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RATIONALISING RENEWABLES

A Case Study on Renewable Energy Development in Zambia

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Abstract

Renewable energy pursuit and implementation are undoubtedly one of the most important steps in sustainable development across the globe. So far there are several developed high-income countries in the world, that have replaced their fossil fuel-powered electricity systems for renewable energy technologies, however, most of the world still relies on non-renewable energy sources. This research will study the motivations behind Zambia's pursuit of renewable energy from the rational choice theory framework. The theory is used to help analyse whether the choices that Zambia has made and energy policies they have set up, meet the assumption of maximising expected payoff during conditions of uncertainty. The analysis explores several indicators related to pursuing renewable energy and its payoffs. The findings suggest that, based on relevant data and previously implemented research, Zambia's decisions regarding energy policies fulfil the basic notions of the rational choice theory. It could be suggested that Zambia will benefit from renewable energy pursuit, as it will help them increase electricity access and especially bring electricity access to rural areas, distant from the main grid, additionally it is expected to boost economic growth and support poverty alleviation.

Word count: 9960

Key words*: renewable energy, sustainable development, Sub-Saharan Africa, Zambia, rational choice theory*

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List of abbreviations and acronyms

AfDBG	African Development Bank Group
GHI	Global horizontal irradiance
IFC	International Finance Corporation
IRENA	International Renewable Energy Agency
PV	photovoltaic
RE	Renewable energy
RC	Rational choice
SA	South Africa
SSA	Sub-Saharan Africa
UNECE	United Nations Economic Commission for Europe
ZESCO	Zambia Electricity Supply Corporation Limited

1.Introduction

The transition toward renewable energy is an essential part of sustainable development around the globe, as the basis for any type of mass-production is the use of energy. Access to energy can coincide with economic development, as consistent and sufficient supply of electricity improves life quality, creates more job opportunities as well as increases the quality of educational and health services. Renewable energy is a great solution as it provides electricity in an affordable price range and the systems are convenient, as they are portable (World Bank, 2015).

There are many places in the world, where people are living in areas that are not electrified, however, in many of these areas, there is major potential for renewable energy, such as solar, hydro, thermal, wind, etc. Setting up renewable energy technologies can create opportunities for poverty alleviation in many areas in SSA, especially implementing mini-grid access to people in rural areas, where access to the main grid would be too far away and extending access would be too pricy (CIF). Renewable energy can create an opportunity for poverty alleviation as well as economic growth. In addition, recently the price of renewables has had a major decrease, making them more available for developing countries (Amankwah-Amoa, 2015).

This paper will cover the effort to transition toward renewable energy in Sub-Saharan Africa, more precisely exploring the development of the renewable energy sector in Zambia. It will be studied, why have some countries, like Zambia, put a lot of effort into providing renewable energy access to their citizens and the policies and funding in the energy sector will be analysed. It will be reviewed from the rational choice theory perspective, meaning that the analysed actors are expected to maximize their gain within the choices they make, so in essence, the renewable energy policy choices should also be made with the goal to maximise expected payoff and benefits.

1.1. Aim, research question and significance

The aim of this research is to find out why some countries are more motivated to move toward renewable energy sources than others in Sub-Saharan Africa. More specifically the paper aims to find out the more detailed reasons behind countries' decisions regarding renewable energy and whether to pursue implementing it. This paper will analyse the approach of Zambia to their road towards adopting renewable energy sources and their success with it. The thesis will analyse the country's policies, their mobilisation of private investment as well as targets and incentives set up by the government in order to pursue renewable energy development in the country. Therefore, the main question, that the thesis is seeking an answer to is the following:

What are the main reasons behind different renewable energy developments in Sub-Saharan Africa?

The ratio of renewable energy generation of all energy generation in Zambia is already quite high, more than 80% of electricity is produced by renewable sources (that said, only around 40% of the population has access to electricity). However, now they have a new challenge of diversifying energy sources, as only relying on hydropower has become untrustworthy as climate change and changing weather patterns have made the rainfall to be unpredictable. Additionally, their main aim is still increasing energy access, especially in rural areas and that's where renewables are expected to be the means toward the goal (Zambia, 2019).

The significance of this thesis comes from the fact that renewable energy development and research, especially regarding the political science aspect of it, is quite a new research field, especially in developing countries. So far there has been more development in the energy transition research in the global North, as the transitions have been more prominent there, whereas, in SSA, it might not necessarily be a transition from non-renewable to renewable, but could be increasing general electricity access by increasing the amount of renewable energy

systems. Therefore, this research will add to a relatively small, but growing topic of research.

2. Background

Climate change is one of the most pressing issues faced globally in this century. As greenhouse gases (GHG) increase and the global average temperature rises, it could have devastating implications on the environment and people, especially in poor, rural areas if global action is not taken to reduce GHG emissions (Arent, et al., 2017). As energy production is one of the biggest contributors to climate change (65% of global emissions comes from energy production (El- Ashry, 2012)), the way it is produced needs to be rethought and remodelled. Moreover, the conventional production of energy can also contribute to a number of health problems in the developing world. For example, burning solid fuels in spaces with bad ventilation systems contributes to increasing mortality rate for women and children in developing countries. On a larger scale, emissions from non-renewable energy production release fine particles in the air as well as precursors of acid deposition that contribute to air pollution and environmental degradation. On a global scale, the use of fossil fuels can even alter weather patterns due to emissions of GHGs, that affect hydrological systems, as well as marine and terrestrial ecosystems (Johansson & Goldemberg, 2002).

Moreover, as the population keeps growing, so does the energy consumption, as well as CO2 emissions. This path is not at the slightest compatible with the sustainable development goals. It also creates extra vulnerability for developing countries, as prices fluctuate, and oil prices keep increasing while demand rises as does the risk of being solely dependent on fossil fuels. The energy demand rate is expected to rise by about 60% by 2030 and CO2 emissions will rise at the same rate (El- Ashry, 2012).

Even though many countries today have agreed to some types of policy target regarding renewables (55 countries in 2005 and 118 countries by 2011 (El- Ashry, 2012)), to reach a long-term sustainable energy supply, countries need to go

through extensive changes politically, economically and socially, as well as technologically and are faced with resistance in many cases.

The change that energy transitions bring about is extensive in many areas: electricity, heating, transportation, etc. However, the policies created in regards to energy production vary widely, as some countries show commitment to the Paris Agreement and are generally optimistic about the modernisation of the energy production systems, however, others choose to maintain their non-renewable energy production, as there is a fear of energy transitions colliding with local development (Hess & Renner, 2019) (Zarate-Toledo, et al., 2019).

According to an article written in 2015, at that point of time, there were 1,4 billion people globally who did not have access to grid electricity but live in areas with sunlight for most days of the year. Using solar energy creates an opportunity for poverty alleviation as well as economic growth. Solar energy can provide people with affordable electricity, that are not connected to the local grid or when the grid energy is too expensive, distant, or unreliable. In addition, solar panels have recently decreased in price immensely thanks to production in China and technological innovations (Amankwah-Amoa, 2015).

This research will use the term ‘renewable energy’ frequently throughout the text, therefore a definition is necessary. The definition of renewable energy, or sometimes referred to as green energy has been provided by the UN Economic and Social Council and goes as follows:

> *Renewable Energy Source is the equivalent of the terms “deposit” or “accumulation” used for petroleum and solid mineral resources. Renewable Energy Source is the primary energy (e.g., earth thermal energy, energy from sun, wind, biomass, river* (UNECE, 2016).

Another definition that further explains the term renewable energy comes from Hendrik Lund, that wrote a book on renewable energy systems:

Renewable energy is defined as energy that is produced by natural resources—such as sunlight, wind, rain, waves, tides, and geothermal heat—that are naturally replenished within a time span of a few years. Renewable energy includes the technologies that convert natural resources into useful energy services:

- *Wind, wave, tidal, and hydropower (including micro- and river-off hydropower)*
- *Solar power (including photovoltaic), solar thermal, and geothermal*
- *Biomass and biofuel technologies (including biogas)*
- *Renewable fraction of waste (household and industrial waste)* (Lund, 2010).

2.1. Barriers for renewables in developing countries

The challenges many developing countries face are mostly regarding setting up new energy production opportunities as well as making electricity available for more people, rather than just transitioning currently set up production processes to using renewable sources instead. This is mostly because even though in some areas, the percentage of renewables in use is quite high, nevertheless, the percentage of people who can either afford electricity or for whom it is available for is quite low.

Even though energy production is transitioning toward renewable energies and there are many positives about this process, there are also challenges and hurdles along the way. One of which is economic and financial challenges. Firstly there could be market actors interested in keeping the country dependant on fossil fuels, therefore blocking and obstructing the negotiations to move toward renewable energy; secondly, the capital that goes into creating the new necessary infrastructure and acquire expert knowledge is not a small sum, and even with a gradual transformation, it comes together as a large investment (Cherp, et al., 2011). Essentially, the costs of technological transition are seen immediately, but the sum of benefits is uncertain, could be unevenly distributed and mostly meant for future generations (Jenkins & Karplus, 2017).

Another big topic for renewable energy transitions is the new price point. For higher prices of electricity, there are two differing opinions. On one hand, high prices could negatively affect social welfare and local businesses, on the other hand, if the prices are high, it could create incentives and motivation for innovation and improvement ideas for better efficiency (Johansson & Goldemberg, 2002). Therefore, politics need to play their role in setting the price point, creating subsidies and incentives for renewable energy production. In addition, there is a lot of discussion on the inabilities of technologies to achieve economies of scale, the price often affects the end-user the most and their inability to afford the renewable energy products and services may have a devastating effect if alternative approaches are not found. 'While this challenge may be addressed by incentives such as government subsidies, tax breaks and feed-in- tariffs, these have mainly been effective in increasing interest from developed countries, rather than improving affordability in developing countries' (Gabriel, 2016, p. 367)

Additionally, something that is mentioned in the literature is the problem with lack of skilled and knowledgeable labour in developing countries. As new technologies are set up, there will be a need for maintenance and service support, that require specific technical know-how for renewable energy technologies (Gabriel, 2016).

As of now the industry of renewables is growing, but it will not remain so if besides businesses, activists and scientists, the public policies are not facilitating the change.

> *"Public policies that create markets, remove barriers, level the playing field, and establish clear objectives and targets for renewable energy and energy efficiency, help shape the future. Energy policies affect the price, availability, and advancement of new technology; therefore, they determine how quickly we reach the point at which consumers can choose [renewable] electricity" (El- Ashry, 2012, p. 108).*

As technologies develop, policies must do as well, as without it, conventional energy systems may still be favoured price-wise (Turkenburg, 2002). According to

IRENA (2015) if government's aim is to scale-up renewables, then policymakers are expected to create a policy framework to mobilise private investments. It is added that political measures are the most effective if they are bundled with a broad range of policy instruments to encourage maximising socio-economic benefits (IRENA, 2015, p. 49).

2.2. Country context

The country chosen for the case study is Zambia. Zambia is a Sub-Saharan African country in the Southern-Central part of the continent with an area of 752,610 km2 and a population of 17,4 million people and it is one of the biggest copper producers in Africa. Their GDP per capita is 1539 US, and since 2011, according to the World Bank (World Bank) they have achieved the status of a middle-income country, as the economic growth was 7,4% in an average from 2004-2014 (in 2018 the number was 3,7%), the main contributor for the growth being the service sector (IRENA, 2013). However, the high growth did nothing to alleviate poverty, as the wealth was mostly divided between a small urban population and Zambia has one of the highest inequalities globally; in 2015 58% of Zambians earner less than 1,9 US per day that is the international poverty line (World Bank).

Zambia is considered to be a politically stable country in Africa, where in every 5 years democratic elections are held (World Bank). The human development index was registered in 2018 as 0,591, whereas the world average is 0,731 (UNDP, 2018), however, there is a big improvement to be seen, as in 2013 Zambia ranked 163 out of 187 countries with a HDI of 0,45 (IRENA, 2013). The percentage of people who have access to electricity is 40% of the population (energypedia, 2018). When it comes to using electricity from renewable sources, they have been one of the leading countries in SSA. According to the document of National Energy Policy (NEP), from the installed energy capacity 83% of electricity generation comes from renewable sources (Zambia, 2019).

3. Theoretical framework and previous research

The theoretical framework for this thesis will be based on the rational choice theory, that has been used in many fields, including political science. The theory has been around since the 18th century, however, until recently it was mostly used by economists. Rational choice theory can be used to predict, analyse or explain policy choices in different contexts. 'Rational choice theory gives us a set of useful tools to look at how the design of institutions and other trappings of the political system affect the quality of deliverables from the political system: policy outcomes' (Oppenheimer, 2012, p. 94). It is said by scholars following the theory that alternative approaches do not have the same explanatory power as the RCT has (Fumagalli, 2020).

For the chosen theory, there are many different definitions, however, most practitioners agree on some features of said definition. The first aspect that most theorists agree on, is that rational choice includes utility maximization, meaning that the choice is made by picking the alternative that best serves one's objectives. 'The maximizing assumption requires only that some schedule of preferences is maximized; it does not specify any particular goal' (Green & Shapiro, 1994, p. 14). This is the most fundamental idea in the rational choice theory and will also loosely be the basis of the analysis.

Uncertainty is a major part of rational choice theory, as mostly assumptions are used to make choices, even though the future is unknown. Therefore, the theory assumes that individuals maximize the expected value of their payoff, the word expected is especially emphasized, as the decision between choices was made during conditions of uncertainty (Green & Shapiro, 1994).

An assumption that is often made is that the agents making a choice must be individuals. However, some scholars argue that collective action is essentially the action of individuals that choose to accomplish goals collectively rather than alone (Green & Shapiro, 1994), therefore in this case the state would be the actor making the rational choices.

Rational choice theory is rooted in the assumption of instrumental rationality. A rational actor is one who, when confronted with "two alternatives which give rise to outcomes, … will choose the one which yields the more preferred outcome" (Quackenbush, 2004, p. 95)

To be more specific and explain how this framework suits for this thesis, one must first look at the payoffs. In theory, if a country has significantly invested already in fossil fuels and set up the proper infrastructure for existing electricity access, that is not based on renewable sources, then theoretically, investing in energy transition toward renewables, would most likely not end up in bigger payoff. That is because all existing technology would have to be switched out: old technology disregarded and new systems set up, people trained, clients notified as well as for many systems, like wind power, land rights need to be received to set up wind turbines. In addition, depending on a country's renewable sources' potential, and type of energy infrastructure for some it will be simpler than for others, e.g. 'for some like France, the transition will be less difficult, given the country's existing nuclear fleet and geographical advantages in developing solar and wind energy. But for others like Poland, which rely on coal for more than 80% of their electricity, the shift to low-carbon energy sources will be more challenging and require a larger financial effort' (Morgan, 2019). Then one could argue that rational choice theory would not apply in many cases for renewable energy transitions, as some countries have more initiative and motivation toward socio-economic development, to pursue renewables, as well as more RE potential, whereas some countries might start switching to renewables per international agreements to lower CO2 emissions or just in the pursuit of environmental protection.

However, in places like Zambia, where there are a lot of areas that are not electrified, or rural areas too distant to access the grid, then one part of the process

which would apply for previous cases, that are likely to be more developed countries, becomes to some extent, redundant, which would be the disregard of old technologies. According to Mathur and Spencer (2019) as latecomers to the industrialisation, many developing countries have now been able to benefit from the improvements that renewables have gone through over the years, including technology development and price decrease, and they have been able to achieve higher income per capita, without higher consumption of fossil fuels (Mathur & Spencer, 2019).

Therefore, it is presumed for this thesis that in order to abide by the chosen theory, Zambia should comply with the following:

1) Have sufficient renewable energy potential, e.g. solar, hydro, thermal, etc.
2) Expect proper payoff and socio-economic benefits by pursuing renewable energy
3) The main issue is with providing more energy access rather than switching out old systems and changing the whole energy infrastructure

3.1. Renewable energy in Sub-Saharan Africa

Energy access is recognised by many SSA countries as a necessary tool for alleviating poverty, as well as overall country development and quality of life. It is also one of the Sustainable Development Goals acknowledged by the UN, that affordable, reliable and sustainable electricity access is a necessity for development (Dagnachew, et al., 2018). In 2018, there was still 47,66% of the population in SSA that did not have access to electricity, which makes up to essentially more than 500 million people in the region without electricity access (World Bank, 2018).

Moving towards renewable energy is an important step in development for SSA countries. However, within ca 50 countries in the region, the process of development differs greatly between countries, when it comes to policies, subsidies, investment, and overall effort by the government. According to BloombergNEF (2020) the renewable source with the highest investment for new

technologies has been for solar energy and the main investors have been development banks (BloombergNEF, 2020).

Energy policy in SSA does not change fast and according to need, meaning, innovative policies, national climate initiatives and energy market reforms progress quite slow. However, recently clean energy auctions have opened up a possibility for investors and developers to enter the renewables market in the region. Before auctions, tariffs were introduced in some countries, however, they were quite rare. If auctions are well-organised and managed, they can have many positive effects, such as decreasing subsidy costs as well as spur competition. However, they can also be confusing and ill-managed, in addition, they are "more administratively complex, and require interest from investors" (BloombergNEF, 2020, p. 11).

Most of the energy transitions processes in SSA start with a foreign investment programme. However, for the investment to be successful and profitable, the governments need to be working toward the same goals and create policies that are favourable to new energy production processes, e.g. remove different market, regulatory and policy barriers (BloombergNEF, 2019). Therefore, supportive environment needs to be created by the government so that renewable energy systems could prosper.

4. Methodology

In this section of the thesis, the methods for the research will be discussed and motivated. It summarises the research design and strategy and discusses the suitability of them for the chosen research question.

4.1. Research design

This study will follow qualitative research strategy that allows the author to deeply analyse textual data, e.g. policies, governmental strategies, reports, etc., that will help pursue the answer to the chosen research question. Most work will be done using qualitative data, meaning that the research will mainly emphasise words instead of numerical data for analysis, however, it does not mean that the data will completely be discarded of numbers, which will be used to illustrate findings (Bryman, 2012, pp. 380-381).

This research will be done using a case study design, as a single case will be studied and analysed intensively. This method was chosen as it suits best with the aim of the thesis and helps answer the research question. 'Case study research is concerned with the complexity and particular nature of the case in question' (Bryman, 2012, p. 66). For this thesis, the term *case* will imply to a single country that will be studied extensively and it allows to study the phenomenon of renewable energy adoption in-depth in the context of Zambia.

However, as with every type of research design, case study comes with some challenges and limitations, one and the main one being generalisability of the study

and whether the findings of this particular case could be useful in other contexts (Bryman, 2012, p. 77).

4.2. Data collection and analysis

The analysis for this thesis will rely on secondary sources, which means that the data used will be provided by other researchers and the author has not been involved with the collection of the used data (Bryman, 2012). The data will be provided by the national policy reports as well as reports by independent research agencies, articles from academic journals as well as topical books and news articles.

The data for this research has been chosen from many different sources. Firstly, key word search was conducted on LUBsearch and Google Scholar to find appropriate academic articles to use for the theoretical part and literature review of the thesis. Secondly, to gather data about energy production, investments, etc information from the reports of IRENA and BloombergNEF was used. In addition, documents from ministries of Zambia were used to analyse policies, goals, and targets.

For the purpose of analysing the case study of renewable energy sector development in Zambia, a basic framework to better structure the data analysis has been developed. The proposed indicators were developed based on available information and useful factual data brought out in section 5.1. and then separated under two main categories: economic and technological indicators and governance and social indicators. The aim is to present well-structured and data-based analysis to find the answer to the proposed research question. Each chosen indicator will be discussed from the rational choice perspective and concluded whether the choices that the government and involved governmental organisations have made are complying with the RC theory.

1.Economic & Technological indicators	2.Governance & Social indicators
1.1.Cost of technology set up and production of renewable energy	2.1. Poverty alleviation and renewable energy
1.2.Foreign investment	2.2. Energy accessibility
1.3.Renewables potential vs non-renewables potential	2.4. Environmental protection

Table 1: Chosen indicators for empirical analysis

4.3. Case selection

The case of Zambia was chosen as it presented an interesting puzzle amid other countries in SSA. Zambia has quite low GDP, a high number of people living in poverty and their Human Development Index, in general, is lower than the world's average (UNDP, 2018). However, the percentage of renewable energy generation added up to 83% (Zambia, 2019) of installed energy capacity, which could be considered quite high. In addition, it was important for the research to be able to access and understand country policies and documents, which made Zambia a good choice, as their official language is English.

Therefore, the case of Zambia was chosen to research what are the reasons why Zambia's renewables adoption can be deemed fairly successful, while some other countries in the region, who might have a higher developmental status are lagging in that area.

4.4. Limitations

A significant limitation for this thesis is that only secondary data will be used for analysis, which does offer a higher amount of usable information, than it would for

self-gathered data, however, it also means that the quality of that data cannot be verified, also it limits the thesis in a way of what can be analysed based on what data is available to the author (Bryman, 2012, pp. 315-316). However, taking that into account, the author, in this case, assumes the accuracy of the data, based on the chosen high-quality sources.

5. Empirical analysis

The following section consists of two separate parts: the first one will give an oversight of the current energy situation in Zambia: including energy policies and opportunities for renewables, as well as financing, investment and organisations that are related to the energy sector in Zambia.

The second part will analyse Zambia's renewable energy policy choices from the view of rational choice theory. In that section, first, the price point will be discussed and shown, whether it is sensible to pursue renewables: production and set-up wise; second, private investment for increasing energy access will be analysed; third, the potential between renewables and non-renewables will be discussed and whether it is sensible to develop renewables and what is the country's potential for the renewable sources, or do they also have good potential for fossil fuel industry; fourth, the relationship between poverty alleviation, renewables and economic growth will be discussed; fifth, electricity accessibility will be talked about; and finally environmental protection will be discussed, as it has been mentioned many times in Zambia's policies.

5.1. Renewable energy in Zambia

The percentage of for renewable energy generation in Zambia seems quite high, however, the percentage of renewables was 83 of total energy generation, that is available for only 40% of the population, therefore there is still room for much improvement when it comes to increasing renewable energy production. According to IRENA (2018), in 2016 the number for renewable energy production was 11 108 GW out of 11 695 GW of total production. According to Zambia's own National

Energy Policy document, energy generation consisted of 80% hydro, 3% solar, 10% coal, 3,5% of heavy fuel oil and 2,7% diesel (see figure 1) (Zambia, 2019).

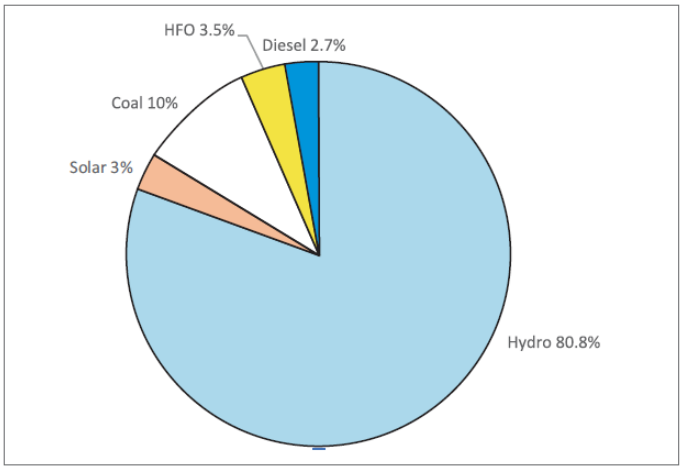

Figure 1. Electricity generation in Zambia (Zambia, 2019)

5.1.1. Renewable energy potential

Zambia has a very high potential for using renewable energy, as their resources are abundant, including hydro, solar, biomass, wind and geothermal energy. According to their National Energy Policy, the main sources of energy are currently hydro, biomass, coal, wind, geothermal, solar, uranium, waste, and petroleum. When it comes to solar energy, "(s)olar power generation accounts for 3 per cent of the total installed generation capacity. The level of investment in solar energy electricity generation has been low due to, *inter alia*, the high cost of capital and inadequate regulatory frameworks for renewable energy systems that have caused uncertainties for investments" (Zambia, 2019, pp. 7-8). Zambia also has good solar energy potential, having 2000-3000 hours of sunshine per year (Get.invest) and their GHI [1]lies in the range of 5.58- 6.15 kWh/m2 (Global Solar Atlas, 2020). To put this to a perspective, the GHI for Sweden is 2.55-2.99 kWh/m2 and the number for China, that has the biggest solar energy capacity in the world currently has the GHI at 2.64-5.93 kWh/m2 (Global Solar Atlas, 2020) (Finder, n.d.)

[1] the total amount of shortwave radiation received from above by a surface horizontal to the ground. This value is of particular interest to photovoltaic installations and includes both Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance' (DIF) **Invalid source specified.**.

As of now, the country is heavily dependent on hydroelectric generation, mostly large hydro[2] is being used. The estimated potential for hydropower generation in Zambia is more than 6000 MW (Get.invest), in 2014, the installed capacity was 2257 MW. 'The Zambezi River is the major hydropower resource in southern Africa. Zambia's territory occupies a larger area of the river basin, at 41 per cent than any of the other seven riparian nations' (IHA, 2014). However, as mentioned previously, the country aims to diversify the energy sources, as because of climate change, rain patterns have become unpredictable.

According to the national energy policy, the major reason for the high use of hydropower has been climate change (Zambia, 2019), which in itself means that sustainability of natural resources as well as environmental development has been an important aspect within the context of increasing electricity access and developing the energy market.

5.1.2. Legislative and regulatory framework

The regulatory framework of the national electricity sector has been provided by domestic Electricity Act as well as the Energy Regulation Act. The public body that supports and oversees the investment toward the energy sector was set up in 1999; the Office for Promoting Private Power Investment (OPPPI) was set up to help develop the energy sector and make the private investment easier by reducing the complex procedures, rules and bureaucracy that is generally related to investment in the energy sector, as different approvals, permits, etc. is needed (IRENA, 2013).

The electricity sector is composed of a state-owned organisation called ZESCO, that manages the grid and off-grid systems, the latter mainly being small hydro sources. The main consumer of electricity is the local mining industry, using up to 40% of generated electricity (IRENA, 2013).

[2] The definitions for large and small hydro differ, the ones used for this thesis come from IRENA, as their data is repeatedly used for this research. Therefore, large hydro has a capacity of 100 MW or more, medium hydro has the capacity from 20-100 MW and small hydro counts as 1 MW to 20 MW **Invalid source specified.**.

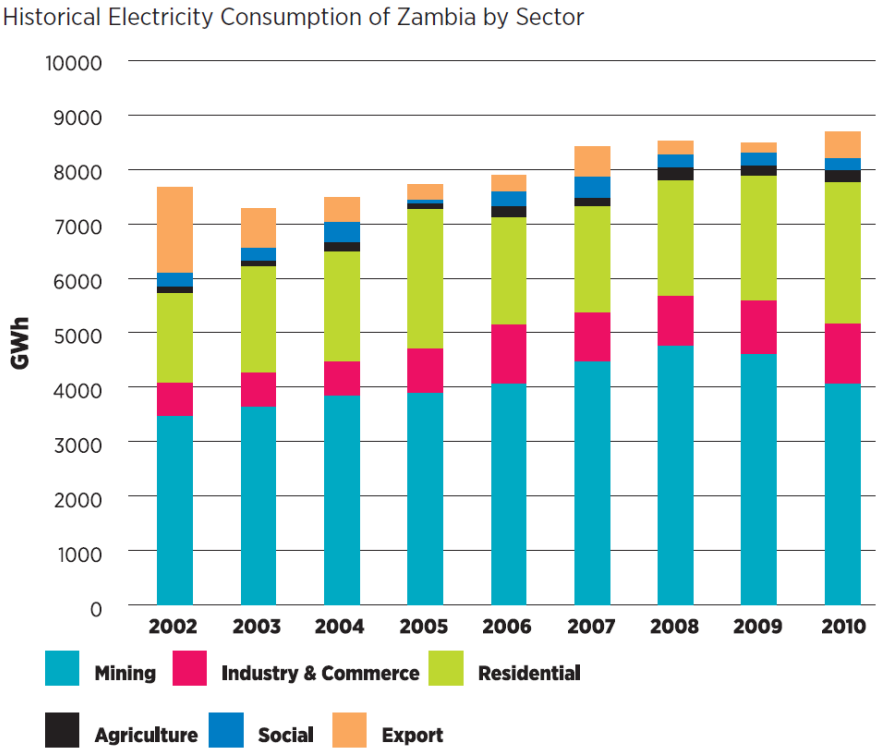

Figure 2. Historical Electricity Consumption of Zambia by sector (IRENA, 2013)

However, the demand is expected to increase, in a report published in 2013, it was projected that within a couple of years, mining would to take up 49% of generated electricity, industry/commerce sector to consume 20%, then 15% for residential use, and 10% for agricultural use. 'The current total installed capacity of 1,976 MW is only providing about 1,650 MW of power while peak demand is estimated at 1,800 MW and growing at 100 MW per year' (IRENA, 2013, p. 10).

Energy policies in Zambia

Setting up renewable energy policies is detrimental to influence preferred action in the long term, however creating a policy is just a starting point, the actual challenge is implementing the policy and seeing through the changes. According to the World Energy Council, energy policy should address three main aspects, called the energy Trilemma: energy security, energy equity and environmental sustainability (Doorsamy & Cronje, 2015).

Already as early as 2006, a policy on Environment was finalised, that 'recognizes the requirements set out in the national constitution and acknowledges the responsibility of civil society and all citizens to protect and conserve the

environment. The Policy calls for the importance of managing the environment in partnership with the private sector, non-governmental organizations (NGOs) and the local people for the benefit of the present and the future generations' (Zambia, 2008, p. 11/1).

The NEP currently in use was put in place in 2019, before that a previous policy was implemented for ten years since 2008. The previous policy had the main goals as attaining a market environment that promotes private sector investment as well as creating overall macro-economic policy objectives for sustainable energy development. The changes necessary to implement in NEP 2019 came over the years out of necessity to: provide reliable and affordable energy to reduce poverty and promote the development of local businesses; promote investment through pushing for more cost-reflective tariffs; updating institutional mandates to enable their response to changes in the energy sector; and promote renewable energy sources for clean energy generation (Zambia, 2019, pp. 17-18).

As for policy objectives, there is one goal specifically set for renewable energy, which is the following:

> *4.2.5 Exploitation of Renewable Energy*
> *Objective 5. To increase exploitation of renewable energy in order to diversify the energy mix.*
> *Policy Measures*
> *5.1 Strengthen institutional capacity for research in renewable energy;*
> *5.2 Enhance coordination among key stakeholders for effective implementation of renewable energy technologies; and*
> *5.3 Promote wider usage of renewable energy technologies* (Zambia, 2019, p. 20).

It has been brought out in the NEP later on when the implementation is expected to take place and what activities are expected to lead the country toward this objective, some of which are conducting awareness campaigns, networking campaigns, research in renewable energy, etc. However, according to Mallon (2006), who wrote a handbook on renewable energy policies and politics, for

renewable energy policy objectives to be successful, they need to be well-defined, and specific; expected outcomes should be built into policies in order to achieve them. In addition, Mallon (2006) finds that policies should pay attention to specify the resources and technologies in their policies, the definition can be implemented by either resource or outcome, so, for example, one can have specific targets regarding photovoltaics development and generation or have policies regarding generic renewable industry development, with the lowest cost being the main objective (Mallon, 2006). It seems as if Zambia has decided to have the lowest cost as their main goal (Zambia, 2019). Generally, the policies provided by the NEP seem to have good direction but remain fairly vague of what exactly is it exactly that is hoped to be achieved and what measures are used for it.

Increasing renewable energy generation is a major priority for the national government and they recognise the fact that to meet the electrification needs of the growing population, sustainable and renewable sources need to be taken advantage of. However, the approach needs to be well-coordinated and systematic to be successful (Zambia, 2019).

In addition, they acknowledge the aspects of climate change, gender and health in the overall energy sector. Climate change and changing weather patterns have been detrimental to the hydropower energy production, therefore the government recognises that energy diversification is necessary. The gender aspect has been emphasized as especially in rural households, firewood is being collected to prepare meals, which is mainly women's responsibility, therefore they are more vulnerable to the scarcities in biomass. Health is also mentioned in the NEP in response to using firewood and traditional cookstoves, as they may cause respiratory illnesses from smoke exposure as well as women's health, especially their back, has negative consequences from carrying firewood daily (Zambia, 2019, pp. 14-15).

As previously mentioned, the access to electricity in Zambia is quite low, currently 40%, but according to a Renewables Readiness Assessment done in 2013, it is expected to improve, essentially due to a Rural Electrification Master Plan (REMP) created in 2003. Their target is to improve electricity access in rural areas by 15%

in 2015 and 51% in 2030. However, that would require sizable financing. For the target, the funds are coming from Rural Electrification Fund that 'is mainly drawn from a 3% levy on every unit of electricity consumed, as well as grants and loans from development partners, and is aimed at encouraging private-sector participation by providing finances for project preparation studies and smart-capital subsidies' (IRENA, 2013, p. 15). In addition, REA promises to offer capital subsidy up to 100% to public-led rural electrification programmes and provide 50% of capital costs to privately-driven projects (IRENA, 2013).

In most situations, the best way generally to electrify rural villages is to extend existing grid access, as it is available 24 hrs per day and the access is stable, however, with the sparse population density and remote villages, it would require a long construction process for limited potential power (Zambia, 2008) therefore, the usual grid-extension would not be the most sustainable nor price-worth solution. According to REMP in Zambia, the way to increase access in rural places must be onsite renewable energy systems, even if the quality and quantity would be lower for that system, it would be the most effective method (Zambia, 2008).

SADC

Zambia is also a member of SADC, that is the Southern African Development Community, that was established in 1992 and includes the membership of 15 countries. The organisation has many goals including energy production for member countries: first and most general being providing affordable and reliable energy access for everyone in the region, more specifically one objective was to lessen the amount of population without energy access by 50% by 2020 and then halve that remaining number every five years until the main goal is achieved (IRENA, 2013).

5.1.3. Economy and financing

The ease of doing business[3] rank of Zambia is 85 out of 190 countries, however, if one were to only compare countries of SSA, Zambia would be in 5th place after Kenya and South Africa (World Bank, 2019).

In 2016 Zambia was going through some financial troubles, as their main source of export is copper and ever since the peak of copper prices in 2011, the prices were plummeting, and the economy in the country slowed down. As Zambia was going through some rough patches, it also affected the energy access, resulting in 10-14 hours of shedding a day as well as fiscal deficit of 8% in 2015 (AfDB, 2016). Therefore, the country's financial situation has a big effect on electricity access.

Energy Financing

The national energy sector has currently four mechanisms for energy financing:

1) Rural Electrification Fund (REF)
2) Strategic Reserve Fund (SRF)
3) Uniform Petroleum Pricing (UPP)
4) Electricity Fund (EF)

> *The REF was established in 1994, by committing the sales tax on electricity where a levy of 3.45 per cent on electricity consumption was introduced. The fund was created to supplement the national budget on capital expenditure for rural electrification* (Zambia, 2019, p. 14).

Trouble that Zambia has experienced with procuring private investment is partly related to their electricity tariffs, namely, they are one of the lowest ones in the region and so far the attempts to adjust the tariffs to be more cost-reflective have not been too successful. This means that private investors in the energy sector are also not interested in investing, as the tariffs are not cost-reflective. 'In order to

[3] A high ease of doing business ranking means the regulatory environment is more conducive to the starting and operation of a local firm. The rankings are determined by sorting the aggregate scores on 10 topics, each consisting of several indicators, giving equal weight to each topic (World Bank, 2019)

meet the growing electricity demand, ZESCO[4] has in the recent past procured power from independent power producers at a higher tariff than the average selling tariff. This tariff gap has generated unsustainable annual losses for ZESCO' (Zambia, 2019, p. 14). Since 2009 the country adopted a new tariff path to meet future energy demands, where the plan was to increase tariffs on average from 0,05 in 2012 to 0,13 in 2016 (IRENA, 2013).

It seems as if the plan to increase the electricity tariffs has not necessarily gone according to the plan, as it was proposed for 2012-2015, however in the NEP that was published in 2019, low tariffs were still emphasised as a problem in the policy. According to Climatescope (2019) the tariff increase was approved by the Energy Regulatory Board, however, it was cancelled by the president, right before the local elections (Climatescope, 2019).

Zambia has also created tax incentives for private companies to encourage them to develop small hydro and PV plants. For the first five years, the developer is relieved of paying tax on dividends and profits, however, 'projects must be developed in the multi-facility economic zone, an industrial park or a priority sector (the latter includes energy) and invest in a rural enterprise under the Zambia Development Authority act.' Tax breaks are only given to projects over 500 000 USD, and they receive non-fiscal incentives, that also smaller-scale projects receive, namely 'investment guarantees and protection against nationalisation and facilitation of immigration permits and land acquisition' (Climatescope, 2019).

Following are some examples of RE projects, that Zambia has been a part of.

Auctions

Renewable energy auctions have become more and more influential during the past decade globally as well as in SSA. The auctions are motivated by their potential to reach lower prices by encouraging competition. They are attractive to investors, because of the income that is generated through the sale of energy to the utility

[4] ZESCO Limited is a vertically integrated power utility and is responsible for generation, transmission, distribution and supply of electricity in the country (Zambia, 2019, p. 4)

companies per long-term power purchase agreements. The auction schemes are especially beneficial for the recipient countries, as in most cases there are specific requirements on the auctions to contribute to political and socio-economic development goals, e.g. generating more jobs, having local ownership, etc. (Hansen, et al., 2020).

According to IRENA (IRENA, 2018) 'The success of auctions in these markets builds on clear linkages with a country's renewable energy deployment strategy, which incorporates political commitment, longterm targets, high-quality planning and reliable contractual schemes, such as power purchase agreements (PPAs).' (IRENA, 2018, p. 6). One of the reasons why the prices of RE technology have decreased majorly in the recent past, are the auctions. They have demonstrated the ability to optimise the costs of RE systems (Piana, et al., 2018).

Scaling Solar

Scaling Solar was an auction as well, where in 2015 Zambia was chosen as the first SSA country to cooperate with IFC, who is a member of the World Bank Group, on the project to develop two 50 MW solar PV power projects. This was the first utility-scale PV project implemented in Zambia, offering competitively priced sustainable and clean energy that would also decrease Zambia's dependence on hydropower and diversify energy sources (IFC). An addition to hydropower was necessary as changing climate patterns have changed rainfall patterns, therefore hydropower could be at times unreliable (Zambia, 2019).

The deal was signed with Zambia's Industrial Development Corporation[5], that at the current moment had a goal to add 600 MW solar power generation capacity due to power deficit from hydropower (Zambia, 2019). In 2016 Power Africa and USAID provided 2 million US to support the programme, which was expected to increase the solar energy generation by 100 MW. According to USAID 'This support helps finance the critical costs necessary to establish and implement a

[5] State-Owned Enterprise (SOE) charged with the mandate to spearhead the Zambian Government's commercial investments agenda aimed at strengthening Zambia's industrial base and job creation **Invalid source specified.**

transparent, competitive bidding process to attract qualified solar power developers and to build institutional capacity and catalyse market growth' (USAID, 2020).

Scaling-up Renewable Energy Program for Low-Income Countries (SREP)

SREP programme is a 720M USD programme organised by Climate Investment Funds, that aims to empower the world's poorest countries by supporting scaling up of renewable energy sources, as solar, geothermal and biomass to increase overall electrification of countries. The investments through the programme usually align with the countries' priorities and policies, but recently mini-grid systems are becoming more and more popular for countries with many areas isolated from the main grid access (CIF). Zambia will be able to receive an investment in size of 40M USD through the World Bank to assist private sector project financing. The finances are meant to support private sector developers to scale up their renewable energy programmes (Zambia's Ministry of Energy)

5.2. Rational choice theory and renewable energy pursuit in Zambia

1.1. Cost of technology set up and production of renewable energy

The first thing that will be reviewed is the price point between renewables and non-renewables in Zambia. When it comes to cost difference between renewable and non-renewable energy, the main objective for Zambia in their national energy policy was to meet the domestic needs 'at the lowest total economic, financial, social, environmental and opportunity cost' therefore one of the aims to increase energy access is for the service to be provided inexpensively and the technology set up to have as low price-point as possible (Zambia, 2019, p. 17). According to a report by BloombergNEF (2019) in the energy markets there are two tipping points for the prices, The first comes when building and operating a new clean power plant is more cost-efficient than doing the same for a fossil plant. The second comes when a newly built clean energy plant can undercut the economics of an existing fossil plant on a levelized cost of electricity (LCOE) basis. The report argues that

in most countries today it is already cheaper to install and operate RE systems, except in Southeast Asia and Turkey (BloombergNEF, 2019, pp. 18-19). In addition, according to Jain (2017), the cost of coal power is now competitive with the cost of renewable energy (Jain, 2017). However, the same prices are not available everywhere. According to a report by IRENA (2013), Zambia is one of the countries where the right type of regulatory and policy frameworks are in place and low-cost finance is obtainable, therefore, solar energy has an equal footing with fossil fuels, pricing wise (IRENA, 2016). Additionally, one can already see that in 2013 the price for large hydro production in Zambia was 0,02-0,03 USD whereas for diesel power plants the number was 0,35 USD per kWh (IRENA, 2013).

Therefore, pursuing renewable energy technologies makes sense for Zambia in the long run, as prices for building and operating keep decreasing and if they want to have the lowest cost of energy, pursuing solar energy, as they do currently, makes the most sense. Moreover, it complies with the theoretical approach, where Zambia is expected to maximise their gains, therefore if renewable energy production and set up is more inexpensive than producing from non-renewable sources, it could be classified as a rational choice.

1.2. Foreign investment

Second reason why Zambia is pursuing renewables, could be argued, is to receive investment from investment banks, organisations and developed countries to increase their electricity access. The receiver of the investment must have proper policies and strategies in place for the investment to be effective and sustainable as well as attract the investors. According to a report on financial risks in RE investment in South-Central Africa 'risk mitigation becomes paramount and the use of financial de-risking instruments coupled with a sound policy can reduce the financial overall costs of renewable energy investments and help attract both debt and equity capital at scale' (Bicciato, et al., 2018, p. 49). In addition, to apply for different investment opportunities, or programmes for increasing electricity access, renewables are the starting to be the more attractive way to go in the energy sector, as developed countries and investment banks seem to prefer renewables over fossil fuels (BloombergNEF, 2019). Additionally, renewables seem to be gaining

momentum currently, as realisation sinks in everywhere that fossil fuels are finite and the concern for environment is increasing (Curtis, 2020), a helping factor for the investment is also the decreasing cost of technologies (Kuepper, 2019). Moreover, according to International Energy Agency, in 2019 they reported that investment, in general, had decreased in SSA, however, investing less in oil and gas had offset a small increase in renewables (IEA, 2019).

As in general, increased electricity access boosts the economy, welfare, employment and international trade. Therefore, mobilising renewable energy financing to increase electricity access with the help of private investment, aligns with the RC theory.

1.3.Renewables potential vs non-renewables potential

Zambia has produced coal since 1967 (Baruya & Kessels, 2013). According to the data by worldometer, Zambia does have proper coal reserves, ranking them 64th in the world by reserves and 59th in the world by production out of 66 countries (worldometer, 2016). Therefore, it could be said that compared to some other countries, the potential for coal production is quite low.

The demand for coal is low as well, and the main consumer of coal is the copper mining industry, that consumes half the coal produced. Zambia does not have a coal-powered electricity generator yet, however, it was in the plans in 2013, according to a report by the international energy agency, however the report was critical about the idea: 'the construction of a 300 MW coal-fired plant is an interesting development although the technology is subcritical' (Baruya & Kessels, 2013, p. 50).

However, according to a report by Carbon Tracker (2020) coal power is on the decrease and continuously unsustainable. By 2030 it is expected that running already existing coal plants have become uneconomic, and all coal plants are expected to become stranded estates. In their main findings, it is said specifically that 'New investments in renewables are cheaper than new investments coal in all

major markets today' and 'it could be cheaper to build renewables than run coal in all major markets by 2030' (Carbon Tracker, 2020).

It turns out that Zambia does have coal energy potential and there is a possibility of pursuing it with a new coal-powered plant. However, that does not seem to matter anymore, as reports like these are public and investors in the energy sector know that the coal industry is not sustainable anymore, the only way to bring in investors to increase electricity access is through renewables, where as mentioned before, Zambia's potential is abundant. Thus, in the case of different energy sources' potential, Zambia has chosen the one, that is expected to benefit them the most.

2.1. Poverty alleviation and renewable energy

According to different policy documents, Zambia believes strongly that increasing electricity access is a way forward to alleviate poverty: their vision is 'to reduce national poverty head count to less than 20 per cent of the population; to reduce income inequalities measured by a Gini coefficient of less than 40' by 2030 (Zambia, 2006). The poverty rate in Zambia is fairly high, 58% of the population is living under the poverty line, therefore, to encourage economic growth in the whole country, more and more people need to be lifted out of extreme poverty in order to become valuable puzzle pieces in the national market. As one can see in their national energy policy, renewable energy is associated with poverty alleviation, it is believed that increasing access to sustainable and efficient energy helps reduce poverty, especially among vulnerable groups like women and children; and poverty alleviation, in turn, helps facilitate the expansion of businesses (Zambia, 2019).

According to a study from 2011, it was concluded that by simply installing solar water heaters in SSA, household capitals rose, as money was saved by not using other measures for water heating that were determined to be more expensive (Wlokas, 2011). By installing technology for affordable energy access in rural areas, a lot of women would also be relieved of firewood collecting duty, as it would not be necessary for food preparation. Therefore, even as the future is

unknown, the decision to pursue renewables is done in the hopes of reaching the set-out goals, that is poverty alleviation and in turn economic growth and is fulfilling the requirements of the RC theory.

2.2. Electricity accessibility

Currently, energy accessibility is really low in Zambia, especially in rural areas, where 11,8% of the population has access to electricity (Zambia, 2019). Something that could be of a solution in isolated and rural areas could be mini-grids, that are able to 'provide electricity where the practicalities or cost of extending the national grid are prohibitive but there is a main load centre or sufficient loads in a cluster to favour an interconnected grid over individual stand-alone systems' (GET.invest, 2019, p. 41). They are small-scale electricity generators that are able to serve a limited number of citizens in isolation from the main grids with the same quality. Mini-grids are not meant to be a temporary fix until the main grid is developed, but are rather a permanent solution and could expand all over the country. There are possibilities of a fossil fuel mini-grids, however, according to a report by GET.invest, renewable energy mini-grids can reduce costs, make maintenance simpler as well as lower greenhouse gases (GET.invest, 2019).

As previously mentioned, it is not financially reasonable for Zambia to increase their main-grid access, as many areas are remote, and they are missing the necessary infrastructure as well as funds to extend grid access. Therefore, to successfully increase electricity access in rural areas, with the cheapest price, available, renewable mini-grids are a good choice; and it seems to also comply with the rational choice theory.

2.4. Environmental impact

Environmental protection and sustainability is something that is mentioned several times in Zambia's different policy documents. For example, a larger policy goal for 2030 the country has set, is 'A productive environment and well-conserved natural resources for sustainable socio-economic development' (Zambia, 2006, p. 40).

Using renewable sources for electricity production has several positive impacts to a country: firstly, most renewable energy systems produce little or no emissions towards global warming, as an example, burning coal for electricity releases between 1.4 and 3.6 pounds of carbon dioxide per kilowatt-hour, whereas the number for solar would be 0,07-0,2 CO2/kWh (UCSUSA, 2017). Therefore, again, pursuing renewable energy implementation is coherent with the idea of making decisions based on expectations to fulfil previously set goals.

6. Discussion

It could be argued that pursuing renewable energy and increasing its accessibility is generally a reasonable choice for Zambia, as they have the proper potential for hydro, thermal and solar sources, supporting governmental policies in place to procure investment and economic incentives exist for the country as well, as in their case, pursuing renewables turns out to be cheaper than to increase non-renewable energy access. Additionally, they do not have a dominating fossil fuel industry, that would sabotage the efforts to transition nor the problem of switching out old technology and discarding old systems.

To compare to other countries in Sub-Saharan Africa, for example, South-Africa (SA), then the situation there is vastly different. SA's main source of energy is currently coal: it dominates energy production, as 77% of the country's energy needs are supplied by coal (Republic of South Africa). In addition, they have a very high rate of electrification, where around 90% of the population has access to electricity (World Bank, 2018). Even though they have mentioned in their annual energy report, that there are plans to pursue renewables (they are planning to implement a build of 40 000 MW of additional electricity capacity of which 20 000 is planned to come from renewable sources (Republic of South Africa, 2018)), in their webpage they do note that coal is their main energy source and they do not expect it to change within the next two decades, as they find that the alternatives are not competitive (Republic of South Africa). And even though, South Africa has abundant potential for renewable energy, meaning there are opportunities to exploit solar, wind, hydro and even bioenergy to some extent (Get.invest), they have less drive and put in less effort to pursue renewables, as there are no quick payoffs, but rather could see benefits in the long run. Additionally, according to an article on renewables investments in SSA (2020), most foreign investments go towards projects that are developed in countries that currently do not have much renewables

infrastructure set up yet, and outside mature markets like SA (Renewable Energy World, 2020).

It is noticeable in the energy sector report in SA, that seemingly much less emphasis has been put on pursuing renewables (Republic of South Africa, 2018), than in Zambia, however one could say that they may not be in a rush to pursue them, as their only added value would be transitioning energy sources to more environmentally sustainable ones, and perhaps in the future save on production cost, however, the transition period would have quite high costs.

A similar case would be Botswana, where the main source of energy is also coal (79% of total generation of electricity). The country has some renewable energy potential, however, they are only used as 18% of electricity production (World Bank, 2014). Botswana's case is a little more similar to Zambia's as their GDP is more similar (18M USD for Botswana and 26M for Zambia, whereas the GDP of SA is 368M (World Bank, 2018)). According to the World Bank (2014), Botswana has 66% of Africa's coal resources and they are very motivated to take advantage of those resources (World Bank, 2014), additionally, the country is not suitable for large hydropower development, as there are already problems with water restrictions and supply interruptions; their wind speeds are also slow, making it not attractive for wind-power development; however solar-powered systems could be developed in the area (Get.invest). To date, Botswana has not made it a goal to completely transition towards renewables, however they have made a deal with the World Bank to develop solar energy generation in the country, that's in order to decrease dependence on importing electricity from neighbouring countries (Ngounou, 2019). Therefore, Botswana does not seem to have their main aim on pursuing renewables, when it comes to the energy sector and they do not have the same preposition as Zambia.

Therefore, it could be argued, that rational choice theory explains the RE pursuit in the case of Zambia, but for some other cases, efforts towards renewable energy investment and implementation are smaller, as is the expected payoff.

7. Conclusion

The question that was asked at the beginning of this thesis was '*What are the main reasons behind different renewable energy developments in Sub-Saharan Africa?'* It was decided after careful collection of empirical data, that rational choice theory would help shape the thesis and find the answer to the chosen question. The paper explored the energy transition barriers, energy sector in Sub-Saharan Africa and then analysed the energy sector of Zambia in-depth, with the help of some directing variables, that are brought out in the methods section. It was found out, that Zambia's choice of pursuing increase of renewable energy access is compatible with the main idea of RC theory that is maximising utility and expected value of payoff. It is presumed that Zambia was making decisions based on their knowledge of available resources as well as expectations of the decision to best serve their goals, some of which are poverty alleviation, boosting economic growth and increasing electricity access with the lowest cost possible. According to the available information, analysis was completed, and it was found, that the decision to pursue renewable energy complies with the rational choice theory. Therefore, the answer to the research question would be that Zambia is putting effort into pursuing renewables, as it brings about major projected socio-economic benefits for them, and is expected to do that in the future as well, whilst some other countries would have to transition to renewables for the sake of environmental protection, that might not offer as much motivation and incentives as the former case.

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