

**IMPACT OF WEIGHTED AVERAGE COST OF CAPITAL (WACC) ON
UTILITY-SCALE SOLAR PHOTOVOLTAICS (PV) LEVELIZED COST OF
ELECTRICITY**

By

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ABSTRACT

Namibia has one of the highest solar irradiation levels in the world, making it an ideal destination for renewable energy investments. The country receives an average of 300 days of sunshine per year. This means that there is an abundance of solar energy that can be harnessed for electricity generation using solar photovoltaic (PV) technology. The levelized cost of electricity (LCOE) is a key metric used to evaluate the financial viability of a solar PV project and is influenced by a range of factors that impact the cost of generating electricity from solar energy.

The parameters that affect LCOE for solar PV systems include solar irradiation, O&M cost, financing cost, inverter efficiency, system design, system lifetime, regulatory environment, and the weighted average cost of capital. These parameters can interact with each other, and changes to one parameter can impact the LCOE in different ways. Several studies have considered the sun's strength as the primary exogenous factor driving the cost of electricity and have treated other parameters such as the WACC, as largely endogenous and thus irrelevant to their analysis.

This study has analyzed how the weighted average cost of capital from twenty-six projects in Namibia between 2014 -2022, impacts the levelized cost of electricity of utility-scale photovoltaic. This study has shown that while both solar irradiation and the WACC are essential factors that influence the LCOE of a solar PV project, WACC has a more significant impact on the LCOE for solar PV projects than solar irradiation because the cost of capital represents a substantial portion of the total cost of a solar PV project, while solar irradiation mainly affects the electricity generation potential of the project.

DECLARATION

I, Severus Twahafa Shedile, declare that this research report is my own work except as indicated in the references and acknowledgments. It is submitted in partial fulfillment of the requirements for the degree of Master of Management in Finance & Investment at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Name: Severus Twahafa Shedile

Signature:



Signed at ...Windhoek...in..... Namibia

On the 20..... **day of** October..... 2023....

DEDICATION

I dedicate this thesis to my loving mother Tresia Elifas, and late father Serag Shedile. Meme you have always been my source of inspiration and motivation, you instilled in me the value of education and supported me throughout my academic journey.

I also dedicate this thesis to Pine, who provided assistance, support, love, and invaluable guidance throughout my master's degree.

Lastly, I would like to dedicate this thesis to my friends, and family who have been my constant source of encouragement and support. Their unwavering faith in my abilities has been a source of inspiration, and I am grateful for their friendship.

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CHAPTER 1. INTRODUCTION

Context of the Study

Sub-Saharan Africa (SSA) is one of the regions in the world with a chronic electricity supply shortage. More than two-thirds of people in sub-Saharan Africa have no electricity connection, which translates to about 600 million people. There has been robust economic and population growth on the continent over the last decade, which has been the key driver in an increase in the electricity demand. However, the region does not have enough generation capacity to meet the demand. Access to electricity is critical to fuelling any nation's economic growth and social development. (Eberhard et al., 2016)

Namibia is not immune to the energy pandemic that the rest of the SSA countries are facing energy insecurity. About 47% of the Namibia population has no access to energy, and according to the World Bank, in 2020, approximately 56.26% of the country's population had electricity (n.d.). Namibia is a country in Southern Africa, with an area of about 850 000m² (square kilometres) with a population of about 2.5 million, making it one of the less densely populated countries in the world (Olakunle Alao and Anton Eberhard, 2019). The Namibian electricity industry is relatively small and depends on the Ruacana hydro power station and power trades (imports) from the neighbouring countries.

Namibia is abundantly endowed with rich renewable energy resources such as solar and wind, which are readily accessible, untapped, safe, and clean, yet the country cannot locally generate electricity to meet its demand. The state-owned utility company, NamPower, only generates about 40% of the national demand, and 60% is imported from neighbouring countries. In 2018, NamPower imported 60% of the demanded electricity from the Southern Africa Power Pool (SAPP), Eskom (South Africa), ZESCO (Zambia), and ZPC (Zimbabwe) (MME, 2019). This has made Namibia to be a net importer of electricity. Eskom worsening electricity supply shortage has threatened Namibia's energy security, which has

led the government through the 2017 National Renewable Energy Policy (NREP) aims to achieve a minimum 70% share of GWh supplied from RES (wind, solar PV, CSP, biomass and hydropower) gradually by 2030 (MME, 2016). It will require considerable investment from both public and private sources if Namibia is to address the lack of generation capacity, and the sector is on the right path to address this challenge of the supply shortage through utility-scale projects by Independent Power Producer (IPP).

Utility-scale projects are power generation plants which are equal to, or greater than, 5MW, and they are developed, constructed, and operated by private investors, and the state-owned power utility is the off-taker of the generated power. The introduction of IPPs in Namibia's power sector has transformed the industry since 2014. Namibia had no renewable utility-scale IPP in 2014 and no private investors in the power sector. As of 2020, Namibia was ranked fourth in SSA with the most renewable-based IPPs. At least 31% of the generation capacity comes from renewable energy sources. Namibia's power sector transformation is accompanied by one of the lowest base tariffs in the region. In 2016, the Levelized Cost of Electricity from solar was US\$c 6.3/kWh, dropping to US\$c 2.9/kWh in 2020. (Kruger, 2022)

Levelized cost of electricity (LCOE) is an academic modelling tool used in literature to measure the average unit cost of electricity generation. The cost involved engineering procurement and construction (EPC), operational and maintenance (O&M) over the project lifetime period of the plant until the electricity connection point to the grid and the cost of financing (Vartiainen et al., 2020). The cost of capital associated with PV projects is either financed through debt (borrowing money from investment banks) or through equity (selling a portion of the project to equity investors). Irrespective of how the project is financed, the present value of all costs must be equal to the present value of all generated electricity sales. So, the most significant parameter that impacts the LCOE is the weighted average cost of capital (WACC) rate, which is determined by the ratio of debt to equity, cost of debt and equity (Harvey, 2020).

There are studies (Breyer, 2013) that have considered the strength of the sun as the primary exogenous factor driving the cost of electricity, and have treated other drivers of PV cost, such as investment and operating costs, as well as the cost of capital, as largely endogenous and thus irrelevant to their analysis. So, this study will analyse how the cost of capital impact the levelized cost of electricity of utility-scale solar photovoltaics in Namibia's power sector.

Research Problem

Namibia's electricity demand exceeded the installed local capacity in 2016, and the gap has widened since about 60% of the shortfall demand is imported from South Africa and the Southern Africa Power Pool through the short-term energy market (Kruger, 2022). The government is aiming to achieve a minimum of 70% generation capacity from renewable energy sources by 2030 (MME, 2016).

Namibia's urgency of alleviating its energy security, reduced fiscal space, and favourable energy policy have created a conducive environment for private power investors to participate through the Independent Power Producers projects. The success of these IPP projects will depend on the cost of capital that private developers have access to. The WACC can account for 20-50% of the levelized cost of electricity of utility-scale solar PV projects, so lower financing costs are critical for the affordability of electricity (IEA, 2021).

The cost of capital is an important input to the calculation of the levelized cost of electricity (LCOE), as it determines the rate by which both costs and electricity yields are discounted over the lifetime of a solar PV system (Ondraczek, 2015). This research analyses how the project cost of capital and capital structure which effectively form the weighted average cost of capital (WACC), impact the levelized cost of electricity of utility-scale photovoltaic in Namibia.

Research Objectives

The research aims to examine the impact of the weighted average cost of capital on the utility-scale solar photovoltaic levelized cost of electricity in Namibia. The study analyzes various solar PV projects from 2014 until 2022.

It focuses on the LCOE model by focusing on the following parameters:

- Project capital structure
- The project cost of debt and equity
- Project escalation factor (rate)
- Calculate the weighted average cost of capital (WACC)
- Capital expenditure (CAPEX)
- Operational and maintenance cost (O&M)

Significance of the study

This study provides insight into the significance of the cost of capital in providing a critical benchmark to assess investors' risk and return preferences and determine the base tariffs that utility-scale solar developers and utility companies sign for long-term power purchase agreements.

Policymakers lack access to reliable financing metrics across sectors and geographies, especially in Namibia. Flawed assumptions around the cost of capital can lead to the mispricing of risk and the potential for under- or overinvestment in the power sector. So, policymakers can use this consolidated research in analysing the impact of the cost of capital on past and future utility-scale PV projects.

Delimitations of the study

While the levelized cost of energy (LCOE) is a useful metric for comparing the cost of different energy sources, its use has some limitations. It doesn't consider

externalities, LCOE does not consider external costs or benefits, such as the environmental or social impacts of energy generation. It doesn't consider system integration, LCOE does not consider the costs and challenges associated with integrating renewable energy sources into the existing energy system, such as the need for backup power or grid upgrades. LCOE is a useful tool for comparing the cost of different energy sources, it should be used alongside other metrics and considerations to fully evaluate the costs and benefits of an energy project.

All projects analysed in this study are in the Namibian solar PV industry, with off takers either the national utility company or trading on the Southern Africa Power Pool. Namibia started its Renewable Energy Feed-in Tariff (REFIT) program in 2014, and as a result, most of the financial information is concealed by financiers and developers. The researcher acquired data for twenty-six (26) projects from a possible thirty-six (36) projects installed in Namibia upon the writing of this research. There is generally a lack of information related to solar PV projects in Namibia in the public domain, which has constrained the study from using actual data to make some assumptions.

Battery storage is one of the most important parameters in the LCOE calculation model in certain situations, such as when evaluating the costs and benefits of a renewable energy project that includes energy storage. Still, due to Namibia's high cost and relatively underdeveloped industry, this study has not considered battery storage as a parameter. Furthermore, it has not included the decommissioning costs involved at the end of the power plant life span because none of the projects has reached its lifespan yet in Namibia.

Structure of the report

This paper's outline is as follows:

- i. Chapter 1 – Introduction: This chapter provides background on the Namibian electricity industry and the importance of this study.
- ii. Chapter 2 – Literature Review: This chapter includes a review of publications including journals, studies and papers reflecting the work that has already been conducted on the levelized cost of electricity globally. This assisted in highlighting the identified areas which need further research work or the gap that exists in this area of research.
- iii. Chapter 3 – Methodology: the study's research technique is discussed in this chapter. There are descriptions of the study's geographic scope, methodology, population, and sample. The data collection tool is detailed, along with the techniques used to maintain the tool's reliability and validity.
- iv. Chapter 4 – Results and Discussion: This chapter covers the results and discussions of the study.
- v. Chapter 5 – Conclusion: this section covers the empirical results obtained concerning the initial objectives of the study.

CHAPTER 2. LITERATURE REVIEW

Introduction

This section contains a brief synthesis and critical evaluation of the literature review on the effect of the cost of capital on the unit cost of photovoltaic electricity generation in Namibia and around the world. This section covers the following theoretical topic: financing of renewable projects, cost of capital for renewable projects, levelized cost of electricity, escalation factor (rate), Experience learning curve, and the impact of solar irradiance and cost of capital on the levelized cost of electricity.

Financing of Renewable Projects

New energy power projects are either financed by public or private investors, and there are two main financing structure alternatives, corporate and project financing (Steffen, 2018). When a project is financed through corporate finance, a credit guarantee for the project is extracted from the sponsor (company) balance sheet and existing project cashflows. On the other hand, the project finance model creates a new special purpose vehicle (SPV) which is legally and commercially self-contained and serves only to realise the project. The SPV is financed without guarantees from the sponsors, such that lenders to the SPV depend on future project cash flows only and cannot recourse on the sponsors' other businesses (Steffen, 2018).

According to the Basel II framework, project finance has been defined as: “a method of funding in which the lender looks primarily to the revenues generated by a single project, both as the source of repayment and as security for the exposure. [...] In such transactions, the lender is usually paid solely or almost exclusively out of the money generated by the contracts for the facility's output, such as the electricity sold by a power plant. The borrower is usually an SPE that is not permitted to perform any function other than developing, owning, and

operating the installation. The consequence is that repayment depends primarily on the project's cash flow and on the collateral value of the project's assets" (Basel II, 2009, p. 5) Project financing model has mainly been used traditionally for big, high-risk projects where firms want to protect and decouple their core business from a future potential of project failure and, as a result, it comes with a higher transactional cost compared to corporate financing. Since lenders only rely on expected cash flow as a guarantee, proper due diligence needs to be carried out to ensure that projected cashflows are in check. Hence transactional costs such as contractual, commercial, technical, and legal checks can account for about 5-10% of the project value (Li, 2019; Steffen, 2018).

There has been a global surge in capital projects financed through the project financing model. As shown in the figure below, project finance has increased from 16% in 2004 to 52% in 2014. The large share increase in project finance is in parallel with the investment in renewable energy (Steffen, 2018).

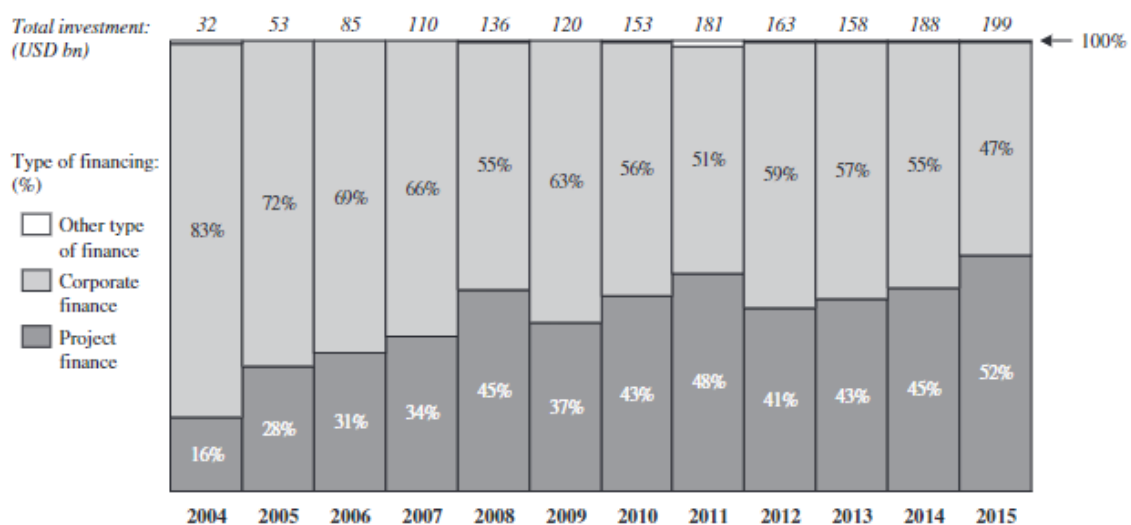


Figure 1. Project Financing in Germany

The research carried out by (Steffen, 2018) analysed how power projects are financed in Germany, which is an ideal place for this study due to its low-risk electricity generation sector and its efficient capital market. The results indicate that most utility-scale power projects in a range of 10-20 MW capacity are 83% project financed and only 17% are corporate-financed, as shown in the figure

below (Steffen, 2018). Most utility-scale projects that are installed in the Namibian generation power sector are in a range of 5-20 MW capacity, which resembles Germany's scenario (Kruger, 2022).

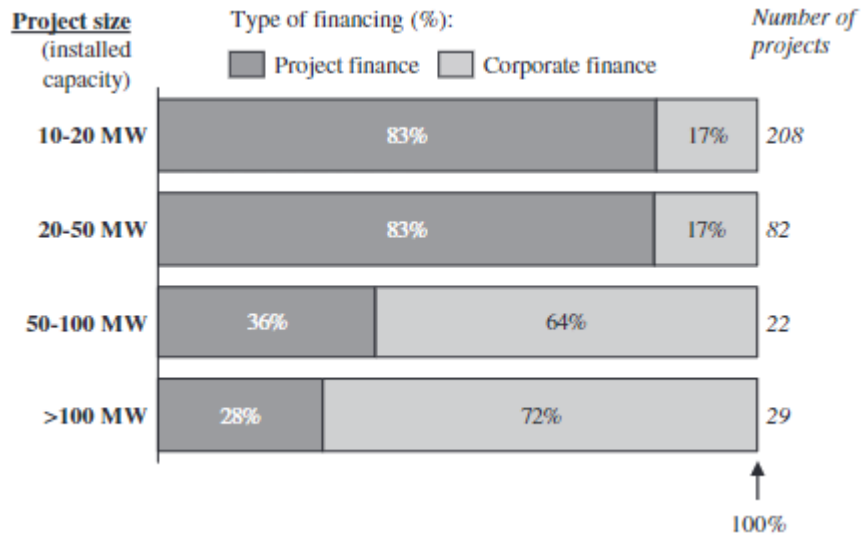


Figure 2. Project Financing in Namibia

If we analyse the paper (Steffen, 2018) further on how different types of power technology are being financed, the research has shown that 96% of solar PV projects are preferred to be financed through project finance, as shown in Figure 3 below (Steffen, 2018).

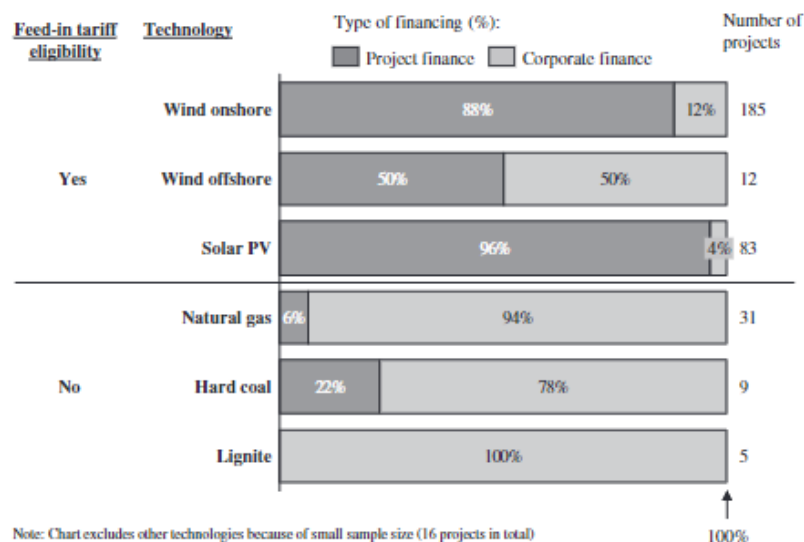


Figure 3. Solar PV projects financed through project finance

Project financing is preferred over corporate finance for renewable generation power projects for several reasons such as contamination risk, debt overhang, securitization, information asymmetry between sponsor and lenders, and the independence of the civic project. This research was carried out in a low-risk country with a well-developed financial market and the conditions will be different to Namibia which is a developing country. So, this research will assume that solar projects are funded with project finance, which will also affect the cost of capital.

Cost of Capital for Renewable Projects

The cost of capital expresses the expected financial return, or the minimum required rate, for investing in a project. This expected return is closely linked with the degree of risk associated with project cash flows. Cost of capital is also referred to as financing costs, discount rate, or hurdle rate commonly used terms, though this refers to the minimum cost of funds, or internal rate of return (IRR), required to fund a particular investment, in contrast to the overall cost of funds for a firm(IEA, 2021).

The cost of capital is the sum of a base rate plus a premium. The base rate incorporates the return on investment with low perceived default or reinvestment risk in a benchmark global economy such as the United States. The premium accounts for the risk perceptions associated with a specific investment and can be grouped into two categories: systematic and unsystematic risks. Systematic risks are difficult to avoid, while unsystematic risks can be managed through portfolio diversification (IEA, 2021).

The cost of capital also reflects the funding structure of a project. It is calculated as the weighted average between the costs of debt and equity. The cost of debt is the interest rate (or yield) that the project can secure from lenders (or bond subscribers). Cost of equity is the financial return expected by shareholders in exchange for providing capital; it is also referred to as the expected return on equity (IEA, 2021).

Renewable energy projects can be financed either by the project developers and are referred to as internal financing, through equity investors, which occurs when a portion of the project is sold to external equity investors, or through the borrowing of money from banks or investors which is referred to as debt financing. Equity investors are usually pension fund managers, other companies, bank equity fund managers or equity funds. On the other hand, debt financing is usually supplied by investment banks (Harvey, 2020).

Renewable energy requires a large sum of start-up capital; hence the cost of capital makes up a significant portion of the cost during the project lifecycle. It has been reported that the cost of capital can make up about 50% of the LCOE for solar PV projects in developing countries, and in a developed country like Germany, the cost of capital accounts for about 12-37% of the LCOE. Renewable energy projects are mainly financed through private cost capital. (Steffen, 2020)

Private financing of renewable energy projects structure usually comprises non-traded equity investments with a bank debt financing model, which is not available in the public domain like corporate financing setup, that is available from publicly traded platforms. Since the cost of capital is kept as confidential information to developers and bankers, this poses a challenge to researchers and policymakers to find suitable empirical data to verify the actual project figures. To make up for the lack of information on the cost of capital, scholars use three main methods for calculating or measuring the cost of capital in literature: average cost of capital, internal rate of return and the weighted average cost of capital (Li, 2019; Steffen, 2020).

Levelized Cost of Electricity

The levelized cost of electricity (LCOE) is a metric used to measure and compare the unit cost competitiveness of different energy generation technologies to determine grid parity. LCOE calculates the unit cost of electricity over a photovoltaic project's lifetime, including construction costs, operating and maintenance, and financing costs. Generally, LCOE is calculated by taking the

total cost of a project and dividing it by the total energy production over a lifetime (Jung, 2019). Alternatively, total capital investments (NPV) over the discounted energy yield. The project breaks even when the NPV reaches zero. (Sung, 2019) (Aldersey, 2019)

The LCOE is a worldwide indicator which provides us with the minimum required tariff to recover the project costs over a lifetime, but in the actual business world, it's not a perfect approach when it comes to a financial point perspective (Jung, 2019). The results produced by the LCOE calculation only include the project costs but do not include basic financial concepts of revenue and profit. But still, the results produced are informative in the energy generation industry for comparing different technologies. (Aldersey, 2019) There are two widely used LCOE methods discussed below.

1.1.1 *National Renewable Energy Laboratory (NREL) - USA*

The method used by the US department of energy for LCOE calculation is referred to as NREL or annualizing method. This method calculates total costs over an annual period and divides them by the energy generated in the same period. Capital costs are expressed in terms of cost per kW installed and modified by a capital recovery factor which calculates the equivalent annuity payment required to service the overnight capital over the term of the project's financing, and operating costs are expressed in terms of cost per kWh. (Sung, 2019) (Aldersey, 2019)

NREL methodology states that the LCOE returned by its formula is “the minimum price at which energy must be sold for an energy project to break even”, meaning that the energy price required for a project to exactly meet its operating costs in a year and the share of capital costs (including the costs of financing those costs) in that year.

Department for Business, Energy & Industrial Strategy (BEIS) – UK

The LCOE BEIS method is used in the United Kingdom, defined as “the discounted lifetime cost of ownership and use of a generation asset, converted into an equivalent unit of cost of generation in £/MWh” (Aldersey, 2019, p. 4). BEIS method calculates the lifetime cost of energy for the project by considering the cost over the duration of a project. This method divides the discounted sum of costs by the discounted sum of energy production.

Although the BEIS method states that LCOE “should not be seen as a guide to potential future strike prices”. It is apparent that it reflects a minimum required real price for a project. A similar analysis finds that if nominal costs with constant inflation factors are used as inputs, and the nominal inflation rate scales up the discount rate, this method returns the average through-life nominal price required for the project to achieve an IRR equal to the nominal discount rate. When used with real costs, the metric returns a value which equates to the minimum constant real price required for a project to achieve a target return. When using nominal figures, and a nominal discount rate, it will return the average nominal price required through the project's life to generate the required nominal return (Aldersey, 2019) (Sung, 2019).

To the best knowledge of the author, there is no published theoretical justification for the BEIS methodology found in the literature.

The following section will review some of the LCOE studies that have been done around the world, starting with Europe:

LCOE in Europe

Europe is one of the continents with the least solar irradiation in the world, yet they have seen the greatest development in utility-solar PV. This is due to their advanced financial market and strong energy policies which were implemented in the 2000s. There is a study by (Vartiainen et al., 2020) on the impact of the

cost of capital on utility-scale PV LCOE analyzed and projected future LCOE in several European countries.

The study used the most recently available public input data from Finland, UK, Germany, France, Italy, and Spain to project future LCOE from 2019 – 2050. This study varied different nominal WACC rates in the analysis: 2%, 4%, 7%, and 10%. The capital structure used is a 70/30 debt-to-equity ratio. Figure 4 below shows Photovoltaics' levelized cost of electricity in six European locations for the years 2019 to 2050.

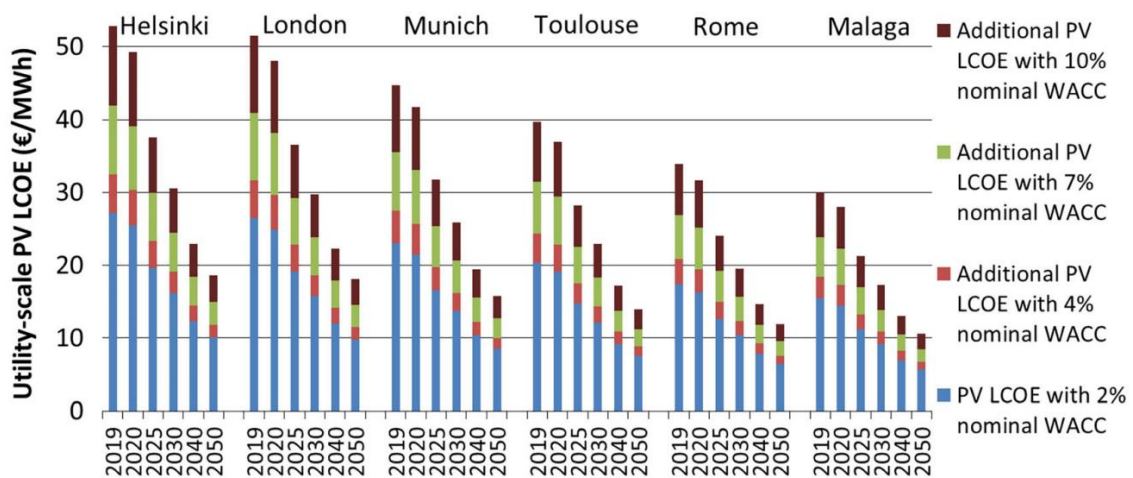


Figure 4. Photovoltaics levelized the cost of electricity in six European locations for the years 2019 to 2050

Figure 4 above shows that with a 7% nominal WACC, the LCOE in Helsinki and Malaga ranged from 24 - 42 €/MWh in 2019. In 2030 and 2050, the LCOE for these two cities is expected to be in the range of about 14 – 24 €/MWh and 9 – 15 €/MWh, respectively. This projection study shows that if the WACC increases from 2% to 10% the levelized cost of electricity will double, meaning that WACC has a huge impact on the LCOE.

Impact of Solar Irradiance vs Cost of Capital on LCOE

Researchers such as (Breyer, 2013) have treated the cost of capital as an endogenous factor when it comes to determining the levelized cost of electricity and mainly considered solar irradiation as the primary exogenous that mainly drives the average cost of electricity. But if we look at the table below (Ondraczek, 2015), countries with the highest cost of capital are all located close to the equator with high solar strength, meaning that high solar irradiance doesn't translate to a low cost of electricity. Ondraczek, 2015 has shown in his paper that factors that influence the levelized cost of electricity for solar PV are more than just the strength of the sun.

Table 1. Countries with the highest cost of capital

Five highest and lowest countries for GHI, WACC, LCOE and difference between LCOE and grid price, assuming global average investment costs.

	Population-weighted GHI ^a	Weighted average cost of capital	Levelized cost of electricity	Delta between LCOE and grid price
	[kWh/m ² /a]	[%]	[USct/kWh]	[USct/kWh]
Highest ranked countries:				
1.	Niger (2382)	Japan (3.7)	Spain (29.7)	Spain (6.7)
2.	Namibia (2352)	Ireland (3.8)	Puerto Rico (31.0)	Italy (8.1)
3.	Djibouti (2318)	Switzerland (3.9)	Japan (32.2)	Japan (10.2)
4.	Grenada (2317)	UK (4.1)	Israel (32.9)	Cyprus (12.1)
5.	Botswana (2302)	Netherlands (4.3)	Malta (33.4)	Malta (12.4)
Lowest ranked countries:				
139.	Belgium (1203)	Sao Tome & Principe (21.6)	Kyrgyz Rep. (81.3)	Kyrgyz Rep. (79.3)
140.	Finland (1181)	Brazil (28.4)	Madagascar (99.4)	Georgia (79.8)
141.	UK (1128)	Madagascar (29.0)	Brazil (108.1)	Brazil (87.1)
142.	Norway (1103)	Congo DR (32.4)	Congo DR (124.6)	Congo DR (120.6)
143.	Ireland (1055)	Zimbabwe (254.9)	Zimbabwe (772.5)	Zimbabwe (771.5)
Median value:	1939	12.8	53.8	38.6

The journal article titled - WACC the dog: The effect of financing costs on the levelized cost of solar PV power investigated the importance of the cost of capital as a driving factor in determining the cost of electricity from solar PV. The paper estimated LCOE from 143 countries across the world, by populating the global LCOE model with input parameters such as Engineering Procurement Construction (EPC) costs, Operation and Maintenance (O&M) costs, cost of finance and decommissioning costs (Ondraczek et al., 2015, p. 893).

The result of the study (Ondraczek, 2015) has found a strong association between the weighted average cost of capital and the levelized cost of electricity for solar PV, which is 0.82. On the other hand, there was no strong correlation between the country's solar irradiance and the LCOE. This is a suggestion that

countries with a well-developed financial market (developed) like Germany have lower LCOE even though their sun is not the strongest.

Even though the results from (Ondraczek, 2015) clearly indicate that the weighted average cost of capital has a bigger influence on the LCOE than the solar radiation, some of the data inputs that were used in the computation are not specifically for renewable projects. In countries where project-specific data are not available like lending interest rates, the data was collected from IMF loans for prime customers, which is different from loans that lenders will avail to renewable projects, which might carry more risk. Some of the rates from the IMF appear to be high compared to the actual solar PV projects. Evidence from the literature (IEA, 2021) suggests that Germany's actual WACC is in the range of 4-6%, but the calculated one is 9.2%, which is way above. This can lead to an LCOE which might be under or overestimated for a specific country.

Furthermore, the analysis of this study mainly focused on the global average cost of installing a commercial (50kW) and residential (10kW) solar system (Ondraczek, 2015). Economies of scale play a big role when it comes to determining the cost of electricity as the overall cost declines with an increase in capacity (Hummel, 2001). This means that the LCOE of 50kW will be higher than the utility-scale solar project of 5MW. So, the study by (Ondraczek, 2015) and (Breyer, 2013) give an indication of the influence of solar radiance and the cost of electricity, but they do not address how the WACC impact the LCOE on a utility-scale and the researcher aims to tackle this gap.

CHAPTER 3. RESEARCH METHODOLOGY

This thesis was conducted using a quantitative approach. Bhandari (2020) defines quantitative research as the process of collecting and analysing numerical data, which can be used to make predictions, test relationships, and generalize results to wider populations. This thesis assesses the impact of weighted average cost of capital (WACC) on utility-scale solar photovoltaics (PV) levelized cost of electricity (LCOE), as well as the effect major components attributing to LCOE have on it. After examining the conceptual foundations of the study, the data collection methods are described. During the examination of the relationships of the components to LCOE, the data used, and the interpretations discussed, the thesis further explores the parameters considered, and the justifications for each selection as the impact of WACC on LCOE is analysed. A brief description of the study's setting is followed by a discussion of the sampling strategies used and selected, a discussion of the processing methods, and a summary of the study design's constraints. The techniques used to maintain the tool's reliability and validity are detailed.

RESEARCH APPROACH AND DESIGN

Research Design

Durakovic, 2021 reiterates that in the recent years, the society is witnessing growing share of renewable energy projects as an effort towards decarbonised economy and more sustainable future. He further states that in the evaluation of different renewable energy technologies, Levelized Cost of Electricity (LCOE) is most common measure that investors use a criterion for project prioritization. (Baptiste, 2018) agrees solar energy will become one of the main generation technologies and its intermittency will result in important changes in the energy system. In his paper, Durakovic, 2021 stresses that considering that most renewable energy technologies have low or zero fuel cost with the fact that they

are capital intensive, the weighted average cost of capital WACC commonly have most critical impact on LCOE.

According to (Park et al., 2021), many reputable institutions and government agencies provide LCOE, to which they apply different levels of discount rates to reflect project risk. To this end, the weighted average cost of capital (WACC) is frequently used as a proxy for project risk-adjusted discount rate. LCOE estimation is critical in supporting both policymakers and investors in key investment decisions or the determination of the most viable energy mix. However, the traditional method of calculating the LCOE cannot reflect the individual status of risk per variable because it depends on a deterministic method using a WACC. The WACC does not apply a specific level of risk in a target project since it is approximated from comparable projects or industry averages. (Shah, 2018) clearly outlines the importance of the varying components that go into calculating LCOE, and the effect they have on investment decisions and therefore the implementation of the project.

This is an explanatory research study because, in addition to offering a narrative, it attempts to explain why certain events occur with limited information (George & Merkus, 2021). It is possible to describe the study's research methodology by focusing on the 26 projects made available for the research. To conduct the study holistically, all connections and activities inside and outside the study's environment were considered. Several data gathering methods were used throughout this procedure in order to get a broad idea of the research. Since certain data were obtained based on one point and time while other data were acquired on several points and times, a combination of cross-sectional and longitudinal methodologies were employed to perform an extensive study.

Research Approach

In a quantitative approach, collecting, analysing, and interpreting numerical data are the main objective. Databases and organizational records are typical methods for gathering quantitative data. Bhandari, 2020 states that researchers may use a quantitative approach to find patterns and averages, make predictions, test casual relationships, and generalize results to wider populations. Below follows variables that will be studied and their justification.

Weighted Average Cost of Capital

The WACC is an important factor in the LCOE calculation because it reflects the overall cost of the capital invested in the project, including both the cost of equity and the cost of debt. The cost of equity represents the return required by investors to compensate them for the risk of investing in the project, while the cost of debt represents the interest rate paid on any loans used to finance the project. (Aldersey, 2019; Shah, 2018; Vartiainen et al., 2020)

Since solar energy projects typically require a significant amount of upfront capital, accurately estimating the WACC is critical for evaluating the economic feasibility of the project and determining its LCOE. A higher WACC will result in a higher LCOE because the higher cost of capital will increase the overall cost of the project. (Shah, 2018)

Moreover, the WACC can be influenced by various factors such as interest rates, inflation, credit rating, and market conditions. Therefore, understanding the impact of these factors on the WACC and how it affects the LCOE is crucial for making informed investment decisions and evaluating the economic feasibility of solar energy projects.

Capital Expenditure (CAPEX)

As suggested by the white paper (Carroll, 2022) Capital expenditures are a significant component of the total cost of building and operating an energy project, and therefore they are an important factor in determining the levelized cost of

energy (LCOE). CAPEX includes all the costs related to the initial construction and installation of the project, such as land acquisition, engineering, procurement, and construction (EPC) costs, as well as the cost of equipment, materials, labor, and other necessary expenses. The CapEx also includes the financing costs, such as interest on loans, and any contingencies for unexpected events that may arise during the construction. (Li, 2019; Steffen, 2020)

The higher the CapEx of a project, the higher the initial investment required to build it, which may have a significant impact on the LCOE. This is because the LCOE calculation includes the total cost of the project over its entire lifetime, which means that the initial CapEx investment will be spread out over the project's operating life. A higher CapEx will therefore result in a higher LCOE, all else being equal. (Shah, 2018; Steffen, 2020)

Moreover, CapEx also plays an important role in determining the financing and the return on investment of the project, which can have a significant impact on the overall profitability and viability of the project. Therefore, accurately estimating CapEx is critical to the success of an energy project and understanding its impact on the LCOE is essential for making informed decisions and evaluating the economic feasibility of different projects or technologies.

Operations and Maintenance

O&M (Operations and Maintenance) costs are an important factor in determining the levelized cost of energy (LCOE) for solar energy projects. O&M costs refer to the ongoing costs associated with operating and maintaining the solar panels and other equipment used to generate electricity. Solar panels are exposed to the elements and can degrade over time due to weather, soiling, shading, or other factors, which can reduce their performance and efficiency. To maintain optimal performance, regular cleaning, inspection, and maintenance of the panels and other equipment are necessary. These O&M costs can include labor costs, equipment and material costs, and overhead costs.

The O&M costs for solar energy projects can have a significant impact on the LCOE because they represent a significant portion of the total cost of the project over its lifetime. The O&M costs are typically spread out over the entire operating life of the project, which means that the ongoing costs will impact the overall profitability and competitiveness of the project. Moreover, as solar technology continues to evolve, the O&M costs may also be affected by advances in technology, changes in regulations or standards, and other factors that may impact the efficiency and reliability of the system. Therefore, accurately estimating the O&M costs and accounting for them in the LCOE calculation is critical for evaluating the economic feasibility of solar energy projects and making informed investment decisions.

RESEARCH SETTING

The study was conducted in Namibia, Sub-sahara Africa. The Namibian government introduced the renewable energy feed-in tariff (FIT) program in 2014, which aims to incentive the deployment of utility scale renewable energy system. Under the FIT program, independent power producers (IPPs) are encouraged to invest in and install renewable energy systems, such as solar photovoltaic (PV) and wind turbines, with a capacity of up to 5 MW. The electricity generated by these systems is then sold to Namibia's national power utility, NamPower, at a fixed price for a period of 25 years. (MME, 2019)

The FIT program aims to support Namibia's renewable energy targets, which include achieving 70% of its electricity generation from renewable sources by 2030. Since its launch, the FIT program has attracted interest from local and international investors, and several utility-scale renewable energy projects have been developed and connected to Namibia's national grid (Harvey, 2020). This study analyzed twenty-six projects in Namibia which have been constructed between 2014 to 2022.

THE STUDY POPULATION AND SAMPLE

According to (Krieger, 2012), a population is defined as the whole collection of units from which a sample may be drawn. The study population consists of solar PV projects in Namibia.

A convenient sample of 26 PV systems was selected. (Creswell, 2012) defines a sample as a subgroup of the target population that the researcher plans to study for generalizing about the target population. “A convenience sample is a non-probability sample in which the researcher uses the subjects that are nearest and available to participate in the research study” (Crossman, 2019). Available subjects were entered into the study until a sample size of 26 was reached. Subjects who met the sample criteria were identified by the researcher and personnel at several different electricity-providing institutions.

The sample size of 26 PV systems was the total of subjects who were willing to participate in the research and who met the sampling criteria during the two-month period of data collection.

The Sampling Criteria

Subjects included in the sample were selected to meet specific criteria. The PV systems had to meet the following criteria to be included in the sample. They should have the following parameters available:

- Installation capacity >5MW: Only projects with an installed capacity of 5MW or more have been sampled and considered utility-scale solar PV project because they generate electricity for utility-scale power grids (Kruger, 2022, p. 1).
- Project capital structure: The project capital structure is important for the levelized cost of energy (LCOE) because it can significantly impact the cost of financing the project and the cost of capital. The cost of financing and capital structure can then have a direct impact on the LCOE.

- **Weighted Average Cost of Capital:** The WACC is an important factor in the LCOE calculation because it reflects the overall cost of the capital invested in the project, including both the cost of equity and the cost of debt. The cost of equity represents the return required by investors to compensate them for the risk of investing in the project, while the cost of debt represents the interest rate paid on any loans used to finance the project.
- **Project escalation factor (rate):** The escalation rate refers to the rate at which costs are expected to increase over time due to inflation, changes in technology, and other factors. As the cost of generating electricity increases over time, the LCOE of a project will also increase.
- **Capital expenditure (CAPEX):** CAPEX is a significant parameter of the total cost of building and operating an energy project, and therefore they are an important factor in determining the LCOE. CAPEX includes all the costs related to the initial construction and installation of the project, such as land acquisition, engineering, procurement, and construction (EPC) costs, as well as the cost of equipment, materials, labor, and other necessary expenses.
- **Operational and maintenance cost (O&M):** The O&M costs for solar energy projects can have a significant impact on the LCOE because they represent a significant portion of the total cost of the project over its lifetime. The O&M costs are typically spread out over the entire operating life of the project, which means that the ongoing costs will impact the overall profitability and competitiveness of the project.

DATA COLLECTION

Data Collection Instrument and Procedure

Most of the projects are spread all over Namibia, hence it was not possible to visit every site for data collection due to time and cost constrain. A cost-effective approach of contacting various stakeholders via email as attached in APPENDIX

C – Data Collection Instruments was used. Furthermore, email requests were followed up through telephonically.

A Microsoft Excel attached in APPENDIX C – Data Collection Instruments was created adopted from the Electricity Control Board database of the commercial installed renewable energy projects in Namibia. The excel sheet was chosen as the data collection instrument for ease of manipulation. The excel sheet was shared with participants to provide inputs for their respective projects. They were requested to provide the base tariff, escalation (inflation) rate, capital structure, cost of debt/equity, capital expenditure and the fixed operational and maintenance cost. Solar irradiation for Namibia were acquired from the global atlas database.

Quantitative data analysis methods are utilised in this study, where the data acquired from the Development Bank of Namibia, IJG Namibia, NORED Electricity, Electricity control board of Namibia, Bank of Namibia and Global solar atlas database were converted and manipulated in into the Microsoft Excel format.

RELIABILITY AND MANIPULATION

Reliability

According to IBO (As Cited by John, 2015), reliability is the accuracy of measurement resulting from an assessment and how likely it is that the same result will be produced in a slightly different circumstance. The Microsoft Excel sheet was given to different stakeholders in the electricity industry to provide input information from databases. Reliability is ensured as sources were minimised. Data collection bias was minimised by the researcher as the conditions of data collection have no personal linkage to the researcher.

Validity

The validity of an instrument is the accuracy of the measuring instrument in performing its measuring function (Sudaryono et al., 2019). Content validity refers to the extent to which an instrument represents the factors under study. Parameters were chosen based on information gathered during the literature review to ensure that necessary information has been included. The Microsoft Excel sheet was provided to institutions personally. Clear instructions were provided. For validation, the sheet was submitted to the supervisor and a statistician. As a result, more parameters were added for ease of analysis and validity.

ETHICAL CONSIDERATIONS

The conducting of research requires not only expertise and diligence but also honesty and integrity. This is done to recognise and protect the rights of project developers and financiers. To render the study ethical, the researcher asked for consent to include the 26 chosen PV systems in the study, and the researcher was thus required to sign non-disclosure agreements.

DATA ANALYSIS

Once in Microsoft Excel format, manipulation of raw data to extract information was done as follows:

- I. Firstly, the PV systems were listed in chronological order of development from the first year, 2014, to the latest year, 2022.
- II. Secondly, WACC (%), the most crucial parameter affecting the LCOE, was calculated for each system, using the following formula:

$$WACC = \text{cost of equity} \times \%Equity + \text{cost of debt} \times \%Debt \times (1 - \text{Tax Rate}).$$

Equation 3:1

Where Namibian Tax Rate = 32%.

III. The LCOE (c/kWh) was then calculated for each system with the formula:

$$LCOE = \frac{NPV \text{ of Total Costs Over Lifetime}}{NPV \text{ of Electrical Energy Produced Over Lifetime}} \quad \text{Equation 3:2}$$

IV. The chi-Square test was done to test the significance of the relation between WACC and cost of debt and equity, and the relationship between LCOE and major contributing factors. This test was done using the SPSS IBM Statistics tool and was found suitable as it tests for association and significance.

Significance testing was done on the null hypothesis at a 5% level of significance, using the t-test to check the significance of the data and the results.

V. A Correlation test was calculated to test the relationship between WACC and cost of debt and equity, and the relationship between LCOE and major contributing factors. The test was done using the IBM SPSS Statistics tool to test the effect these components have on each other if any.

VI. A trend line was used to study the changes in WACC over the 8 years.

VII. Cronbach's Alpha was used to test the reliability of the data collected.

The research problem examined using the above methodology is given below:

the impact of the weighted average cost of capital on the utility-scale solar photovoltaic levelized cost of electricity in Namibia. The study will analyse various solar PV projects from 2014 until 2022.

CONCLUSION

The researcher used a quantitative research design. A Microsoft Excel sheet was administered by the researcher himself to collect the data from different stakeholders in the electricity industry in Namibia. The sheet has 15 parameters. The sample included 26 willing participants in the form of solar PV projects. Consent was obtained from all stakeholders. Non-disclosure agreements were

signed. The Microsoft Excel sheet was distributed to the institutions to ensure validity.

This chapter discussed the research methodology, the sample chosen, the data collection techniques and instruments, and the ethical standards, reliability and validity of the study.

CHAPTER 4. RESULTS AND DISCUSSION

Analysis Used

The study analyzed various solar PV projects from 2014 until 2022 in Namibia. The analysis focuses on the relationship between the levelized cost of electricity (LCOE) and with major components.

Two major formulae were used, the WACC (%) and LCOE. They are

WACC formula:

$$WACC = \text{cost of equity} \times \%Equity + \text{cost of debt} \times \%Debt \times (1 - Tax Rate).$$

Equation 3:1

Namibian Tax Rate = 32%

The study focused on the LCOE model as shown in the formula below:

$$LCOE = \frac{NPV \text{ of Total Costs Over Lifetime}}{NPV \text{ of Electrical Energy Produced Over Lifetime}}. \quad \text{Equation 3:2}$$

The formula above can be simplified as shown below:

$$LCOE = \sum \frac{\frac{(I_t + M_t + F_t)}{(1+r)^t}}{\frac{E_t}{(1+r)^t}} \quad \text{Equation 4:1}$$

Where:

The initial cost of investment expenditures (I)

Maintenance and operations expenditures (M)

Fuel expenditures (if applicable) (F)

The sum of all electricity generated (E)

The discount rate of the project or the weighted average cost of capital (WACC) (r)

The life of the system (t)

Analysis of Results & Discussion

1.1.2 Effect of WACC on LCOE

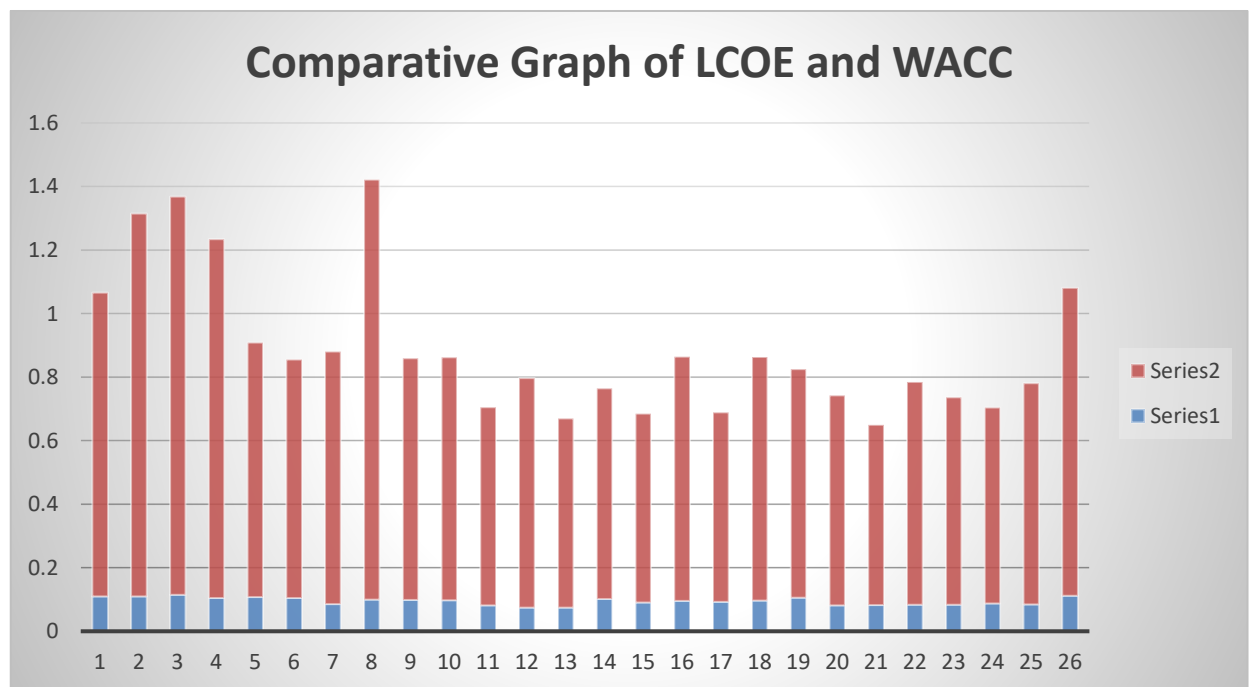


Figure 6: Effect of WACC on LCOE

Figure 6 shows the LCOEs for the 26 different projects established in Namibia during the years 2014 to 2022. The orange bar in the figure shows the LCOE and the blue bar shows the WACC for each project. Project 8 recorded the highest LCOE at N\$ 1.32 c/kWh, with a WACC of 9.96% in 201. Project 21 in Katima recorded the lowest LCOE at 0.57 c/kWh with a WACC of 8.30% in 2022. The highest WACC calculated belongs to project 3 which rank as the second highest LCOE.

Table 2. Chi-Square Tests of the Relationship Between LCOE and WACC in the 26 projects

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	546.000 ^a	525	0,025
Likelihood Ratio	158,331	525	1,000
Linear-by-Linear Association	11,126	1	0,001
N of Valid Cases	26		

Table 2 shows: 572 cells (100%) have an expected count of less than 5, the minimum expected count is 0.04. There is a Pearson chi-square, the p-value is 546a which is statistically significant at a 5% level of significance based on 525 degrees of freedom and the likelihood ratio, the p-value is 1, and statistics is 158.331 based on 525 degrees of freedom. This suggests that the LCOE and WACC are associated with each other.

Table 3. Correlation between LCOE and WACC of the 26 Projects

		Value	Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
Interval by Interval	Pearson's R	0,667	0,087	4,387	0.000 ^c
Ordinal by Ordinal	Spearman Correlation	0,723	0,083	5,125	0.000 ^c
N of Valid Cases		26			

According to Table 3, LCOE and WACC have a positive correlation: as WACC increases, so does LCOE.

In the case of utility-scale solar photovoltaic (PV) projects, the WACC has a significant impact on the levelized cost of electricity (LCOE). This is because the cost of financing a solar PV project can be a significant portion of the overall cost of the project.

The results have shown that a higher WACC will increase the cost of capital and, in turn, increase the LCOE of a solar PV project. This is because a higher discount rate will lower the present value of future cash flows, increasing the overall cost of the project.

Conversely, a lower WACC will decrease the cost of capital and, in turn, decrease the LCOE of a solar PV project. This is because a lower discount rate will increase the present value of future cash flows, reducing the overall cost of the project.

1.1.3 Base Tariff and LCOE

The base tariff represents the price at which electricity is sold to customers, while the LCOE represents the average cost of producing electricity over the lifetime of a solar project. Figure 7 below shows all 26 projects LCOE with their base respective base tariffs.

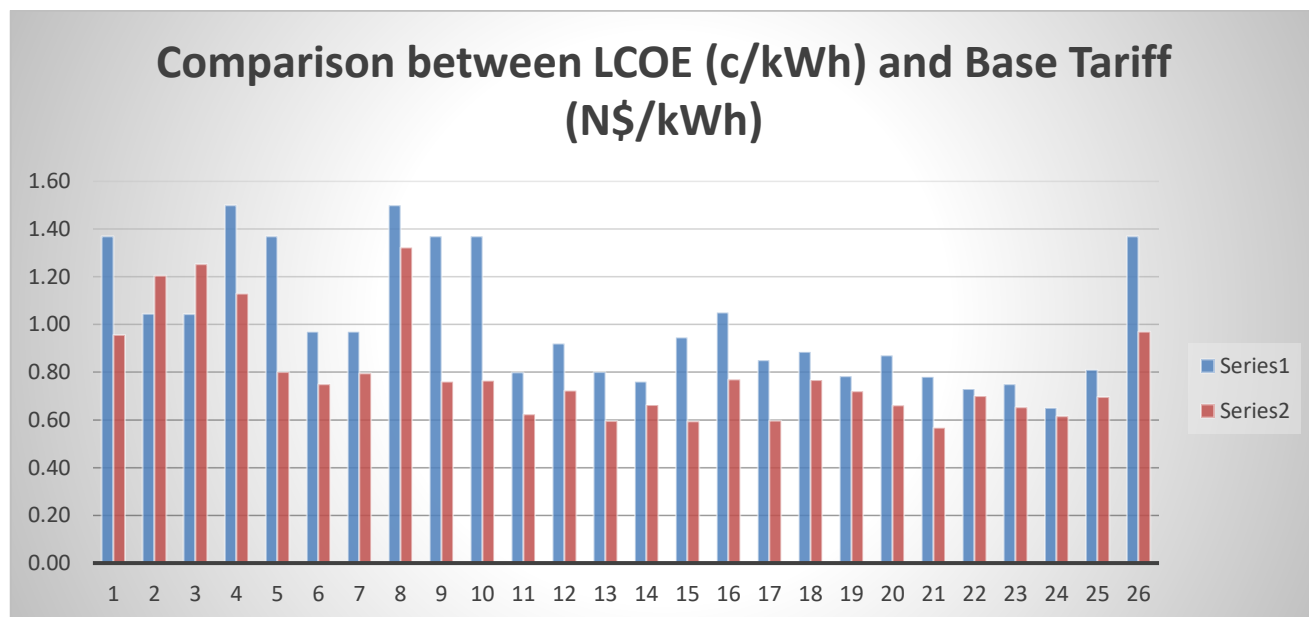


Figure 7. Comparison between LCOE (c/kWh) and Base Tariff (N\$/kWh)

Figure 7 shows a comparison between LCOE (c/kWh), the orange bars, and base tariff (N\$/kWh), the blue bars, for 26 projects. The base tariff is higher than the LCOE, If the base tariff is higher than the LCOE, then the solar project can

generate profits for the project developer. Conversely, if the base tariff is lower than the LCOE, then the project may not be economically viable.

Table 4. Chi-Square Tests of the Relationship Between LCOE and Base Tariff in the 26 projects

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	494.000 ^a	475	0,264
Likelihood Ratio	147,781	475	1,000
Linear-by-Linear Association	8,482	1	0,004
N of Valid Cases	26		

Table 4 shows: 520 cells (100%) have an expected count of less than 5, and the minimum expected count is 0.04. There is a Pearson chi-square, the p-value is 494a which is not statistically significant at a 5% level of significance based on 475 degrees of freedom and the likelihood ratio, the p-value is 1, and statistics is 147.781 based on 475 degrees of freedom. This suggests that the LCOE and base tariff are not associated with each other.

Table 5. Correlation between LCOE and Base Tariff of the 26 Projects

		Value	Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
Interval by Interval	Pearson's R	-0,582	0,066	-3,511	0.002 ^c
Ordinal by Ordinal	Spearman Correlation	-0,678	0,075	-4,516	0.000 ^c
N of Valid Cases		26			

According to Table 5, LCOE and base tariff have a negative correlation: as base tariff increases, LCOE tends to decrease.

1.1.4 Effect of Cost of Capital on WACC

Figure 8 illustrates the relationship between the cost of debt, the orange area, and the cost of equity, the blue area, against WACC, the grey bars. It is clear there is an effect, as it can be seen over the years, as the cost of equity and cost of debt decreases, WACC increases gradually.

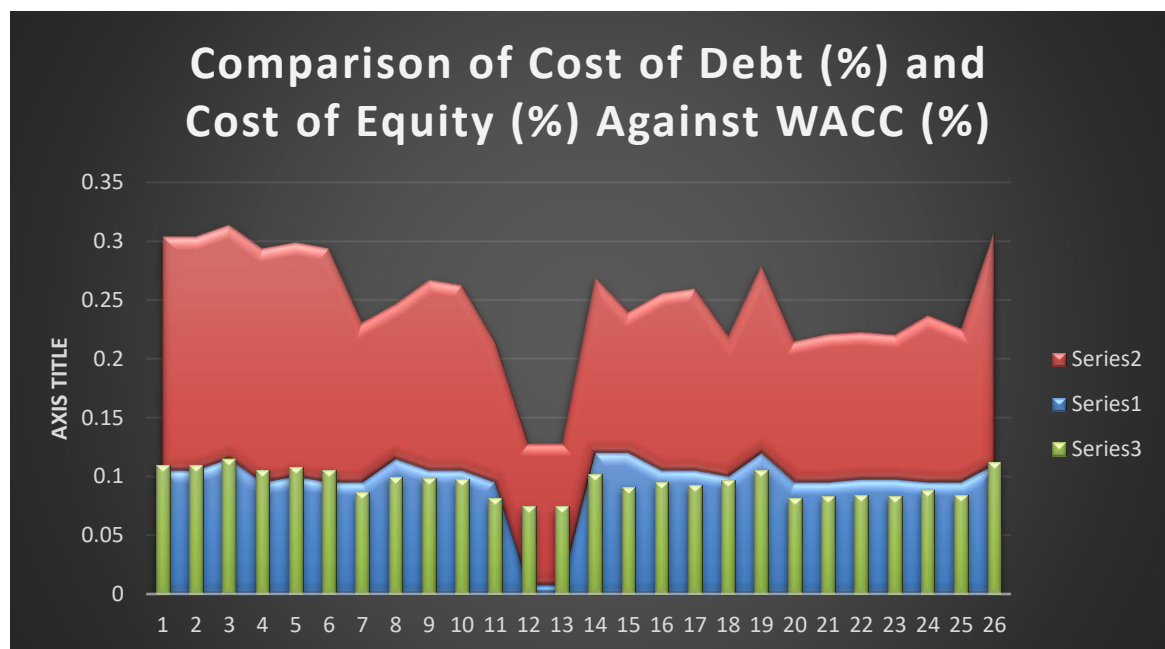


Figure 8. Comparison of Cost of Debt (%) and Cost of Equity (%) Against WACC (%)

Table 6. Chi-Square Tests of the Relationship Between Debt (%) and Cost of Equity (%) Against WACC (%) in the 26 projects

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	208.000 ^a	200	0,033

Likelihood Ratio	99,739	200	1,000
Linear-by-Linear Association	0,898	1	0,343
N of Valid Cases	26		

Table 6 shows: 234 cells (100%) have an expected count of less than 5, the minimum expected count is 0.04. There is a Pearson chi-square, the p-value is 208a which is statistically significant at a 5% level of significance based on 200 degrees of freedom and the likelihood ratio, the p-value is 1, and statistics is 99.739 based on 200 degrees of freedom. This suggests that the cost of debt and the cost of equity are associated with WACC.

Table 7. Correlation between Debt (%) and Cost of Equity (%) Against WACC (%) of the 26 Projects

		Value	Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
Interval by Interval	Pearson's R	-0,189	0,165	-0,945	0.354 ^c
Ordinal by Ordinal	Spearman Correlation	-0,225	0,187	-1,132	0.269 ^c
N of Valid Cases		26			

According to Table 7, the cost of debt and cost of equity has a low negative correlation to WACC: if the cost of debt and cost of equity is low, WACC may be high.

The results have shown that the higher the proportion of debt financing used, the lower the WACC will be. This is because debt financing is less expensive than

equity financing, and a higher proportion of debt financing will lead to a lower weighted average cost of capital.

Figure 9 shows the trend line of WACC over the 8 years. The slope is negative, therefore, as years pass WACC is decreasing.

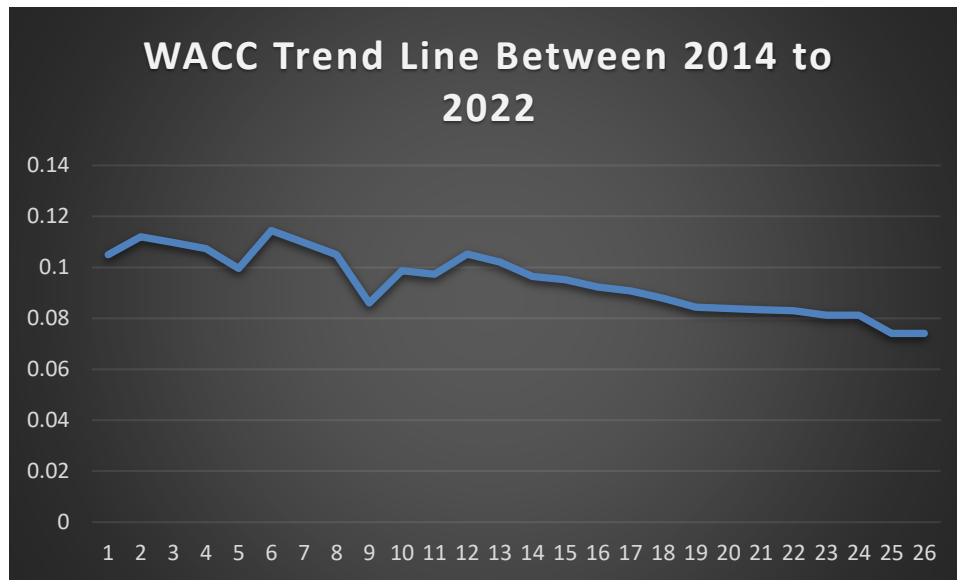


Figure 9. WACC Trend Line Between 2014 to 2022

The reduction in the Weighted Average Cost of Capital (WACC) in Namibia over time can be attributed to various economic factors. Regulatory changes is one of the biggest factor, The introduction of the modified single buyer (MSB) regulatory change in Namibia's energy sector has significantly impact project financing for energy-related projects. MSB encourages increased competition among power producers, leading to more favourable power purchase agreements (PPAs) and stable revenue streams for project developers. Moreover, the shift in responsibility for power procurement has reduce the offtake risk, making projects more attractive to investors and lenders, potentially lowering financing costs.

Private sector participation is also encouraged, attracting private investment and reducing the financial burden on the government. This has improve access to diverse sources of financing, both domestically and internationally. With market-driven pricing dynamics and more flexible contract structures, projects have enjoy improved financing terms.

1.1.5 LCOE Sensitivity to Major Components

Figure 10 The sensitivity of levelized cost of electricity (LCOE) between 2014 to 2022 on input parameters in Namibia are as follows: 0.151 N\$/kWh capital expenditure (CAPEX), 0.138 N\$/kWh Operational and Maintenance Cost (O&M), 0.208 N\$/kWh Total Cost, 6.5% cost of debt, 9.1% cost of equity, 0.957 N\$/kWh Base Tariff, 0.745 kWh/kWp solar Irradiation, 7.8% weighted average cost of capital (WACC), 8.4% escalation rate, and 0.192 (N\$) NPV of Total Costs.

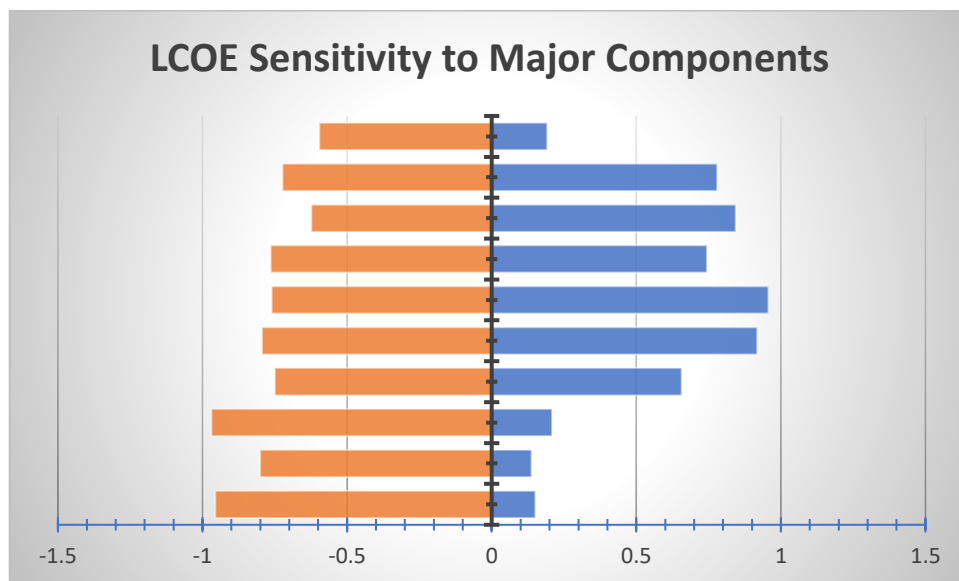


Figure 10. LCOE Sensitivity to Major Components

1.1.6 Effect of Solar Irradiation on LCOE

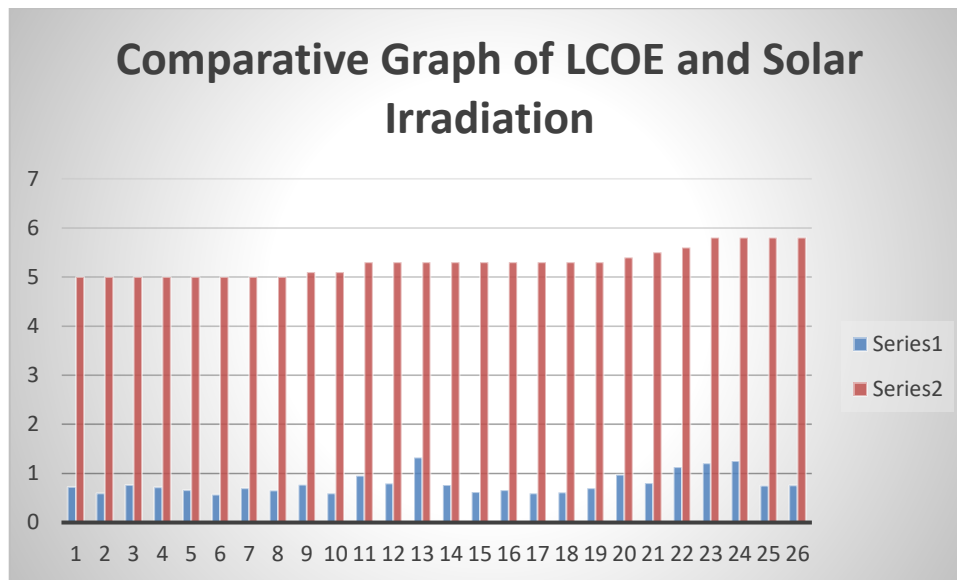


Figure 11. Comparative Graph of LCOE and Solar Irradiation

Figure 11: A comparison between LCOE (c/kWh), the orange bars, and solar irradiation (kWh/kWp), the blue bars, for 26 projects. It can be seen that LCOE does take into account the change in solar irradiation. As solar irradiation changes, LCOE is directly proportional with it.

Table 8. Chi-Square Tests of the Relationship Between LCOE (c/kWh) and Solar Irradiation (kWh/kWp) in the 26 projects

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	156.000 ^a	150	0,352
Likelihood Ratio	82,737	150	1,000
Linear-by-Linear Association	8,113	1	0,004
N of Valid Cases	26		

Table 8 shows: 182 cells (100%) have an expected count of less than 5, the minimum expected count is 0.04. There is a Pearson chi-square, the p-value is 156a which is not statistically significant at a 5% level of significance based on 150 degrees of freedom and the likelihood ratio, the p-value is 1, and statistics is 82.737 based on 150 degrees of freedom. The correlation is significant and Figure 10 also shows some level of co-movement between the two

Table 9. Correlation Between LCOE (c/kWh) and Solar Irradiation (kWh/kWp) of the 26 Projects

		Value	Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
Interval by Interval	Pearson's R	0,570	0,141	3,396	0.002 ^c
Ordinal by Ordinal	Spearman Correlation	0,555	0,115	3,270	0.003 ^c
N of Valid Cases		26			

According to Table 9, solar irradiation has a moderate positive correlation to LCOE: if solar irradiation increases, LCOE may increase as well.

Cronbach's Alpha:

A 15 Microsoft Excel sheet was filled in by 26 participants (PV systems) where $\alpha=0.702$. This presents an acceptable reliability analysis.

CHAPTER 5. CONCLUSIONS

Namibia is abundantly endowed with rich solar energy resources, yet the country cannot locally generate electricity to meet its demand. In order to alleviate the electricity shortage, the Namibian government introduced the renewable energy feed-in tariff program in 2014 which included solar PV. As discussed in the literature review section, there are studies that have considered the strength of the sun as the primary exogenous factor driving the cost of electricity and have treated other parameters such as the cost of capital, as largely endogenous and thus irrelevant to their analysis. The aim of this study was to analyse how the levelized cost of electricity of solar PV is impacted by the weighted average cost of capital in Namibia.

The main challenge that the researcher encountered during this assessment is that developers and financiers conceal financial information related to solar projects due to a variety of factors, including the company's strategic goals, regulatory requirements, competitive landscape, and perceived risk associated with the project. Despite this challenge, the researcher managed to acquire data on 26 projects from about 36 projects in Namibia, so a total of 26 solar projects were analysed between 2014 to 2022.

This study has shown that while both solar irradiation and the cost of capital are essential factors that influence the LCOE of a solar power project, the cost of capital impact is more significant. Among the analysed data, projects with the lowest LCOE are located in Katima which has the lowest solar irradiation of about 5 kWh/kWp in Namibia and these projects have the lowest WACC in the range of 7.4 – 10.52%. WACC has a more significant impact on the LCOE for solar PV projects than solar irradiation because the cost of capital represents a substantial portion of the total cost of a solar PV project, while solar irradiation mainly affects the electricity generation potential of the project.

The weighted average cost of capital in Namibia has been declining since the renewable feed-in tariff program was launched. The declining WACC for solar PV

projects in Namibia is due to a combination of factors, including a favourable regulatory environment, lower financing costs, improved infrastructure, and technological advancements. These factors have made solar PV projects more attractive to investors and helped to support the growth of the renewable energy sector in Namibia.

References

- Aldersey, J. (2019). Levelised cost of energy – A theoretical justification and critical assessment. *Energy Policy*, 124, 169–179. <https://doi.org/10.1016/j.enpol.2018.10.004>
- Baptiste, C. (2018). *Analysis of the cost of electricity in a 100\% renewable energy system*. 75.
- Basel II (Ed.). (2009). *Enhancements to the Basel II framework* (July 2009). Bank for Internat. Settlements.
- Bhandari, P. (2020, June 12). *What Is Quantitative Research? | Definition, Uses & Methods*. Scribbr. <https://www.scribbr.com/methodology/quantitative-research/>
- Breyer, G. (2013). Global overview on grid-parity: Global overview on grid-parity. *Progress in Photovoltaics: Research and Applications*, 21(1), 121–136. <https://doi.org/10.1002/pip.1254>
- Carroll, S. (2022, February 7). *Trina Solar publishes CAPEX and LCOE assessment white paper—Electrical connection*. <https://electricalconnection.com.au/trina-solar-publishes-capex-and-lcoe-assessment-white-paper/>
- Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed). Pearson.

Crossman. (2019, July 17). *Convenience Samples for Research—A Brief Overview of the Sampling Technique*.
<https://www.thoughtco.com/convenience-sampling-3026726>

Durakovic, F. (2021). LEVELIZED COST OF ELECTRICITY OF RENEWABLE ENERGY TECHNOLOGIES AS A CRITERION FOR PROJECT PRIORITIZATION. *Lappeenranta–Lahti University of Technology LUT*.
<https://lutpub.lut.fi/bitstream/handle/10024/163284/Master%20thesis%20-%20LCOE%20of%20Renewable%20Energy%20Technologies%20as%20a%20Criterion%20for%20Project%20Prioritization%20-%20LUT.pdf?sequence=3&isAllowed=y>

Eberhard, A., Gratwick, K., Morella, E., & Antmann, P. (2016). *Independent Power Projects in Sub-Saharan Africa: Lessons from Five Key Countries*. Washington, DC: World Bank. <https://doi.org/10.1596/978-1-4648-0800-5>

Harvey, L. D. D. (2020). Clarifications of and improvements to the equations used to calculate the levelized cost of electricity (LCOE), and comments on the weighted average cost of capital (WACC). *Energy*, 207, 118340.
<https://doi.org/10.1016/j.energy.2020.118340>

Hummel, R. L. (2001). Solar distillation with economies of scale, innovation and optimization. *Desalination*, 134(1–3), 159–171.
[https://doi.org/10.1016/S0011-9164\(01\)00123-0](https://doi.org/10.1016/S0011-9164(01)00123-0)

- IEA. (2021). *The cost of capital in clean energy transitions – Analysis*. IEA.
<https://www.iea.org/articles/the-cost-of-capital-in-clean-energy-transitions>
- Krieger, N. (2012). Who and What Is a “Population”? Historical Debates, Current Controversies, and Implications for Understanding “Population Health” and Rectifying Health Inequities: *Who and What Is a “Population”? Milbank Quarterly*, 90(4), 634–681. <https://doi.org/10.1111/j.1468-0009.2012.00678.x>
- Kruger, W. (2022). A quiet transition: The role of Namibia’s state-owned power utility in the renewable energy auction program. *Utilities Policy*, 78, 101392. <https://doi.org/10.1016/j.jup.2022.101392>
- Li, H. (2019). Cost of Capital: Literatures Review about Calculation Methods and Influencing Factors. *Journal of Service Science and Management*, 12(03), 360–370. <https://doi.org/10.4236/jssm.2019.123024>
- MME. (2016). *National Integrated Resource Plan for the Electricity Supply Industry in Namibia*.
[https://www.ecb.org.na/images/docs/Noticeboard/ELECTRICITY%20SECTOR%20NATIONAL%20INTEGRATED%20RESOURCE%20PLAN%20\(NIRP\)%202016%20Version%201.pdf](https://www.ecb.org.na/images/docs/Noticeboard/ELECTRICITY%20SECTOR%20NATIONAL%20INTEGRATED%20RESOURCE%20PLAN%20(NIRP)%202016%20Version%201.pdf)
- MME, M. (2019). *Namibia Detailed Electricity Market Design*. MINISTRY OF MINES AND ENERGY.
https://www.ecb.org.na/images/docs/Rules_and_Regulations/MSB/MSB_Detailed_Design_Report.pdf

- Olakunle Alao and Anton Eberhard, W. K. (2019). *Namibia Country Report Report 3: Energy and Economic Growth Research Programme (W01 and W05)*. PO Number: PO00022908. Power Futures Lab. <https://www.energyeconomicgrowth.org/sites/default/files/2020-03/Namibia%20Country%20Report.pdf>
- Ondraczek, J., Komendantova, N., & Patt, A. (2015). WACC the dog: The effect of financing costs on the levelized cost of solar PV power. *Renewable Energy*, 75, 888–898. <https://doi.org/10.1016/j.renene.2014.10.053>
- Ondraczek, J., Patt, Komendantova, Nadejda, Anthony. (2015). WACC the dog: The effect of financing costs on the levelized cost of solar PV power. *Renewable Energy*, 75, 888–898. <https://doi.org/10.1016/j.renene.2014.10.053>
- Park, S., Langat, A., Lee, K., & Yoon, Y. (2021). Measuring the impact of risk on LCOE (levelized cost of energy) in geothermal technology. *Geothermal Energy*, 9(1), 27. <https://doi.org/10.1186/s40517-021-00209-9>
- Shah, N. (2018). ANALYSIS OF THE KEY FACTORS AFFECTING LEVELIZED COST OF ELECTRICITY OF SOLAR PV IN INDIA. *PDPU Journal of Energy and Management*, 3(1), 7.
- Steffen, B. (2018). The importance of project finance for renewable energy projects. *Energy Economics*, 69, 280–294. <https://doi.org/10.1016/j.eneco.2017.11.006>

Steffen, B. (2020). Estimating the cost of capital for renewable energy projects.

Energy Economics, 88, 104783.

<https://doi.org/10.1016/j.eneco.2020.104783>

Sudaryono, Rahardja, U., Aini, Q., Isma Graha, Y., & Lutfiani, N. (2019). Validity

of Test Instruments. *Journal of Physics: Conference Series*, 1364(1),

012050. <https://doi.org/10.1088/1742-6596/1364/1/012050>

Sung, S. (2019). Economic Competitiveness Evaluation of the Energy Sources:

Comparison between a Financial Model and Levelized Cost of Electricity

Analysis. *Energies*, 12(21), 4101. <https://doi.org/10.3390/en12214101>

Vartiainen, E., Masson, G., Breyer, C., Moser, D., & Román Medina, E. (2020).

Impact of weighted average cost of capital, capital expenditure, and other parameters on future utility-scale PV levelised cost of electricity. *Progress in Photovoltaics: Research and Applications*, 28(6), 439–453.

<https://doi.org/10.1002/pip.3189>

World Bank. (n.d.). *Access to electricity (% of population) | Data*. Retrieved

November 22, 2022, from

<https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS>

APPENDIX A – Ethics Clearance Certificate

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg



Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number: WBS/FI1988599/516

This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below).

This certificate is only valid if accompanied by formal permission from the relevant stakeholder(s).

Project title Impact of weighted average cost of capital (WACC) on utility-scale solar photovoltaic (PV) levelized cost of electricity

Investigator / Researcher Mr Severus Twahafa Shedile

Nature of Project MM in Finance and Investment

Decision of the Committee Approved, provided stakeholders and participants are guaranteed anonymity and confidentiality.

Issue Date of Certificate 2022-12-15

Expiry date Date of submission of the project / research report

Chairperson Prof Anthony Stacey
 +27 11 717 3587
 +27 82 880 4531
 anthony.stacey@wits.ac.za

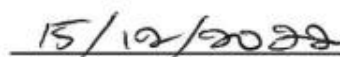
Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.



 Signature



 Date:



4th Floor, 1@Steps
C/O Grove and Chasie Street
Kleine Kuppe, Windhoek

P O Box 136
Windhoek
Namibia

Tel: +264 (81) 9583 500
Fax: +264 (61) 304 671
www.ijg.net

NON-DISCLOSURE AGREEMENT

between:

IJG CAPITAL (PTY) LTD

("IJG")

Address: 4th Floor 1@Steps, C/O Grove & Chasie Street, Kleine Kuppe, Windhoek, Namibia

and

Severus T. Shedile

("Severus")

Address: Flat 15, Apple Apartment, Tanganyika Street, Ondangwa, Namibia

and

WITS BUSINESS SCHOOL

("WBS")

Address: 2 St Davids Pl &, St Andrew Rd, Parktown, Johannesburg, 2193, South Africa

INTRODUCTION

In the course of discussions and correspondence between the parties relating to Severus' research project into the "Impact of weighted average cost of capital (WACC) on utility-scale solar photovoltaics Levelized cost of electricity (LCOE) in Namibia" ("Project"), the Recipient will acquire or be informed of confidential details and information concerning the Disclosing Party and/or its Associated Companies, if any (as defined below). The Recipient recognises and acknowledges the competitive value and confidential nature of the same and that damage could result to the Disclosing Party if it is disclosed to any third party, other than in terms of this agreement. The purpose of this agreement is to set out the conditions on which the Disclosing Party makes confidential details and information available to Recipient and/or its Associates.

These conditions are as follows:

1. Definitions and Interpretation

1.1. For the purposes of this agreement -

1.1.1 "Associate" means, in relation to each party, any holding company or subsidiary company of such party and any other subsidiary undertaking of any such holding company (an "Associate Company")

and any director, officer, employee, consultant, representative, agent or adviser of such party or of any Associate Company of such party. For these purposes "holding company" and "subsidiary company" have the meanings given in the Namibian Companies Act No. 28 of 2004.

1.1.2 "Commencement date" means the date on which the last party appends their signature hereto.

1.1.3 In relation to the obligations of the Recipient "Confidential Information" includes -

(a) all information of whatever nature relating to the Disclosing Party or any Associate Company of the Disclosing Party or its or their business and/or to the Project provided in writing, orally, on disk, in electronic format or otherwise by or on behalf of the Disclosing Party or any of its Associates to (or otherwise obtained by) such party or any of its Associates including but not limited to any information relating to the operations, plans, intentions, know-how, trade secrets, software, market opportunities, customers and potential customers, business and/or financial affairs of the Disclosing Party or any of its Associate

Directors: M Spáth, M Hamutenya, H Maier, J De Klerk
Company Registration Number: 2007/0268





12 Daniel Munamava Street, Windhoek • PO Box 235, Windhoek, Namibia • Tel + 264 61 290 8000 • Fax + 264 61 290 8049
E-mail info@dbn.com.na • www.dbn.com.na

From: Jerome Mutumba

Head: Marketing & Corporate Communications

To: Severus T Shedile

University of the Witwatersrand Business School

Master's Degree in Finance and Investments

1988599@students.wits.ac.za

Date: 11 January 2023

Dear Mr Shedile

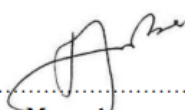
Subject: GRANTING OF INSTITUTIONAL PERMISSION FOR RESEARCH

I, Jerome Mutumba, the Head: Marketing and Corporate Communications of DBN, herewith grant permission to collect data at this site for your research project.

I grant this permission as the authorized person to do so in the Bank and am aware of the following.

1. The study is conducted as a University of Witwatersrand researcher and remains the property of University of the Witwatersrand Business School
2. You can use the name of the Bank in your research project. However, DBN client information must be kept **confidential**, anonymous, and purely for academic purposes. No client details such as names, organisation names, contact details, etc., can be publically shared or printed.
3. All data and information collected will be solely in the possession of the researcher
4. I will require feedback of the research and a copy thereof when finalised
5. The research may be published in the public domain under the supervision of the supervisor
6. Participation by DBN employees are voluntary and no individual can be coerced, bribed or forced to participate in any way.

I wish you the best and success in this research endeavour.


.....
Jerome Mutumba
Head: Marketing & Corporate Communications
Tel: 061-290 8000

11/01/2023

Date

Development Bank of Namibia Limited (Registration No: 2003/189)

Board of Directors: Sarel van Zyl (Chairperson), Evangelina Nailenge (Deputy Chairperson) Martin Inkumbi (CEO)
Diana Husselmann, Marsorry Ickua, Patience Kanalelo, Willy Mertens



MUTUAL NON-DISCLOSURE AGREEMENT

This Non-Disclosure agreement (the "**Agreement**") is entered into between:

- (1) **SUSTAINABLE POWER SOLUTIONS INVESTMENTS (PTY) LIMITED**, a company incorporated and duly registered in accordance with the laws of **South Africa**, with registration number **2016/215610/07**; and
- (2) ~~SEVERMS.T.WAKATA.SIBERILE~~....., a ~~company~~ ^{Student} incorporated and duly registered in accordance with the laws of ~~TRUTH~~ ^{South Africa}, with registration number ~~1988599~~....., ^{Student}

each referred to herein as a "**Party**" and collectively as the "**Parties**".

The Parties entered into this Agreement to protect the confidentiality of certain confidential information to be disclosed under this Agreement solely for use in evaluating or pursuing a business relationship between the Parties (the "**Permitted Use**").

TERMS AND CONDITIONS

1. As used herein, the "**Confidential Information**" of a Party will mean any and all technical and non-technical information disclosed by such Party (the "**Disclosing Party**") to the other Party (the "**Receiving Party**"), which may include without limitation: proprietary and confidential information, related to the products and services of each of the Parties, such as information concerning financial information, procurement requirements, customer lists, investors, employees, business relationships/sources, any report, recommendation or advice received, business forecasts, and marketing plans.
2. The Receiving Party agrees that at all times and notwithstanding any termination or expiration of this Agreement it will hold in strict confidence and not disclose to any third party any Confidential Information of the Disclosing Party, except as approved in writing by the

(Handwritten signature)

APPENDIX C – Data Collection Instruments

Renewable Energy Plants with Installed Capacities as at 2022									
Column1	Column2	Column3	Column5	Column6	Column7	Column8	Column9	Column10	Column11
Licensee/Developer	Installed Capacity (MW)	Technology	Location	Year Awarded	CAPEX	O&M	Total Cost	Capital Structure (Debt/Equity)	
ALCON Consulting Services (Pty) Ltd - REFIT	6.318	Solar PV	Aussenkehr						
Alten Solar Power (Hardap) (Pty) Ltd	45.454	Solar PV	Mariental						
Aloe Investment No. 27 (Pty) Ltd - REFIT	5.67	Solar PV	Rosh Pinah						
Ark Industries (Pty) Ltd	5	Biogas	Ondangwa						
B2Gold (Pty) Ltd	7	Solar PV	Otjikoto Mine						
Camelthorn Business Venture No TWO (Pty) Ltd - REFIT	4.992	Solar PV	Outapi						
Dezman Solar Investment	2.75	Solar PV	Okongo						
Diaz Wind Power (Pty) Ltd	44	Wind	Spergebiet						
Ejuva One Solar Energy (Pty) Ltd - REFIT	6.032	Solar PV	Gobabis						
Ejuva Two Solar Energy (Pty) Ltd - REFIT	6.032	Solar PV	Omaheke Region						
GreeNam Electricity (Pty) Ltd	12.636	Solar PV	Keetmanshoop						
GreeNam Electricity (Pty) Ltd	12.636	Solar PV	Mariental						
Grove Mall	2.816	Solar PV	Windhoek						
HOPSOL Power Generation (Pty) Ltd - REFIT	5.73	Solar PV	Grootfontein						
HOPSOL Power Generation (Pty) Ltd	5.61	Solar PV	Otiwarongo						
Ino Investment (Pty) Ltd	3.3	Solar PV	Outapi						
Maerua Mall	2	Solar PV	Windhoek						
Metdecci Energy Investment (Pty) Ltd - REFIT	5.28	Solar PV	Karibib						
Momentous Solar One (Pty) Ltd - REFIT	6	Solar PV	Keetmanshoop						
Namibia Brewery	1	Solar PV	Windhoek						
Namibia Marble and Granite (Pty) Ltd	0.35	Solar PV	Karibib						
NamPower (Omburu)	28.9	Solar PV	Omaruru						
NCF Energy (Pty) Ltd	5.73	Solar PV	Okatope						
OLC Arandis (Pty) Ltd	3.8	Solar PV	Arandis						
Ombepo Energy (Pty) Ltd - REFIT	6	Wind	Luderitz						
Omburu Sun Energy (Pty) Ltd	5.18	Solar PV	Omaruru						
Osona Sun Energy (Pty) Ltd - REFIT	6.696	Solar PV	Osona						
Phase Two Properties	1	Solar PV	Windhoek						
Sertum Energy (Pty) Ltd - REFIT	5.76	Solar PV	Trekkopje						
Skeleton Coast Trawing (Pty) Ltd	2.593	Solar PV	Luderitz						
Sun EQ Four Investment	6.57	Solar PV	Farm Sargberg						
Tandii Investment (Pty) Ltd	5.73	Solar PV	Okatope						
Unisun Energy (Pty) Ltd	5.74	Solar PV	Okatope						
Wernhil Park	2.12	Solar PV	Windhoek						
Zikomo Power (Pty) Ltd	6.1	Solar PV	Oniipa						
#Oab Energy (Pty) Ltd	8	Wind	Elizabeth Mine						

Severus Research Data Collection



Severus Shedile <1988599@students.wits.ac.za>
to ferdi ▾

3 Jan 2023, 16:06



Good day Mr. Nghiyolwa,

My name is Severus Shedile, I am pursuing my Master's Degree in Finance and Investments with the University of the Witwatersrand Business School. As part of my studies, I must undertake a research project, and my topic is the **"Impact of weighted average cost of capital (WACC) on utility-scale solar photovoltaics Levelized cost of electricity (LCOE) in Namibia"**.

This research will analyze how the cost of capital and capital structure which effectively form the weighted average cost of capital (WACC), impact the levelized cost of electricity of utility-scale photovoltaic in Namibia.

I am currently busy with data collection, and I am humbly requesting that your team assist me with the following information (attached excel sheet), Camelthorn Business Venture No Two Solar PV project in Outapi:

- Base tariff
- Escalation rate
- Project capital structure
- Cost of debt and equity
- Capital expenditure (CAPEX)
- Operational and maintenance cost (O&M)

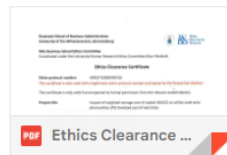
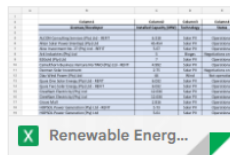
I fully understand that some information is confidential; hence information shared in this study will be kept confidential, anonymous, and purely for academic purposes. So, I have attached my Ethics Clearance Certificate from the university.

Your contribution will be highly appreciated.

Thank you.

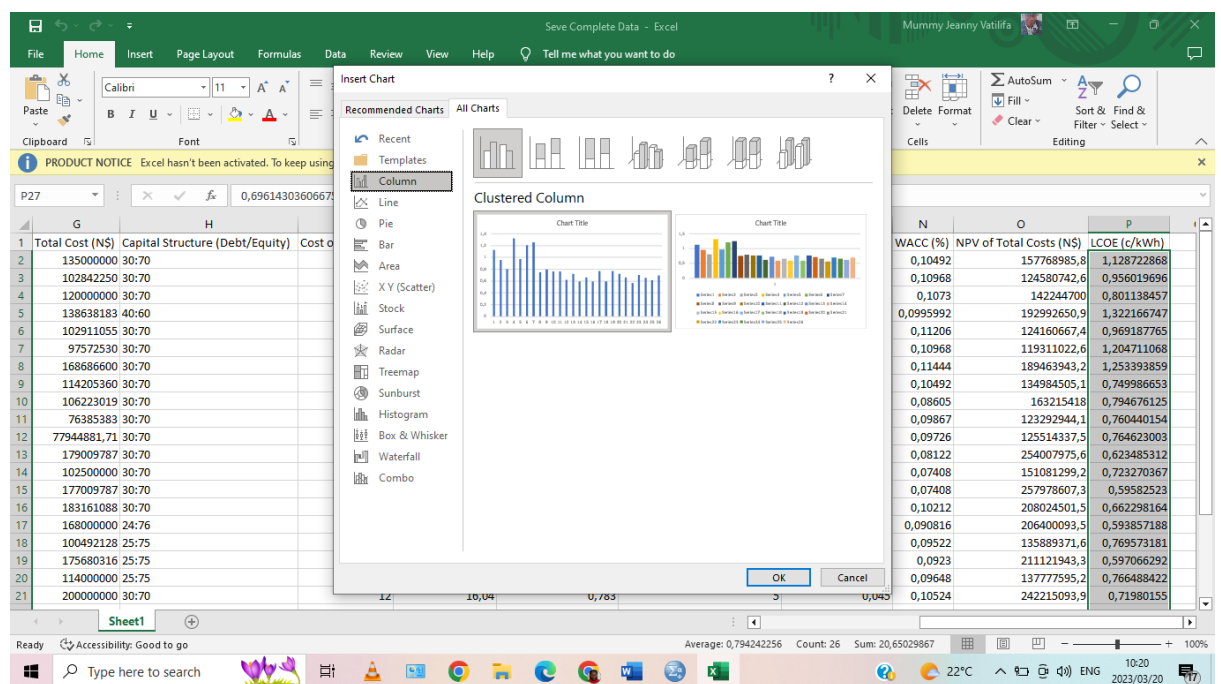
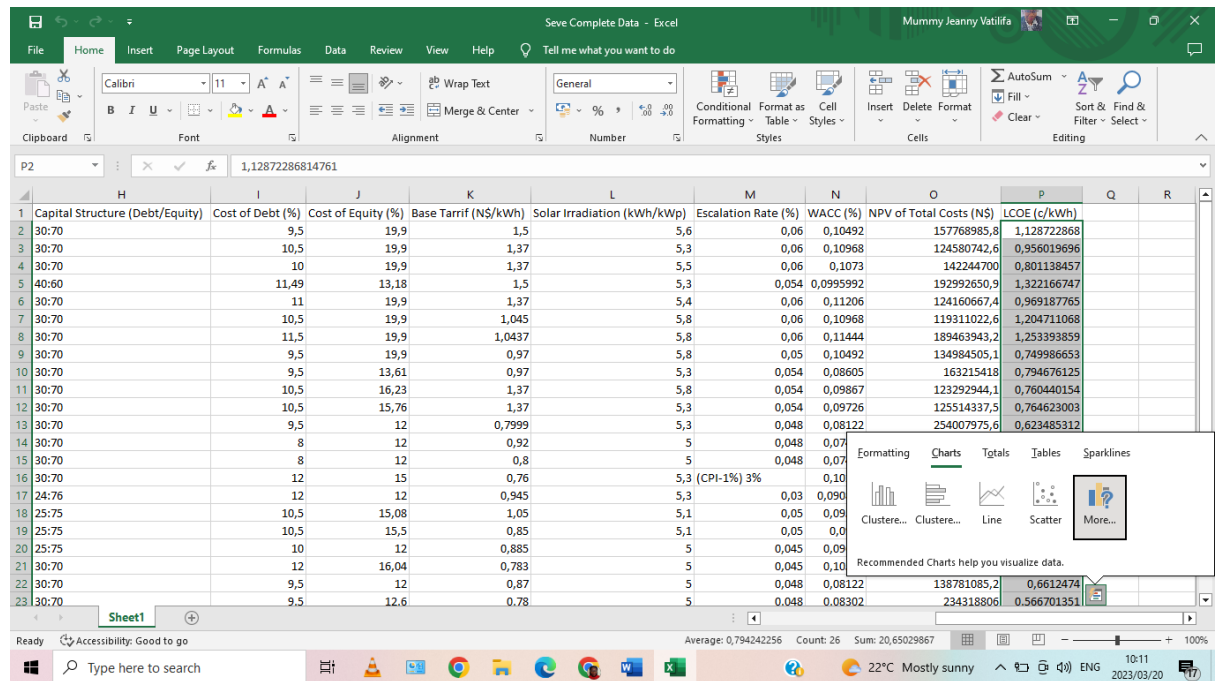
Kind Regards,
S.T. Shedile

2 Attachments • Scanned by Gmail ⓘ



APPENDIX D – Coding Instruments

For comparison graphs and trend lines:



For Chi-Square and Correlation

Save Complete Data.sav [DataSet1] - IBM SPSS Statistics Data Editor

File Edit View Data Transform **Analyze** Graphs Utilities Extensions Window Help

Reports

- Descriptive Statistics
 - Frequencies...
 - Descriptives...
 - Explore...
 - Crosstabs...**
 - TURF Analysis
 - Ratio...
 - E-P Plots...
 - Q-Q Plots...
- Regression
- Loglinear
- Neural Networks
- Classify
- Dimension Reduction
- Scale
- Nonparametric Tests
- Forecasting
- Survival
- Multiple Response
- Missing Value Analysis...
- Multiple Imputation
- Complex Samples
- Simulation...
- Quality Control
- ROC Curve...
- Spatial and Temporal Modeling...
- Direct Marketing

Visible: 16 of 16 Variables

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
1	5.18000000000000										
2	4.99200000000000										
3	6.69600000000000										
4	5.19800000000000										
5	5.00000000000000										
6	3.80000000000000										
7	6.00000000000000										
8	6.57000000000000										
9	6.57400000000000										
10	5.73300000000000										
11	5.74200000000000										
12	12.5300000000000										
13	6.04500000000000										
14	12.5300000000000										
15	11.4000000000000										
16	11.5600000000000										
17	6.08000000000000										
18	11.9000000000000										
19	6.25000000000000										
20	12.5000000000000										
21	6.45500000000000										
22	12.9090000000000										
23	5.00000000000000										

IBM SPSS Statistics Processor is ready | Unicode: ON | 10:16 2023/03/20

Save Complete Data.sav [DataSet1] - IBM SPSS Statistics Data Editor

File Edit View Data Transform **Analyze** Graphs Utilities Extensions Window Help

Visible: 16 of 16 Variables

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
1	5.18000000000000										
2	4.99200000000000										
3	6.69600000000000										
4	5.19800000000000										
5	5.00000000000000										
6	3.80000000000000										
7	6.00000000000000										
8	6.57000000000000										
9	6.57400000000000										
10	5.73300000000000										
11	5.74200000000000										
12	12.5300000000000										
13	6.04500000000000										
14	12.5300000000000										
15	11.4000000000000										
16	11.5600000000000										
17	6.08000000000000										
18	11.9000000000000										
19	6.25000000000000										
20	12.5000000000000										
21	6.45500000000000										
22	12.9090000000000										
23	5.00000000000000										

IBM SPSS Statistics Processor is ready | Unicode: ON | 10:18 2023/03/20

The screenshot displays the IBM SPSS Statistics Data Editor interface. The main window shows a data view with 16 variables (C1 to C11) and 23 rows of data. A dialog box titled "Crosstabs: Statistics" is open, showing the "Nominal" and "Ordinal" sections. The "Nominal" section includes checkboxes for Chi-square, Contingency coefficient, Phi and Cramer's V, Lambda, and Uncertainty coefficient. The "Ordinal" section includes checkboxes for Gamma, Somers' d, Kendall's tau-b, and Kendall's tau-c. The "Nominal by Interval" section includes checkboxes for Eta and Kappa. The "Crosstabs" section includes checkboxes for Display cluster and Suppress table. The "Test common odds ratio equals" field is set to 1. The "Continue" button is highlighted.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
1	5.18000000000000	1	4					00 30.70	9.50	19.9000000000000	1.50000000000000
2	4.99200000000000	1	1					00 30.70	10.50	19.9000000000000	1.37000000000000
3	6.69600000000000	1	5					00 30.70	10.00	19.9000000000000	1.37000000000000
4	5.19800000000000	1	8					00 40.60	11.49	13.1800000000000	1.50000000000000
5	5.00000000000000	1	14					00 30.70	11.00	19.9000000000000	1.37000000000000
6	3.80000000000000	1	2					00 30.70	10.50	19.9000000000000	1.04500000000000
7	6.00000000000000	2	3					00 30.70	11.50	19.9000000000000	1.04370000000000
8	6.57000000000000	1	6					00 30.70	9.50	19.9000000000000	.970000000000000
9	6.57400000000000	1	7					00 30.70	9.50	13.6100000000000	.970000000000000
10	5.73300000000000	1	3					00 30.70	10.50	16.2300000000000	1.37000000000000
11	5.74200000000000	1	9					00 30.70	10.50	15.7600000000000	1.37000000000000
12	12.5300000000000	1	10					00 30.70	9.50	12.0000000000000	.799900000000000
13	6.04500000000000	1	13					00 30.70	8.00	12.0000000000000	.920000000000000
14	12.5300000000000	1	13					00 30.70	8.00	12.0000000000000	.800000000000000
15	11.4000000000000	1	11					00 30.70	12.00	15.0000000000000	.760000000000000
16	11.5600000000000	1	10					00 24.76	12.00	12.0000000000000	.945000000000000
17	6.08000000000000	1	12					00 25.75	10.50	15.0800000000000	1.05000000000000
18	11.9000000000000	1	13					00 25.75	10.50	15.5000000000000	.850000000000000
19	6.25000000000000	1	13					00 25.75	10.00	12.0000000000000	.885000000000000
20	12.5000000000000	1	13					00 30.70	12.00	16.0400000000000	.783000000000000
21	6.45500000000000	1	13					00 30.70	9.50	12.0000000000000	.870000000000000
22	12.9090000000000	1	13					00 30.70	9.50	12.6000000000000	.780000000000000
23	5.00000000000000	1	13					00 30.70	9.75	12.5000000000000	.730000000000000

