-1 280 607	184 235
Difference	**000' USD**	**283 205**	**497 330**	**-54 875**	**100 921**

On the other hand studying the annual unserved demand in the figure below compared to the unserved demand for the base case, the result presents a substantial decrease of the risk of unserved demand, even if there still is a high probability that the demand is not served after year 2017. It also seems as if the first years of analysis are not affected by the postponement of Kinyerezi, since no risk of unserved energy can be identified prior to year 2013.



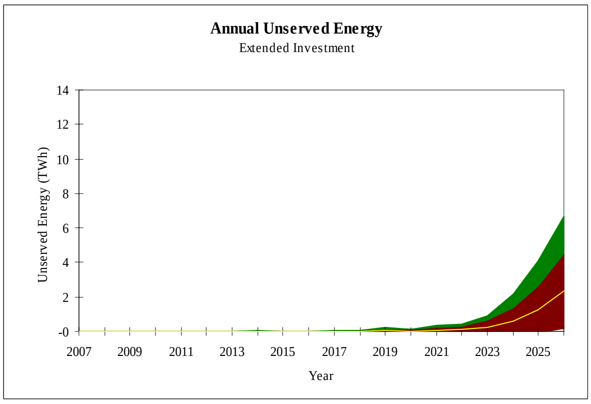


Figure 44: Comparison of Annual Unserved Demand for Base Case versus Extended Investment Plan

9.4 Summary

The stress analysis for high oil price can be summarised as follows. The expected mean of the net present value is about USD 80 million less when high oil prices are assumed compared to the base case. The standard deviation does not change much in comparison with the base case; this is natural since the possible range of values for the oil price was substantially reduced in the stressed situation.

By stressing the annual growth variable in the risk analysis, the results indicate that the high demand forecasts are unrealistic with the assumed base case investment plan. With a total annual growth of 13-15% annually the first 5 years of analysis the average amount of unserved energy will be 52 TWh over the period of analysis. It is however interesting to observe, that even when assuming a high annual growth in demand during the first five years of analysis, the result does not show any risk of unserved demand until year 2012.

Assuming there will be additional investment in generation facilities (above what is assumed in the base case) and a postponement of Kinyerezi gas turbine; this would lead to an 88% reduction of the amount of unserved energy. Simultaneously, the expanded investment plan will, as expected, also affect the net present value, which will increase by 35%.

10. Conclusion and Summary

This chapter provides the conclusions drawn by the author regarding the theoretical and methodological thesis’ objectives. Assumptions and result of the specific case study is hence not discussed in this section. Reflections, concerning investment in Tanzania’s power sector and related issues are presented in chapter 11.

10.1 Thesis’ Objectives

The objective of the master thesis has been to demonstrate how quantitative risk analysis, based on probabilistic methods, can assist utilities in making the right investment decisions. In order to meet this objective, a quantitative risk analysis, based on the theoretical framework developed, has been applied. The case of a power utility was selected as suitable, since it is faced with several uncertain factors and investments with long lead times. The case was analysed from various angles, i.e. base case analysis, stress analysis and variation of investments, in order to demonstrate the flexibility of the method.

10.2 Evaluation of the Method for Quantitative Risk Analysis

10.2.1 Evaluation of Risk Variables

In the initial part of the analysis three risk variables are identified and analysed. These three variables, oil price, hydrology and demand, are chosen to reflect some of the major risks involved in power planning. As can be observed, all of the variables have highly uncertain future values. In traditional assessment of power investment one variable is analysed at a time. However, with the method applied in this thesis, all expected outcomes of the risk variables are incorporated and presented in a lucid way.

With traditional methods, the forecast of a certain variable is represented by a single curve. This is obviously difficult to agree upon for a variable such as the oil price. The result obtained does not include any variation unless scenario analysis is performed. Even with scenario analysis only a few cases are normally presented, usually without indicating their probability. Using the probabilistic approach, the whole range of possible future states of a variable such an oil price is considered.

With support of the analytical tool @Risk, historical values for example oil prices are used to forecast future ones, without neglecting any possible outcomes. For a decision maker assumptions regarding these variables can easily be observed through different presented graphs, showing all possible outcomes and their probability. Problems involved with the definition of each variable are also addressed, giving the decision maker a broader picture of the whole project and underlying variables. Including correlation between different variables further presents how variables are linked to each other and their mutual effects which commonly is neglected in the traditional method for investment appraisal.

In this context, it is important to address the need for careful selection of risk variables. It is not always the case that the variables, which are chosen initially, affect the financial outcome the most. For example, the discussion in section 10.2.3 shows that, for the base case investment plan, the oil price is not as important as might be expected. Secondly, in the case of fitted distribution functions, they should be properly selected and tested. To base the future oil price on historic data may of course be questioned and alternatives could be discussed, e.g. looking at a certain trend pattern for the most recent years.

One should also bear in mind that there might be risk variables, which are overlooked in the identification process. Variables which may be important for the case studied are e.g. capital costs, foreign exchange rate etc. For the thesis' work, as the objective has been to demonstrate the method, only three variables were selected in order to keep the analysis simple. One should notice that including more variables is straight forward, and the result can be presented in the same lucid way. Also interdependence between variables can easily be modelled, which is not the case with traditional methods. For example a link between the oil price, GDP and demand.

10.2.2 Financial Risk Analysis of the Base Case

The defining of assumptions and inputs applied in the financial analysis do not differ from what is used in traditional methods, except that some of the inputs are defined as risk variables with an assumed distribution function.

The initial analysis is performed by using the model to calculate a result based on the risk variables' expected values, i.e. no simulation is performed. This is equivalent to the traditional DCF method with no explicit risk included. The result is a single net present value and an amount of unserved energy. The result may seem acceptable to a decision maker. However, whether using traditional methods or risk analysis, the result based on expected values should be an indicative result which is only useful in comparison with other outcomes.

In the subsequent analysis, the model runs through 1 000 Monte Carlo simulations. The result indicates that, given the fluctuations in input risk variables, the net present value and the amount of unserved demand show quite some variation, which should not be neglected by the decision maker. Looking at the result of the unserved energy which shows a mean of 28 TWh over a period of 20 years, which might be fully acceptable. However the same variable shows a maximum of 80 TWh which might be out of the range of acceptable outcomes. Calculating the probability of these extreme values enhances the basis for decision and quantifies the risk exposure of the project. Further, analysing the distribution of annual unserved energy is useful in examining and optimising investment plans. In conclusion, the risk analysis gives a broader picture of the effects of all factors influencing an investment.

At the same time, it must be pointed out that a quantitative risk analysis in this form makes the basis for the investment decision more complex, as the decision is not based on a single net present value. Nevertheless, this is not a fair reason for not using the method, although it might involve some extended skills on the decision maker e.g. familiarity with the probability theory presented in section 3.3.1. Moreover, as discussed in section 3.4, the investment decision is highly dependent on the firms or decision makers risk aversion i.e. to what extent risk is acceptable as a trade of for a higher project return.

As for the tariff assessment, which was based only on expected value of the risk variables, a risk analysis can be applied as well. For example, studying what tariff increase would be required to attain a positive net present value with a probability exceeding 90 %, etc.

10.2.3 Stress Analysis of Base Case

In order to further demonstrate the benefits of a risk analysis, changes in assumptions, representing a "worst case", are examined. This is referred to as stress analysis. For the case studied, the effect of consistently high oil prices on the project outcome is analysed. The base case investment plan will be affected by high oil prices, but not to the same extent as expected for an investment plan involving large investment in power plants fuelled by oil. Noticeably, by looking at risk variables whose effect is uncertain, the decision maker may determine that their influence is negligible.

Another risk variable stressed is the annual growth of demand. The base case indicated that the investment plan assumed would lead to some unserved demand. Stressing the risk variable of annual growth demonstrated that the net present value shows a tendency of increase with higher demand but at the same time the unserved demand reaches very high levels. This might have been overlooked if the risk variable of demand would not have been stressed. Stress analysis provides the decision maker with additional insight.

Finally, risk assessment increases the opportunity of identifying effects of changes in investment plans and comparing them with the base case both in terms of expected values and in terms of risk exposure.

10.3 Evaluation of Selection of Case

The selection of Tanzania's power sector as the case to be studied is based on a combination of factors. Tanzania is a developing country, currently receiving a large amount of financial support from different donor countries and agencies. TANESCO's own resources are limited and the company has received much government support. The power system has been extremely dependent on hydro power, but is currently trying to balance the system by investing in additional thermal generation. For this reason, the case is highly relevant for a quantitative risk analysis.

When carrying out the research, this choice of case has also revealed some drawbacks. TANESCO is currently in a weak financial position, and operates with tariffs that are shown not to be cost reflective. This has not been the best starting point, since all discussion concerning risk and risk aversion most commonly are applied on a positive financial result. Starting out with a negative net present value is clearly a disadvantage when demonstrating the potential of the method. However, as the purpose of the thesis is to demonstrate the method and not the case study result, this is still acceptable.

Secondly, gathering and verification of empirical data has met with some complications. The various sources used often diverge significantly, e.g. with regard to capital cost, generation cost of different plants, and details of IPP power purchase agreements. Therefore, the quantitative results may not be completely accurate. This has however been considered to be of less importance since the purpose of the thesis is to demonstrate a method, and not to produce specific results. Since for TANESCO, the specific result may have a greater significance than the method, an enhanced assessment is recommended in a close collaboration with TANESCO, to verify in detail the assumptions made. This is further discussed in chapter 11.

10.4 Evaluation of Analytical Tools

It is important to note, that the quantitative risk analysis applied in the thesis would be difficult to execute without the support of the analytical tools presented in chapter 6. The financial model is developed for the specific case study, and therefore the model has served it purpose in order to meet the objective of the thesis as well as reflecting the case. It would however be possible to modify the model for similar cases and analysis. The models ability to produce realistic scenarios of Tanzania's power system will be discussed in chapter 11. Using the risk analysis tool @Risk has been essential, although similar software is available. For the purpose of the thesis the @Risk program has been adequate, but it should be pointed out that @Risk exists in different versions with more advanced methods to apply as well, such as decision trees etc.

10.5 General Contribution

From the theoretical point of view, this thesis has demonstrated the possibility of successfully combining two theoretical tools, i.e. traditional tool for financial analysis such as discounted cash flow calculation combined with quantitative risk analysis. The resulting financial indicators, e.g. net present value, are presented in the form of a distribution function, providing the decision maker with information about both the most likely value of the indicator as well as its variation.

From a practical point of view, the thesis has resulted in the development of a new type of financial model, describing Tanzania's power sector, which should be useful as an additional tool for the power utility TANESCO as well as analysts in financial institutions and consultants. In particular, the financial risk analysis is helpful when trying to obtain a holistic view of a case affected by many uncertain variables.

10.6 Other Fields of Application

As mentioned in the introduction of the thesis, the method of risk analysis is of course applicable to other power utilities than TANESCO and other cases than investments in Tanzania's energy sector. The usefulness of the method is however not limited to the operating utility, but may also be practical tools for other decision makers. Moreover, the general method of quantitative risk analysis demonstrated in this thesis is in no way limited to investments in energy projects or to developing countries. However, for other investments, completely different risk variables may be critical, which may require modification of the general approach.

11. Reflections on the Case Study Result for TANESCO

In this chapter, an interpretation of the results from the perspective of TANESCO is provided, in particular the implications for its investment program and for its future financial situation. It is important to keep in mind that the input data used in the case study may not be fully accurate, and therefore the conclusions should be regarded as indicative more than real facts

11.1 Implications for TANESCO's Investment Planning

The financial result of the investment plan analysed, based on a real discount rate of 7%, shows a negative net present value (NPV), calculated over a period of 20 years, amounts to almost USD 1 billion for an investment program in the amount of USD 4.7 billion, indicating that the current tariffs do not cover all cost involved in new investments, generation and extension of the network. The present value of the cash flow from operating activities shows a positive value of USD 1.2 billion, indicating that revenues from sales cover the cost of generation, operation and maintenance. The revenues are, however, not sufficient to produce a positive cash flow when investment activities are included, which is essential for an investment program to be financially viable. An analysis of the appropriate tariff to attain a positive net present value indicates that a 37% increase of the tariff the first year of analysis would be needed. There is a significant variation in the NPV as a result of the risk simulations, indicating that the three risk variables, oil prices, hydrology and future demand do have a strong effect on the financial outcome of the investment plan.

With regard to unserved energy, the analysis shows that the investments in generation are fully appropriate, and even somewhat excessive, during the first 7 years of analysis, showing no risk for unserved energy during this period. With the assumption of a general annual growth of 10% with a variation amounting to 4% the last years of analysis, the demand will most likely not be served after year 2015. For the entire 20 year period of analysis, the proposed investment plan indicates an amount of total unserved energy amounting to a mean of 28 TWh. This effect appears at the end of the period of analysis, with an unserved demand reaching a mean of 25% of the total energy demand in the last year. Assuming a fictive cost of USD 0.5 per unserved kWh, the present value of the cost of unserved energy amounts to USD 4 billion. It can be concluded that there is an unbalance between future demand and generation capacity by the end of the period. The reason for this may be that the assumptions regarding future demand may be too optimistic, however, if this demand is to be met investment in generation need to be substantially larger at the end of the period.

The stress analysis performed on oil prices shows that, with oil price in the higher range for the whole period of analysis, the mean of the net present value decreases by an amount of USD 80 million. Keeping in mind that the proposed investment plan does not incorporate large investment in oil dependent facilities, the plan seems relative robust against oil price fluctuations. Considering the discussion previously regarding unserved energy, if no actions are taken in the mid term regarding investments in additional base load plants, the need for short term solutions based on oil may be necessary. This would imply a higher sensitivity to oil price fluctuations.

The stress analysis performed on the demand clearly shows that the mean of the net present value increases with a higher demand forecast, but at the same time the variation in net present value also increases. This is however expected, since higher demand leads to an increase in sales. At the same time, the investment plan is not appropriate for these demand growth assumptions, leaving the system with a high amount of unserved energy, which is not captured in the net present value. Without considering the cost of unserved energy one would have a misleading result.

The analysis of the base case investment plan indicates that, with the assumed tariff and using a discount rate of 7%, the investment plan is not financially viable. As a result of this observation, an analysis was performed of an extended investment plan including its effects on both unserved demand and the net present value. The extended investment plan includes a postponement of the Kinyerezi gas plant, and additional investment in both hydro power and coal fired power plants. With these assumptions, the net present value increases substantially at the same time as the amount of unserved demand is significantly reduced. However, even assuming an additional capacity of a total 1600 MW after year 2015, the system still does not meet an increase of demand of 10% annually over the next 20 years.

11.2 Limitations of the Financial Model

Even if the model is developed for the specific case analysed in the thesis, it does not reflect all details linked to Tanzania's power system, t his would have been impossible within the scope of the study. One should bear in mind that the purpose of the thesis is to demonstrate the use of risk analysis. The objective of the model is to comprehensively determine indicative financial results in an investment appraisal. Some drawbacks and limitations of the model with regard to its application to Tanzania's power system are addressed in the following.

The model does not take into account different alternatives in how to handle peak loads, as well as possible opportunities to use hydropower for regulation i.e. adjusting the generation to the daily load curve. This is expected to have minor effects on the financial result, but may reduce unserved energy.

In the model, the calculation of generation costs requires a categorisation of the different power plants and hence general data for each category regarding heat rate, fuel costs and operating and maintenance costs is used. Each plant naturally has its own characteristics, which is not considered in the model. The same holds for plant availability.

Further, the model does not take into account variation in annual growth in consumption depending on consumer categories. However, the applied general variation of annual growth is considered sufficient to reflect different demand scenarios.

In the model, cost of investment in generation plants is assumed to be paid in one year, i.e. the start year of operation. This does not represent the true cash flow, since normally payments of large plants are spread over several years. The effects on the NPV are taken into consideration by adding 25% to the original cost of investment for all large plants.

Finally, the model is developed as a tool for financial analyses and hence not adjusted for economic analyses. However, only minor modifications of the model are needed in order to perform an economic analysis. Assumptions and input data will nevertheless have to be treated differently.

11.3 Reflections on Financing

As mentioned in section 3.1, the investment analysis initially should be performed based on cash flow, and without considering how to obtain the actual financing. There is an obvious problem in choosing an appropriate discount rate if no market rates for similar investments exist. For this analysis a 7% real discount rate for USD was chosen.

It would be expected that TANESCO's capital investment plan will be funded through a carefully engineered financing package consisting of public, private, donor and own funds. Own financing consists of customer contributions, new loans and operational surpluses. Until TANESCO has become financially viable, most financing would have to come from bilateral and multilateral donor funds and government contributions. Once TANESCO's creditworthiness has improved, commercial lending is expected to be the major source of financing.

Since the financing structures for the capital investments are uncertain at the moment, financing has been excluded from the analysis. Considering the actual financing of the investments would lead to a modified cash flow and hence affect the financial result. It should also be pointed out that the discount rate applied in the analysis may not correctly reflect the actual opportunity cost of capital for TANESCO.

A risk that has not been considered is the exchange rate of domestic currency i.e. Tanzanian Shilling to foreign currency in USD, which has been increasing in the last years. This might have a significant effect on the financial result, since 80% of the investments are assumed to be incurred in foreign currency, while 100% of the revenues are collected in domestic currency.

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Tanzania's National Website: http://www.tanzania.go.tz

The Bank of Tanzania: http://www.bot-tz.org

The International Monetary Fund: http://www.imf.org

The Kenya Power and Lighting Company: http://www.kplc.co.ke

The National Bureau of Statistics: http://www.nbs.go.tz

The World Bank: http://www.worlbank.org

This Day: http://www.thisdayonline.com

Umeme (Uganda): http://www.umeme.co.ug

13. Glossary

Bulk Power Trading - The buying and selling of power between actors on the wholesale electricity market.

Capacity - The maximum load a generating unit, generating station, or other electrical apparatus is rated to carry or can actually carry under existing service conditions, expressed in kilowatts or megawatts.

Capacity Charge – The specific cost of capacity being purchased, often expressed in e.g. USD/kW.

Combined-cycle system - Energy system that takes the heat produced by the generation of electricity in a high-temperature gas-fired combustion turbine or other prime mover to create steam that generates additional electricity in a steam turbine.

Connection Charge - Fee paid by a customer for a connection to an electricity-utility's distribution system.

Demand - The total amount of electricity required at any given time by a utility's customers as expressed in kilowatts of megawatts or other units.

Demand Charge - Charge for the maximum rate at which energy is used during peak hours of a billing period.

Demand Charge - The amount to be paid by a large electricity consumer for its peak load usage level, usually expressed as USD/kW/month.

Distribution Line - A line or system for distributing power from the transmission system to customers. Distribution lines carry power at lower voltage than transmission lines.

Distribution System - The part of the electric system that delivers electric energy to consumers.

Elasticity of Demand - The ratio of percentage change in quantity demanded to the percentage change in price.

Energy Charge - The amount of money owed by an electric customer for kilowatt-hours consumed.

Facility - A plant where electric energy is generated from energy sources.

Heat Rate - A measure of generating station thermal efficiency. The heat rate is computed by dividing the total kilo Joule content of the fuel burned by the resulting net kilowatt hours generated, and is expressed in kJ/kWh.

Generating station – A facility where electricity is generated also referred to as power plant.

Generation - The process of transforming other forms of energy into electric energy.

Greenhouse Gases - Airborne water vapour, carbon dioxide and other gases that trap the sun's heat in the atmosphere. Increasing volumes of greenhouse gases in the atmosphere are thought to be causing a rise in average global temperatures.

Kilowatt-Hour (kWh) - Measure of electricity supply and consumption equivalent to 1,000 watts over the period of 1 hour.

Load - Amount of power consumed by a customer or electrical device. Often referred to as demand and expressed in kW or MW.

Load Duration Curve - A curve that displays load values on the vertical axis in descending order of magnitude against percent of time (on the horizontal axis) the load values are exceeded.

Load Factor - The ratio of the average load supplied to the peak or maximum load during a designated period.

Losses - The general term applied to energy or capacity lost in the operation of an electric system. Losses occur principally as energy transformations, transmission or distribution of the electricity.

Monte Carlo Simulation – A simulation technique that approximates the probability of certain outcomes by running multiple trial runs, using random variables.

Network - The total transmission and distribution system.

Outage - Time during which service is unavailable from a generating unit, transmission line, or other facility.

Peak Load - The amount of power necessary to supply customers at the point of maximum demand.

Power Plant - See generating station.

Power Purchase Agreement (PPA) - This refers to a contract entered into by an independent power producer and an electric utility. The power purchase agreement specifies the terms and conditions under which electric power will be generated and purchased. Power purchase agreements require the independent power producer to supply power at a specified price for the life of the agreement.

Tariff - A document, approved by the responsible regulatory agency, listing the terms and conditions, including a schedule or prices, under which utility services will be provided.

Transmission Line - Facility for transmitting electrical energy at high voltage from a power generation source to a substation. Transmission lines carry power at higher voltages than distribution lines.

Transmission System - An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers, or is delivered to other electric systems.