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Analysis of the application of solar energy in the S.A.D.C. region

A potential solution for energy access in remote rural areas.

-Master Final Thesis-

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LIST OF ABBREVIATIONS

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AC: Alternating Current
CHP: Combined heat-and-power
DC: Direct Current
DIS: Directorate for Infrastructure and Services
DME: Department of Minerals and Energy
DRE (systems): Distributed Renewable Energy
DREA: Distributed Renewables for Energy Access
ECB: Electricity Control Board
EE: Energy Efficiency
FBE: Free Basic Electricity
FLS: Frontline States
GDP: Gross Domestic Product
GHGs: Greenhouse Gases
IAEA: International Atomic Energy Agency
IC: International Community's
IEA: International Energy Agency
INEP: Integrated National Electrification Programme
IPPs: Independent Power Producers
IRENA: International Renewable Energy Agency
IRP: Integrated Resource Plan
LCOE: Levelised Costs of Energy
MAREP: Malawi's Rural Electrification Programme
MME: Ministry of Mines and Energy
MS: Member States
MW/h: Megawatt/Hour
NEPAD: New Partnership for Africa's Development
O&M: Operational and Maintenance
OECD: Organisation for Economic Co-operation and Development
OGEMP: Off-Grid Energisation Master Plan
OGEMP: Off-Grid Energisation Master Plan
OPEC: Organisation of the Petroleum Exporting Countries
PAYG: Pay-As-You-Go
PIDA: Programme for Infrastructure Development in Africa
PV: Photovoltaic
REASAP: Regional Energy Access Strategy and Action Plan
REDMP: Rural Electricity Distribution Master Plan
REEESAP: Renewable Energy and Energy Efficiency Strategy and Action Plan
REIPPPP: Renewable Energy IndependentPower Producer Procurement Programme
REN21: Renewables of the Renewable Energy Policy Network for the 21st Century
RES: Renewable Energy Sources
RIDMP: Regional Infrastructure Development Master Plan
RIDSP: Regional Indicative Strategic Development Plan
SABS: South African Bureau of Standards
SACREEE: Centre for Renewable Energy and Energy Efficiency

SADC : Southern African Development Community
SADCC: Southern African Development Coordination Conference
SAPP: Southern African Power Pool
SD: Sustainable Development
SDGs: Sustainable Development Goals
SHS: Solar Home System
SIPO: Strategic Indicative Plan for the Organ
SMEs: Small and Medium-sized Enterprises
SPS: Stand-alone Power Systems
SPSs: Solar Pico Systems
TWh: Terawatt-Hours
UNECA: United Nations Economic Commission for Africa
UNFCCC: United Nations Framework Convention on Climate Change
COP1: Conference of the Parties
UNIDO: United Nations Industrial Development Organisation
WHO: World Health Organisation

INTRODUCTION

The purpose of this paper is to understand and explain the current situation of renewable energy's application in remote rural areas of the Southern African Development Community (from now on referred to as SADC) region. The aim is to demonstrate the advantages of using renewable energy sources, in this case the sun, in order to deal with the energy access challenge of remote rural communities.

This thesis rationale for choosing the African continent is because it faces an enormous energy challenge. But also as important, is the fact that more than half of the global population growth between now and 2050 is expected to occur in Africa, as the continent has the highest rate of population growth[1]. Its growing population and economic development are creating an increasing demand for energy which in turn calls for an increase in energy supply and consequently a transformation of Africa's economy. Therefore, energy is not only fundamental for Africa's socio-economical development, but also because it will set the ways in which the whole continent manages a great amount of its energy demand which can have tremendous global environmental repercussions. Since the energy supply sector is the largest contributor to global greenhouse gases emissions, Africa's energy access strategies will have great significance for our Climate Change generation. More specifically, in order to do a more accurate analysis this paper has chosen a geographical focal point, namely the SADC region. The choice of this region is because of the SADC institution's regional focus on development and intergovernmental integration.

Energy access constitutes a great policy challenge for SADC Member States, because average access in the region is still at 48%, and only 32% in rural areas[2]. Moreover, the most affected by this issue are remote rural communities as their national governments cannot afford to supply them with energy through the main electric grid anytime soon. As this thesis will demonstrate, energy is essential for human progress and socio-economic development, therefore no energy access poses an enormous limitation for these communities. This notion has been reinforced by the United Nations Sustainable Development Goals as there is a specific goal dedicated to "ensure access to affordable, reliable and modern energy for all by 2030"[3]. Bearing this in mind, we will analyse how solar renewable technologies can become the most effective, affordable, reliable and modern solution for energy access in remote rural communities. This research hypothesis were the following:

What is the relationship between energy access and socio-economic development?

What is the best way to harness solar energy as a solution for energy access in remote rural areas in the SADC region?

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[1] UN. *Population* [online] New York, 2019 [Accessed 11 Feb. 2019]. Available at: <https://www.un.org/en/sections/issues-depth/population/>

[2] REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p.77

[3] UN. *Sustainable Development Goals kick off with start of new year.* [online] New York, 2015 [Accessed on 1 March 2019] Available in: <https://www.un.org/sustainabledevelopment/blog/2015/12/sustainable-development-goals-kick-off-with-start-of-new-year/>

This papers' main asset is that it constitutes a multidimensional compilation of all the relevant data regarding how renewable energy can help remote rural communities gain sustainable energy access. In order to gather this information, the analysis combines juridical content and political affairs with environmental awareness and energy technical expertise, which makes it extremely valuable and complex. Since the stakeholders involved come from different realms (being politics, law, science, energy sector and the rural society), transfer of knowledge between them is essential in order for them to work together. However, in most cases this is not given enough relevance which results in inaccurate solutions which ultimately fail. This analysis offers a potential solution which includes all of the information regarding the stakeholders involved and it is written in a way in which anyone could understand their relevance and how they influence each other.

In this regard and since in our legal-political context there are not many works of these characteristics on this topic, the analysis will be laid to structure the exhibition in the following points:

First, we will start by providing a compilation of the historical evolution of our knowledge, usage and exploiting of energy. This will be done through the analysis of the evolution and the role of renewables into the current sustainable development global trend.
In order to put together the historical evolution of the energy sector, the sources for this chapter were very diverse as energy has many dimensions. Information came mostly from electronic journals and articles.

The second chapter focuses on the African region, specifically the SADC. Evaluating the regional management of SADC's energy objectives, competences and instruments applied so far, in order to understand the institution's fundamental role. It explains the political and legal dimension of the analysis and therefore, the information has been extracted mainly from the institution's official documents and publications.

The third chapter is dedicated to the technical analysis of the application of solar off-grid solutions for remote rural communities. It will be done through two case studies which will start by comparing the off-grid legal framework adopted in three different SADC Member States and then it will compare and assess the actual instalment of the solar technologies. It must be noted that all the energy-related technical knowledge on this chapter, has been acquired from experts on the field. Information was gathered from recognised institutions papers and publications such as IRENA, REN21 and IEA. On top of this, during the early stages of the research an interview was conducted with the engineer Josep María Serena who is currently the president of the Spanish Nuclear Safety Council, in order to fully understand the inner-workings of a sustainable energy system.

Finally, the last piece of this thesis will put together some recommendations and several conclusions in order to fully achieve a sustainable rural electrification strategy by harnessing an unlimited energy source, the sun.

KEYWORDS: *Africa, SADC, energy access, renewable energy, remote rural communities, sustainable development, solar energy, off-grid technologies.*

**Since much of the information acquired comes from online sources, this paper incorporates the date of access to such websites both in the footnotes and the bibliography at the end.*

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1. EVOLUTION OF RENEWABLE ENERGIES IN THE POWER SECTOR AS A GLOBAL POLICY

Since energy touches upon many different fields literature tends to focus on a specific sphere of energy, namely the technical or the economical areas. However, for the purposes of this paper it is essential to have an understanding of the technical, political, economic and environmental spheres of energy and how they can converge on this specific case. It is for this purpose that this chapter will gather the historical evolution and emergence of energy's distinct spheres, in order to construct the current international concept of energy development strategies.

> "Access to energy is a key pillar for human wellbeing, economic development and poverty alleviation. Ensuring everyone has sufficient access is an ongoing and pressing challenge for global development"[4].

Energy has been behind all the major economic transitions in the past couple of centuries. Moreover, the three major industrial revolutions which have transformed the world have been triggered by different sources of energy and in turn have allowed for modifications in the global energy mix and the introduction of new sources of energy. From this, we can draw the conclusion that energy is one of the main foundations of human progress.

1.1. Traditional primary energy sources

The First industrial revolution (1750) was fuelled by coal, which allowed for the creation of the steam engine and many other creations[5], this endorsed economic development, social changes and the urbanisation of society. Coal was the primary source for energy between 1830 and 1914, peaking in the year that the First World War broke out[6]. Afterwards, the Second industrial revolution, which happened during the first half of the 20th century, was pioneered by oil. The use of oil for energy production rose from 1% to 40% between 1900 and 1973, peaking in 1979, the year of the first Organization of the Petroleum Exporting Countries (OPEC) oil shock[7]. Finally, the Third industrial revolution which started at the end of the 20th century and lasts until now, is also fuelled by oil and coal, but new sources of energy have been added like natural gas and renewable energy. This third industrial revolution was supposed to be driven by nuclear energy, but the elevated costs for the installation and maintenance of a nuclear power plant due to it's usage of uranium and plutonium and the severe catastrophes of Three Mille Island (1979), Chernobil (1986) and Fukushima (2011), have made nuclear power a less attractive source of energy[8].

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[4] RITCHIE, H. and ROSER, M.. *Energy Production & Changing Energy Sources*. Our World In Data. [online] Oxford, 2019. [Accessed 11 Feb. 2019]. Available at: <https://ourworldindata.org/energy-production-and-changing-energy-sources>

[5] For more information about the industrial revolution inventions go to. McFADDEN, C. *27 Industrial Revolution Inventions that Changed the World.*[online] Interesting Engineering, 2018 [Accessed 11 Feb. 2019]. Available at: <https://interestingengineering.com/27-inventions-of-the-industrial-revolution-that-changed-the-world>

[6] FATTOUH, B., POUDINEH, R. and WEST, R. The rise of renewables and energy transition: what adaptation strategy for oil companies and oil-exporting countries? *Oxford Institute for Energy Studies*, 2018, p.10.

[7] Ibid, p.7.

[8] Ibid, p. 517.

Despite the previously mentioned new alternative sources, the main source for our energy production today are still fossil fuels[9]. However, our use of fossil fuels is limited and according to our most recent studies we will reach the peak in our oil consumption in the next 30 to 40 years[10]. This is not a surprise and has been a recurring concept in the literature, starting with the most influential work by King Hubbert who came up the Oil Peak Theory[11]. The theory explains that our total oil production will reach a historical maximum and from then on it will imperatively start declining[12]. All forms of oil extraction including unconventional methods, such as fracking, will be unable to avoid the decline in production because from this point onwards the problem will not be the amount of oil remaining, but the maximum speed at which we can extract it.

On the other hand, although the use of coal rebounded in 2017 after two years of decline, it's too soon yet to count coal out of the global power mix[13]. Coal is still one of our main global primary sources for energy and the recent shift in international energy production to Asia has led to an increase in implementation of new coal-fired plants[14]. However, coal takes millions of years to develop and there is a limited amount of it, therefore, our consumption is unsustainable.

Finally, the global natural gas resource base is vast and more widely dispersed geographically than oil, which means that natural gas can continue to be one of the major sources of electricity generation. Moreover, the shift from higher-emitting coal to lower-emitting natural gas, due to the increased availability of low-cost gas, thanks to the development of new production techniques, have made natural gas a more attractive source in the recent years. According to the International Energy Agency, natural gas will overtake coal in 2030 to become the second-largest fuel in the global energy mix[15].

The present distribution of our primary energy sources is led by oil, accounting for around 39% of fossil energy, followed by coal and natural gas at 33% and 28%, respectively[16]. However, the burning of fossil fuels, like natural gas, crude oil and coal are the main contributors to carbon dioxide emissions into the atmosphere, and the emissions of other greenhouse gases (from now on referred to as GHGs). The United Nations Framework

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[9] BRUCKNER, T. and BASHMAKOV, I.A. et al. Energy Systems. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* In EDENHOFER, O, PICHS-MADRUGA, R. et al (eds.). United Kingdom and New York, Cambridge University Press, 2014, p. 557.

[10] SANCHEZ, J. Realidad y leyendas sobre el petróleo y su posible agotamiento. *Instituto Español de Estudios Estratégicos,* 2015, p 27.

[11] HUBBERT, K.. *Nuclear Energy and the Fossil Fuels*. Houston, Texas: American Petroleum Institute, 1956, p. 40.

12 According to Matthew Simmons, former Chairman of Simmons & Company International and author of *Twilight in the Desert: The Coming Saudi Oil Shock and the World Economy:* "Peaking is one of these fuzzy events that you only know clearly when you see it through a rear view mirror, and by then an alternate resolution is generally too late".

[13] IEA. World Energy Outlook 2018. *IEA*, Paris, 2018, p.4.

[14] Idem

[15] Idem

[16] RITCHIE, H. and ROSER, M.. *Energy Production & Changing Energy Sources*. Our World In Data. [online] Oxford, 2019. [Accessed 11 Feb. 2019]. Available at: <https://ourworldindata.org/energy-production-and-changing-energy-sources>

Convention on Climate Change (UNFCCC) established the global objective to reduce GHG concentrations in our atmosphere[17]. The first Conference of the Parties (COP1) was held in 1995 in Berlin, this conference has been held annually since then, and serves as the formal meeting of the UNFCCC Parties to assess progress in dealing with climate change. The COP3 was held in Kyoto and resulted in the adoption of the Kyoto protocol[18], which for the first time defined global legally binding targets and timetables for cutting the GHG emissions for the industrialised countries that ratified it. Future energy demand growth, will be constrained by carbon emissions cuts, thus, it is unlikely that our future primary sources of energy will be pioneered by fossil fuels as seen in the historical transitions. This makes it essential for our generation, to reinforce our alternative primary energy sources in a short period of time, no longer than the next 40 to 60 years.

For a graph on the global evolution of our primary sources of energy see Figure 1 of the Annex.

1.2. Surges the need for an international energy political regime

For the purposes of this work, energy governance is understood as the International Energy Agency (IEA) describes it in its Energy Efficiency Governance Handbook:

> "Energy efficiency governance is the combination of legislative frameworks and funding mechanisms, institutional arrangements, and co-ordination mechanisms, which work together to support the implementation of energy efficiency strategies, policies and programmes"[19].

Energy governance became more evident after the oil crisis of 1973 and 1979, due to the dramatic rise of oil prices[20]. In the first era of governance during the 70's, the majority of the global energy was consumed by North America, Europe and Eurasia. When crisis struck, these energy importing countries felt the need to introduce the first global energy laws and regulation. The international cooperation of this era concentrated on "energy security", both in terms of economical instability due to the sudden rise of oil pricing and also in terms of energy supply because of the lack of oil in some regions due to geopolitical tensions[21]. The energy saving laws of this era, established institutions, authorised funding and provided mandates for market interventions. The International Atomic Energy Agency (IAEA), the Organisation of the Petroleum Exporting Countries (OPEC) and International Energy Agency (IEA), which are all autonomous international organisations established to coordinate and unify the energy policies, were created in this period.

In the following decades until the 90's, major improvements in the management of energy took place and the mentality shifted towards the concept of "energy conservation". In

[17] The UNCCC is a landmark international environmental treaty adopted on 9 May 1992.

[18] The Kyoto Protocol was adopted in Kyoto, Japan on 11 December 1997 and entered into force on 16 February 2005.

[19] IEA.Energy Efficiency Governance - Handbook. *IEA,* Second Edition, Paris, 2010, p. 14.

[20] GALES, B., KANDER, A., MALANIMA, P. and RUBIO M. North versus South: Energy transition and energy intensity in Europe over 200 years. *European Review of Economic History* Vol. 11, 2007, num. 2, p.237.

[21] ECOTICIAS. *Breve historia de eficiencia energética.* ECOticias. [online] Spain, 2017. [Accessed on 15 February 2019]. Available in: <https://www.ecoticias.com/especial-eficiencia-energetica-2016/129822/Breve-historia-eficiencia-energetica>

terms of energy sources, government policy of the Organisation for Economic Co-operation and Development (OECD) countries, promoted a shift as it became evident that oil was a volatile source. The OECD also endorsed a switch from the use of coal to natural gas and the greater use of combined heat and power (CHP) systems[22], as they proved less expensive and contaminating. The governance of this period advanced towards the improvement and application of "effective energy management models", which analyse the energy intensity as a result of the calculation between the energy consumption of an economy and its gross domestic product (from now on referred to as GDP)[23]. In other words, it shows the quantity of energy needed to produce a unit of de GDP in an economy. This era was characterised by a more technical and economic mentality rather than political. This mentality shift was enormously encouraged by the implementation of computers and its monitoring techniques.

By the end of the 20th century, energy governance suffered a downfall due to the decrease in energy prices and the privatisation of the public institutions. The liberalisation of the energy sector put the public sector as a secondary role player which caused a fragmentation of the governance guidelines. End-users gained the legal ability to change electricity supplier, increasing competition and thus the interest for efficiency savings within the energy institutions. It was also during this era when the generation and transmission stages were put into separate divisions of vertically integrated firms[24]. On the other hand, during this period the environment gained relevance as a global challenge and many enterprises started incorporating environmental initiatives to their energy management. It was at this point when the concept of Energy Efficiency (from now on referred to as EE) which means using less energy to perform the same task, in order to minimise energy waste, gained relevance. The EE governance of this era featured a dual policy, the combination of incentives and market mechanisms to incorporate the private sector and regulatory and compulsory activities from the public sector. In 1998, the Energy Charter Treaty and the Protocol on Energy Efficiency and Related Environmental Aspects came into force[25]. They are legally binding multilateral agreements for energy cooperation designed to promote energy security, through more open and competitive energy markets, while respecting the principles of sustainable development (from now on referred to as SD) and sovereignty over energy resources[26].

Energy governance of the 21st century, was the time when EE governance expanded to a global scale, environmental protection gained prominence and the climate change agenda became a major focus for individuals, governments and organisations. In 2004, Russia and Canada finally ratified the Kyoto Protocol to the UNFCCC, which made it possible for the treaty to enter into force on February 2005. In this era, the international community (from

[22] OECD. OECD Reviews of Regulatory Reform: Regulatory Reform in Denmark 1999, *OECD Publishing*. Paris, 1999, p.4.

[23] ESTEVEZ, R. *¿Qué es la eficiencia energética?* [online]. EcoInteligencia: Energía, num 35, 2015. [Accessed on 15 February 2019]. Available in: <https://www.ecointeligencia.com/2015/07/eficiencia-energetica/>

[24] OECD., op. cit., in footnote 22, p.9.

[25] The Energy Charter Treaty was signed in December 1994 and entered into legal force in April 1998. The Protocol on Energy Efficiency and Related Environmental Aspects was negotiated, opened for signature and entered into force at the same time (16 April 1998) as the Energy Charter Treaty.

[26] ENERGY CHARTER. *Consolidated Version of the Energy Charter Treaty and Related Documents.* [online] Energy Charter Secreteriat Organisation, 2015. [Accessed on 15 February 2019]. Available at: <https://energycharter.org/process/energy-charter-treaty-1994/energy-charter-treaty/>

now on referred to as IC) became more aware of the impact our energy system and consumption, had for the release of Co2 and other GHGs, increasing global average surface air temperatures, disrupting weather patterns and contaminating the environment. This also happened in the context of the 2008 economic crisis, when oil prices rose again, which motivated the IC's interest for financing energy efficiency programmes both in the public and private sector. Moreover, this was reassured by the international run-up to the 2009 UNFCCC, the COP 15 and fifth session of the Meeting of the Parties to the Kyoto Protocol[27]. COP 15's goal was to establish a binding global climate agreement, for the period from 2012 onwards, after the expiry of the Kyoto's Protocol first commitment period. In the end no global agreement was reached in COP15[28], but the IC's will to construct a world binding climate agreement implied that climate related policies became global including the developing countries which were acknowledged for needing the support of the already developed countries[29]. All in all, price fluctuations, national security concerns over dependence on imported energy sources and growing recognition of the need to reduce emissions of greenhouse gases transformed energy efficiency from an option to a necessity[30]. Energy policies of this era follow the political mentality of "new clean energy", key elements of new clean energy laws include: long-term targets (switching fuels), mobilisation of multiple organisations to implement energy efficiency, creation of more flexible funding arrangements and design of more specific targets[31].

The actual energy political regime is led by EE, its policies encompass the main issues of energy security, economic development and international competitiveness and climate change *(see Figure 2 of the Annex for a more detailed explanation of EE policy)*. Energy security refers to the uninterrupted availability of energy sources at an affordable price[32]. One of its areas of work is to contribute to decouple economic growth from the growth of global energy demand, which increases every year. Thanks to the governance on EE, global energy intensity has decreased by an average of 2.1% per year since 2010. Without improvements in EE since 2000, estimated global energy use would have been 12% higher in 2016, the equivalent of the energy use of the entire European Union. This is relevant as this eluded increase of global energy usage, would have had enormous implications on our global Co2 emissions[33]. Furthermore, the stabilisation, between 2014 and 2016, of global Co2 emissions

[27] Commonly known as the Copenhagen Summit, all the international meetings were held at the in Copenhagen, Denmark, between 7 and 18 December, 2009.

[28] Later on in this paper we will see how finally a binding global climate agreement was reached with the Paris Agreement, adopted by consensus on 12 December 2015.

[29] UNFCCC. Report of the Conference of the Parties on its fifteenth session, held in Copenhagen from 7 to 19 December 2009. *UNFCCC*, Copenhagen, 2010, p. 4.

[30] NATIONAL ACADEMY OF SCIENCES, ENGINEERING AND NATIONAL RESEARCH COUNCIL. Real Prospects for Energy Efficiency in the United States. *The National Academies Press*, Washington, DC, 2010, p.3

[31] IEA. Energy Efficiency Governance - Handbook. *IEA,* Second Edition, Paris, 2010, p. 39

[32] IEA. *Energy Security.* [online] Paris, 2019. [Accessed on 20 February 2019] Available in: <https:// www.iea.org/topics/energysecurity/>

[33] IRENA. *IRENA Expands Effort to Drive Corporate Renewable Energy Use.* [online] IRENA, Abu Dhabi, Press release, 7 June, 2017. [Accessed on 20 February 2019] Available in: <https://www.irena.org/newsroom/ pressreleases/2017/Jun/IRENA-Expands-Effort-to-Drive-Corporate-Renewable-Energy-Use>

associated with energy consumption is mostly attributable to the increase of renewable energy and energy efficiency[34].

Finally, we must take into account that the governance of our energy systems has been historically pioneered by the developed nations and therefore although EE is the main global priority, other priorities arise when looking at the developing world. In developed countries where energy access is almost guaranteed, energy security focuses on the affordable price of energy. However, energy security does not have the same meaning for the developing world. In developing countries there is a need to prioritise energy access and EE becomes a condition of the former, as without access there can be no efficiency. The preferred definition of access is the actual use of the form of energy, access can be disaggregated into the 3 A's: availability, affordability and acceptability (this reflecting both cultural acceptability and the consumers willingness to pay)[35]. For countries like Malawi where its energy access according to SEforALL is at 11% overall, (with only 4% of the rural population connected to electricity)[36]. Inadequate access urges governments to build additional infrastructure and procure fuels. In this context, energy access becomes a security concern and both concepts become interconnected as there is a need for efficient energy technologies.

1.3. Transition towards the promotion of renewable energy

Since the 80's the "new" renewable energies, mainly wind a solar, have slowly made their way through our global energy mix. Renewable energy sources (from now on referred as RES) are the ones which capture their energy from existing flows of energy, from on-going natural processes, such as sunshine, wind, flowing water, biological processes, and geothermal heat flows[37]. RE provides energy in four important areas: power sector, heating and cooling, transport and rural (off-grid) energy services. This paper will focus on the energy access solutions provided by the rural off-grid energy services.

Energy transition, refers to a radical change in the energy system from an existing model to a new paradigm, it is complex and goes beyond only the replacement of one source of fuel with another[38]. Essentially, energy transition involves changes in three interrelated spheres:

> "1.The tangible elements of the energy system which include technology, infrastructure, market, production equipment, consumption patterns and distribution chains; 2. The actors and their conduct, which comprise new strategies and investment patterns, as well as changing coalitions and capabilities of actors; and 3. Socio-technical regimes that contain

[34] IRENA, IEA and REN21.Renewable Energy Policies in a Time of Transition. *IRENA, OECD, IEA and REN21*, 2018, p.18.

[35] Alternative definitions of „energy access" are usefully explored in BREW-HAMMOND A., *Challenges to Increasing Access to Modern Energy Services in Africa*, background paper prepared for FEMA Conference on Energy Security and Sustainability, Maputo, 2007.

[36] SUSTAINABLE ENERGY FOR ALL. *Africa Hub: Malawi.* [online] Sustainable energy for all: Africa Hub, 2019. [Accessed on 20 February 2019] Available in: <https://www.se4all-africa.org/seforall-in-africa/country-data/malawi/>

[37] SCIENCE DAILY *Renewable energy. [online]* Nordic Folkecenter for Renewable Energy, 2018. [Accessed 22 February 2019] Available in: <https://www.sciencedaily.com/terms/renewable_energy.htm>

[38] FATTOUH, B., POUDINEH, R. and WEST, R. The rise of renewables and energy transition: what adaptation strategy for oil companies and oil-exporting countries? *Oxford Institute for Energy Studies*, 2018, p. 5

> formal regulations and policies, institutions as well as mindset and belief systems, discourse and views about normality and social practices"[39].

1.3.1. Tangible elements of the energy system

Up until the 90's, hydropower and solid biomass were the most used RES. Fortunately, in the past decades, as a result of innovation, increased competition and policy support, a growing number of RE technologies have gained a level of technical and economic capability to enable deployment at powerful scale in many regions of the world. Consequently, the growth in their deployment, particularly in the power sector, has come to outpace that of any other energy source[40]. According to the 2018 Global Report on Renewables of the Renewable Energy Policy Network for the 21st Century (REN21):

> "In 2017, RE accounted for an estimated 70% of net additions to global power capacity, solar photovoltaics (PV) led the way, accounting for nearly 55% of newly installed renewable power capacity in 2017. Wind (29%) and hydropower (11%) accounted for most of the remaining capacity additions."[41]

This shift towards a different energy system is encouraged by the increasingly evident downfalls of our dependence on fossil fuels. In the past, our commitment to fossil fuels was based on its affordability and reliability which made fossil fuels the best available source for energy security. The present reality in terms of affordability, is that RE costs are generally higher than that of fossil-based and nuclear energy. However, the average global levelised costs of energy (LCOE) for the more mature RE technologies[42] has remained relatively stable in recent years. Additionally, the LCOE of utility-scale solar PV, fell 73% between 2010 and 2017, making them the most competitive sources of new generation[43]. In this context, the RE costs continue to fall, (in 2018 the LCOE of utility-scale solar PV was at $36 Megawatt/ hour[44] (MW/h)), alternatively, oil prices climbed above $80/barrel in 2018 for the first time in four years[45]. Regarding reliability, centuries of reliance and development on fossil fuel energy have been unable to avoid the insecurity that comes with our dependability on a non-renewable source[46]. Oppositely, RE increase energy security by reducing dependence on energy imports and protecting against unpredictable global energy markets. This is of great importance for low-to-middle economies, islands and isolated areas, for instance several small

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[39] SOVACOOL, B.K. and GEELS, F.W. Further reflections on the temporality of energy transitions: A response to critics. *Energy Research & Social Sciences*, Vol.22, 2016, p.7

[40] IRENA, IEA and REN21., op. cit., in footnote 34, p. 11.

[41] REN21. Renewables 2018 Global Status Report. *REN21 Secretariat*, Paris, 2018, p. 18.

[42] The more mature RE technologies refers to bio-power and hydropower.

[43] IRENA, *Renewable Power Generation Costs in 2017.*[online] Abu Dhabi, 2018. [Accessed on 20 February 2019] Available in: <https://www.irena.org/-/media/Files/IRENA/Agency/ Publication/2018/Jan/ IRENA_2017_Power_Costs_2018.pdf.>

[44] LAZARD. Levelized Cost of Energy and Levelized Cost of Storage. *Lazard, Version 4.0*, New York, 2018, p. 3.

[45] IEA. World Energy Outlook 2018. *IEA,* Paris, 2018 p.1.

[46] Risks oil and gas supply prevail as evidenced with Venezuela's oil downward trajectory and Europe's reliance on Russian's natural gas, with all the geopolitical implications that reliance entails.

islands like Fiji[47] and Jamaica[48] are investing in renewables, citing security as an explicit driver.

In 2017 there was more solar PV installed globally than the net additions of fossil fuels and nuclear power combined[49]. Referent developed and developing countries are also increasing their renewable power capacity with China at the top, followed by the United States and Brazil. All in all, after studying the 250 year history of the energy markets, the Oxford Institute for Energy Studies concluded that wind and solar are inflecting in a way that resembles coal in the19th century and oil in the 20th century, and are therefore likely to be equally transformational over the 21st century[50].

1.3.2. The actors and their conduct

With regard to global investment, developing and emerging economies accounted for 63% of total renewable energy investment, a higher share than developed countries for the third year in a row[51]. There is a logical explanation to this phenomenon, which is that low-to-middle income transitioning economies will always be bigger investors in energy in relative terms compared to high-income economies since in order to fully develop, developing countries need to invest a higher percentage of their GDP into energy supply and infrastructure. The short gestation period for renewables and long-term fixed-price contracts provide strong incentives to both the public and private sector to invest in renewable energy over other sources[52]. The private sector investment plays a big role in the energy transition as corporate commitments have resulted in billions of dollars of investment in new RE power projects. Lastly, RES are also unlocking social changes as individuals and communities play a role in the energy transition by choosing to purchase renewable energy and invest in renewables themselves. Thanks to the possibility of distributed generation, community generation and self-consumption, energy consumers are becoming energy producers. At the community level, individuals are coming together to initiate community-owned renewable energy projects across technologies (e.g. solar and wind power, biogas digesters and biomass power and heat)[53].

Regionally, the EU has always been a global leader in the energy sector and today as well in the promotion of RE. European integration has dealt with energy since its inception, with the 1951 Coal and Steel Community and the establishment of Euratom in 1958, which

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[47] GOVERNMENT OF FIJI. *Government Encourages Investment in Renewable Energy* [online] Ministry of Communications, press release, 2015 [Accessed on 20 February 2019] Available in: <www.fiji.gov.fj/Media-Center/Press-Releases/GOVERNMENT-ENCOURAGES--INVESTMENT-IN-RENEWABLEENE.aspx.>

[48] GOVERNMENT OF JAMAICA *.Jamaica's National Energy Policy 2009-2030.* [online] Ministry of Energy and Mining, 2009. [Accessed on 20 February 2019] Available in: <https://www.mstem.gov.jm/sites/ default/files/ National%20Energy%20Policy.pdf.>

[49] REN21. Renewables 2018 Global Status Report. *REN21 Secretariat*, Paris, 2018, p. 18

[50] FATTOUH, B., POUDINEH, R. and WEST, R. *The rise of renewables and energy transition: what adaptation strategy for oil companies and oil-exporting countries?* Oxford Institute for Energy Studies, 2018, p. 6

[51] REN21., op. cit., in footnote 49, p.24

[52] IRENA, IEA and REN21.Renewable Energy Policies in a Time of Transition. *IRENA, OECD, IEA and REN21*, 2018, p.19.

[53] Ibid, p.20

incited the distinctive supranational integration system of the EU known today. Also the 1991 European Energy Charter, provided the political foundations and established the principles that should underpin international energy cooperation. In terms of the application of renewable energy, the EU has implemented series of strategies and directives aimed at the promotion of the use of energy from renewable sources and the advancement of common norms for their interior energy market which are the most ambitious worldwide. The Europe 2020 strategy and the 2009/28/EC directive were the first to establish a mandatory target of 20% renewable energy by 2020, of the overall EU energy mix[54]. A few months ago, the EU agreed on its latest 2018/2001/EC directive, which establishes a binding Union target of a share of at least 32% of renewable energy in its energy mix[55].

1.3.3. Socio-technical regimes

Still today, one-in-eight of the world's population has no access to electricity[56], this argument will be further developed in this thesis, however, it is important to acknowledge that RE technology is able to bring a change in efficiency which has some fundamental effects on the dynamics of the energy industry in terms of energy access and security. Given the abundance of sunshine and wind, when a solar panel or wind turbine generates a MW/h of energy, it is generated in the form of usable electricity, which is immediately available to consumers[57]. Today, RES still face limitations in power grids to fulfil their full potential because fossil fuels still account for the majority of our energy supply. Moreover, one of the key benefits of RES comes with its unlimited and widespread characteristics, which allows them to adapt to the different needs and capabilities of each region skipping the political tensions derived from fossil fuels unequal distribution and access. This is reflected by the increasing presence of the developing world in the implementation and advancement of RE. Likewise, RE technologies allow for expanded energy access in regions where the national grid is not sufficiently developed to reach all users, by offering a more effective alternative to grid extension. The use of distributed renewable energy (from now on referred to as DRE) systems, off-grid integration and battery storage is a promising solution for mitigating global energy security and access. However, off-grid solutions still represent only a small percentage of the increase in electrification. DRE systems are estimated to be the least-cost option to supply electricity to nearly three-quarters of the people living in remote areas of sub-Saharan Africa which is the population that is considered the most difficult to serve worldwide[58].

1.4. Sustainable development as the new concept for renewables' promotion

[54] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (OJ L 140, 5.6.2009), paragraph 15 recital.

[55] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (OJ L 328, 21.12.2018), paragraph 8 recital.

[56] IEA. World Energy Outlook 2018. *IEA,* Paris, 2018 p.1.

[57] FATTOUH, B., POUDINEH, R. and WEST, R. *The rise of renewables and energy transition: what adaptation strategy for oil companies and oil-exporting countries?* Oxford Institute for Energy Studies, 2018, p. 7

[58] IRENA. *2016 a record year for renewables, latest IRENA data reveals.* [online] Abu Dhabi, press release, 2017. [Accessed on 2 March 2019] Available in: <http://irena.org/newsroom/pressreleases/2017/ Mar/2016-a-Record-Year-for-Renewables-Latest-IRENA-Data- Reveals>

Development of RE policies at a global scale entails the combination of advancements in the energy sector, environmental protection and economic and social development.

> "Energy access is the "golden thread" that weaves together economic growth, human development and environmental sustainability[59]."

The making of RE international agreements and regulations relies heavily on the political agenda of each government. On this basis, each national economic system can either benefit or obstruct implementation, same happens with technical capabilities and finally the perception of environmental uncertainty finishes up the mix, making the implementation of RE a global challenge[60]. Moreover, RE is not only governed by the public sector as there are a plurality of different actors with interests in the energy industry, such as the scientific community, civil society and private institutions. Thus, the RE regime protects global interests but its characterised by an institutional fragmentation. The combination of the different sectors it entails, is realised by the concept of sustainable development.

There is a global binding compromise on SD which surges from the guiding policy principles of the 1987 Brundtland Report and the 1992 Rio de Janeiro Earth Summit, which have been accepted as a framework for policy agendas in environmental policy, economic planning and development policy. Brundtland Report defined SD as development that meets the needs of the present without compromising the ability of future generations to meet their own needs[61]. These conferences were the drivers of the international cooperation for SD, because economic development and environment protection obligations traditionally held a conflicting relation and thus, SD aimed at leveraging sustainability measures as a market opportunity. Concrete targets for SD became global with the 2000 Millennium Development Goals (MDGs) and the launch in 2004 of the UN Decade of Education for Sustainable Development. Surprisingly, the MDGs did not include action on energy poverty, thus, in 2011 the UN created the Sustainable Energy for All (from now on referred to as SE4ALL) organisation. SE4ALL has the main objective of improving energy efficiency, universal access to modern forms of energy and increased role of RE at a global scale. Furthermore, the 2012 UNGA 67/215 resolution, recognised the importance of giving appropriate consideration to energy in the elaboration of the post-2015 development agenda and decided to declare 2014–2024 the United Nations Decade of Sustainable Energy for All.

On January 2016, the UN officially launched a global set of goals with the 17 Sustainable Development Goals (SDGs) for 2030, adopted unanimously by 193 Heads of State[62]. While SDG 7 is the specific goal for affordable and clean energy, energy is at the

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[59] IEA. *Energy Access Outlook 2017.* [online] Paris, 2017 [Accessed on 2 March 2019] Available in: <https://www.iea.org/access2017/#section-4>

[60] The US former and present administrations serve as a good example to understand the policy shifts in this context. During Obama's last week as US president he argued that "any economic strategy that ignores carbon pollution will impose tremendous costs to the global economy and will result in fewer jobs and less economic growth over the long term" (BARACK, O. The irreversible momentum of clean energy. *Science 355*, 2017.) However, Trump's administration has defined itself by a willingness to dismiss scientific findings on climate change and environmental protection.

[61] BRUNDTLAND, G. *Report of the World Commission on Environment and Development: Our Common Future*. United Nations General Assembly document A/42/427, 1987.

[62] UN. *Sustainable Development Goals kick off with start of new year.* [online] New York, 2015 [Accessed on 1 March 2019] Available in: <https://www.un.org/sustainabledevelopment/blog/2015/12/sustainable-development-goals-kick-off-with-start-of-new-year/>

heart of many of the SDG, from alleviating poverty (SDG 1), to good health by reducing local air pollution (SDG 3), to creating local economic value and jobs and economic growth (SDG 8), spurring industry innovation and infrastructure (SDG 9), contributing to sustainable cities and communities (SDG 11), responsible consumption and production (SDG 12) and mitigating climate change (SDG 13). Outside of government and policymaking, sustainable development has achieved an enormous reach, in terms of its use as a framework for desired or intended societal action[63]. *To see all of the UN's 2030 SDG, see figure 3 of the Annex.*

On the other hand, climate change principles also work together with SD as general framework commonly accepted in the fields of energy policies, since the energy supply sector is the largest contributor to global GHG emissions[64]. The Kyoto regime and the 2015 Paris Agreement adopted at the COP 21, culminate the global efforts over decades to address global climate change and to accelerate the actions and investments needed for a sustainable low carbon future[65]. Paris Agreement's long-term goal is to keep the global temperature rise well below 2 degrees celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees celsius[66]. Current climate change governance comprises a plan for peak GHG emissions, an economy-wide absolute emission reduction target and a global goal for technology development mechanisms, capacity building and a transparency framework[67]. All of its mitigation and adaptation policies align perfectly with the concept of sustainable development and the energy shift towards RE. Moreover, Article 2 of the Paris Agreement reflects one of the principles of SD as it urges "to reflect equity and the principle of common but differentiated responsibilities and respective capabilities" opening to the idea of the inevitable development of emerging economies and the harsher responsibility of the already developed nations. Moreover, carbon pricing policies, if well designed, may incentivise the deployment of renewable energy technologies by increasing the comparative cost of higher-emission fuels and technologies, which will increase the total cost for investment in fossil fuels[68].

All in all, during the 21st century, as global interest in renewable energy steadily increased, world leaders convened in several settings to focus on renewable energy policies, financing and technology[69]. Key meetings include the World Summit for Sustainable

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[63] BETSILL, MICHELE M, HOCHSTETLER, K., and STEVIS, D. *Sustainable Development: The Institutionalization of a Contested Policy Concept.* In *International Environmental Politics.* Palgrave Macmillan 6th ed; Basingstoke, 2014, p. 27.

[64] BRUCKNER, T. and BASHMAKOV, I.A. et al. Energy Systems. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* In EDENHOFER, O, PICHS-MADRUGA, R. et al (eds.). United Kingdom and New York, Cambridge University Press, 2014, p. 559.

[65] UNFCCC. *What is the Paris Agreement?* [online] Bonn, 2015 [Accessed on 3 March 2019] Available in: <https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement>

[66] Idem

[67] SIKDER B., and PRODHAN S. International Climate Change Policymaking: An Outline of the Post-Paris Framework. *Journal of Pollution Effects & Control*, Vol 6, 2018, num.2, p. 224

[68] IPCC. *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change.* [online] Cambridge University Press, UK, 2012. [Accessed on 1 March 2019].Available in: <https://www.ipcc.ch/pdf/special-reports/srren/SRREN_Full_Report.pdf.>

[69] IRENA. *History.* [online] Abu Dhabi, 2018. [Accessed on 3 March 2019] Available in: <https://www.irena.org/history>

Development of 2002 in Johannesburg, the annual G-8 Gleneagles Dialogue, the 2004 Bonn International Renewable Energy Conference and the 2005 Beijing International Renewable Energy Conference. After the 2004 Bonn conference, there was also a surge of multi-stakeholder organisations for the regulation of global RE policy, with the establishment in 2004 of Renewable Energy Policy Network for the 21st Century (REN21) and of the International Renewable Energy Agency (IRENA) in 2009.

In consideration of everything mentioned so far, this chapter analysis aimed to reflect the importance of energy as one of the main drivers of human progress. The IC has recognised its relevance with the current energy political regime concerns over EE, energy security, economic development and climate change. Moreover, increasing role of RE is evident, as the rise in their deployment has come to outpace that of any other energy source. Economically they are increasingly becoming more competitive and their unlimited and widespread characteristics makes them the most reliable energy source. This happens in a context of common global concerns for climate change and the SD of all nations. Until 2024 we will live in the United Nations Decade of Sustainable Energy for All, therefore the years to come will witness our inevitable transition towards more sustainable alternative energy sources. The alternative offered by RE has much potential, especially for developing nations which are still investing on the construction of their energy systems.

2. THE SADC, COMPETENCES AND FUNCTIONS IN THE ENERGY SECTOR

Now that we have analysed the current trends of the global energy affairs, this chapter will introduce this paper's geographical focal point, namely the Southern African Development Community. The rationale behind this choice is because as the institution's name expresses it is a community of states aimed to work towards the region's development. Withal, this region is characterised by a plurality of energy challenges with energy access being the most concerning. It is for this reason that the first section will give a historical and geographical overview of the region to fully understand which challenges is facing. Bearing in mind that development nowadays entails the notion of SD, the solutions for the energy access challenges of the region offers an opportunity for the deployment of RE. Therefore, this chapter will analyse the regional management of energy objectives, competences and instruments applied so far, in order to understand the institution fundamental role as a driver for social and environmental sustainability. The emphasis of this chapter will be on the political implementation of energy access and RE policies, rather than on the actual implementation of the technologies.

2.1. Historical and geographical context of the Southern African Development Community (SADC)

The roots of the integration endeavours of the African southern region were formed with the political liberation movements from both colonialism and white-minority governments of the 1960's and 1970's. During this period, the leaders of Angola, Botswana, Mozambique, Tanzania and Zambia formed a loose political coalition known as the Frontline States (FLS), committed to ending apartheid and white minority rule. On April of 1980, FLS leaders together with representatives of Lesotho, Malawi, Swaziland and the newly liberated Zimbabwe, came together in Zambia to adopt the Lusaka Declaration which established the

Southern African Development Coordination Conference (SADCC)[70]. SADCC operated within a decentralised framework with each member assuming complete responsibility for the coordination, administration and project implementation for one or more of the 21 different sectors they previously agreed on. The idea was that the decentralised distribution would give each member an equal standing in the SADCC hierarchy. However, since Member States (from now on referred as MS) were legally responsible for their projects, the SADCC itself did not have any legal status[71]. The transformation from a Coordinating Conference into the Southern African Development Community (SADC) took place on August, 1992 in Windhoek, Namibia. The SADC Declaration and Treaty were signed in 1992, at the Summit of Heads of State and Government in Namibia, giving the organisation a legal character. While the SADCC was an informal association of neighbouring states, the SADC constitutes a legally binding established inter-state organisation with a regional integration agenda to promote sustainable and equitable economic growth and socio-economic development through efficient productive systems, deeper co-operation and integration[72]. In 1994, with the fall of Apartheid and the first free, fair and non-racial general elections, South Africa was admitted to the organisation. Mauritius joined a year later in 1995, the Seychelles and the Democratic Republic of the Congo (from now on referred to as DRC) in 1998, and Madagascar in 2005. Finally, the Union of the Comoros became a full member on August 2018 bringing the total number of members to the current 16 states. *For a map overview of the SADC member states see Figure 4 of the Annex*.

SADC MS enjoy a wide heterogeneity in its demographic and socio-economic features. Altogether, they have a population of about 341 million that grows at around 2% per year (the SADC region accounts roughly for 33% of sub-Saharan Africa's total population)[73]. In particular, their economies are extremely diverse both in size and complexity. South Africa remains by far the largest economy in the region, with a GDP of USD 348.8 billion in 2017[74]. The smallest economy is Comoros with a GDP of USD 1.07 billion in 2017[75]. Predominantly, SADC's economic growth depends heavily on the production and export of minerals and other natural resources. This dependence caused a decline of USD 104,1 billion in the combined GDP of SADC MS from 2013 to 2016, due to the drop in commodity values worldwide[76]. Moreover, the countries dependent on hydropower, suffered a shortfall in energy generation due to the 2016-2017 drought, which also led to reductions in GDP.

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[70] BARLOW, A. *The Southern African Development Community: History to 2001.* [online] HelenSuzman Foundation, 2018 [Accessed on 3 March 2019] Available in: <https://hsf.org.za/publications/hsf-briefs/the-southern-african-development-community-i-history-to-2001>

[71] Idem

[72] SADC. *SADC Facts and Figures.* [online]. Gaborone, Botswana, 2012. [Accessed on 5 March 2019] Available in: <https://www.sadc.int/about-sadc/overview/sadc-facts-figures/>

[73] The sub-Saharan Africa's total population of 2017 was 1.02 billion. Source: REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p.21

[74] WORLD BANK. *World Development Indicators database*. [online] Washington, D.C, 2019. [Accessed 10 March 2019]. Available in: <https://databank.worldbank.org/data/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=ZAF>

[75] Idem

[76] REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p.24

2.2. Constitutive treaty competences and level of integration

We find SADC's legal status in Article 3 of the Treaty of the Southern African Development Community of 1992[77], from now on referred here as the Treaty. The Article defines SADC legal capacity as "the power to enter into contract, acquire, own or dispose of movable or immovable property and to sue and be sued"[78]. The Treaty constitutes the first organic law of SADC, it frames the founding ideals and principles of the Community of members, their objectives and obligations and establishes the institutions for the implementation of these ideals, principles and objectives. The main objectives of SADC are found in Article 5 overall, they focus on sustainable economic growth and socio-economic development with emphasis on poverty alleviation and collective self-reliance amongst members. It is important to mention, that paragraph G of Article 5 is the objective of "achieving a sustainable utilisation of natural resources and effective protection of the environment"[79]. In order to achieve these objectives Article 5 disposes that MS must harmonise their political and socio-economic policies and plans and promote the development, transfer and mastery of knowledge and technology. Moreover, Article 5A, includes the Common Agenda, designed to provide strategic direction with respect to SADC projects, programmes and activities. During the process of transformation into a community and following the independence of the rest of its current members, the organisation's goal widened to include economic integration. Hence, Chapter 7 of the Treaty dedicated to Co-operation, includes Article 21, which defines the areas of co-operation where:

> "Member States shall, through appropriate institutions of SADC, coordinate, rationalise and harmonise their overall macro-economic policies and strategies, programmes and projects" [80]

Such areas are: 1.Food security, land and agriculture; 2. Infrastructure and services; 3. Trade, industry, finance, investment and mining; 4. Social and human development and special programmes; 5. Science and technology; 6. Natural resources and environment; 7. Social welfare, information and culture and 8. Politics, diplomacy, international relations, peace and security[81]. Most of them can relate to the energy sector and the achievement of sustainable energy, energy security and energy access, all of which are relevant concerns of Member States. Therefore, the administration plays a very important role as a driver for social and environmental sustainability.

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[77] The actual version of the Treaty is the Consolidated Treaty of the Southern African Development Community which is a consolidation of the following texts: The Treaty of the Southern African Development Community, 1992; The Agreement Amending the Treaty, 2001; The Agreement Amending Article 22 of the Treaty, 2007; The Agreement Amending the Treaty, 2008; The Agreement Amending Article 10A of the Treaty, 2009 and The Agreement Amending Articles 10 and 14 of the Treaty of 2009.

[78] SADC. *Consolidated Text of the Treaty of the Southern African Development Community.* The Consolidated text was signed the 21 October 2015 but the Treaty was signed 17 August 1992, in force since 30 September 1993, Art 3 g p.5

[79] Ibid, Art 5 g p.6

[80] Ibid, Art 21, p.18

[81] Additional areas of co-operation may be decided upon by the Council. For more information: SADC. *Consolidated Text of the Treaty of the Southern African Development Community.* The Consolidated text was signed the 21 October 2015 but the Treaty was signed 17 August 1992, in force since 30 September 1993, Art 21, p. 18

Chapter 7, in its Article 22, introduces the establishment of Protocols, which is the mechanism devised to join forces on each specific area of cooperation. The text of each Protocol is a legally binding instrument with the objectives, the scope and institutional mechanisms responsible for a collective solution in each of the areas of cooperation. Protocols enter into force upon ratification by two-thirds of the signatory states and members can ratify a protocol through an act of Parliament[82]. The actors involved in the Community, besides the 16 governments and the SADC institution are specified in Art 23 of this Chapter:

> "In pursuance of the objectives of this Treaty, SADC shall seek to involve fully the people of the region and key stakeholders in the process of regional integration"[83].

Key stakeholders is understood as a concept including the private sector, civil society, non-governmental organisations and workers and employers organisations.

Furthermore, in August of 1999, a decision of the Summit of Heads of State and Government held in Maputo, Mozambique, ordered for a reconstruction of the SADC institutions as well as its operations[84]. Two years later in August 2001, the 1992 Treaty was amended, at an extraordinary Summit in Windhoek, to include changes to the SADC structure. The 2001 amendment established the current 8 institutions which now compose the organisation, under Article 9[85]: the Summit of Heads of State or Government; the Council of Ministers; the Organ on Politics, Defence and Security Co-operation; the Ministerial Committee of the Organ, the Standing Committee of Officials; the Tribunal; the SADC National Committees; the Troika (this organ follows the principle of a Troika leadership for decision-making[86]) and the Secretariat. SADC operations are centralised at the SADC Secretariat in Gaborone, Botswana. The Council is responsible for developing and implementing the SADC Common Agenda.

In the 2001 amendment, there was also a collective agreement to establish the Regional Indicative Strategic Development Plan (from now on referred to as RISDP) and the Strategic Indicative Plan for the Organ (SIPO), both of which remain the guiding frameworks for regional integration. These plans provide states, the Secretariat and other SADC institutions with consistent and comprehensive programmes of long-term economic and social policies[87]. The SIPO is more focused on political and security strategies for the Organ, while the RISDP is based on the strategic priorities and SADC Common Agenda. RISDP is

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[82] SADC. *Frequently Asked Questions.* [online]. Gaborone, Botswana, 2012. [Accessed on 5 March 2019] Available in: <https://www.sadc.int/media-centre/frequently-asked-questions>

[83] SADC. *Consolidated Text of the Treaty of the Southern African Development Community.* The Consolidated text was signed the 21 October 2015 but the Treaty was signed 17 August 1992, in force since 30 September 1993, Art 23, p.20

[84] DEPARTMENT OF INTERNATIONAL RELATIONS AND COOPERATION. *Southern African Development Community (SADC).* [online] Department of Foreign Affairs, Republic of South Africa, 2003. [Accessed on 5 March 2019] Available in: <http://www.dirco.gov.za/foreign/Multilateral/africa/sadc.htm>

[85] SADC., op. cit., in footnote 83, Art 9, p.8

[86] The Extraordinary Summit decided to formalise in 1999 the practice of a Troika system, consisting of the Chair, the incoming Chair and the outgoing Chair of the SADC. The Troika is an important institutional organ subordinated to the Summit, that has to keep the integration agenda on track during its frequent meetings. It is responsible for decision making, facilitating implementation and providing policy direction. With its chairperson-ship held on a rotational basis, SADC applies the Troika system to the Summit, the Organ, the Ministerial Committee of the Organ (MCO), the Council of Ministers as well as at the Officials level.

[87] SADC. *Newsletter for December 2018*. [online] News, Gaborone, Botswana, 2012. [Accessed on 5 March 2019] Available in: <https://www.sadc.int/files/8315/4522/9773/Inside_SADC_December_2018_mail.pdf>

designed to provide strategic direction with respect to SADC economic and social projects and activities. The Ministerial Committee has the task of creating the RISDP which renews every 5 years, it is also in charge of its supervision its implementation and reporting about it to the Council. The Council of Ministers, consists of one national minister from each member, it advises the Summit and always meets before the Summit takes place, normally twice a year in March and August[88]. Finally, SADC's activities are harmonised at their annual Summit of the Heads of State and of council of ministers. The Summit is highest decision-making body, it also elects the rotating SADC chairperson each year and appoints the executive secretary. Decision-making in the Summit follows the consensus principle. Lastly, in Art 33 of the Treaty, the SADC allows for sanctions against states which fail to fulfil the obligations assumed under the Treaty and also against states which apply policies undermining the principles and objectives of the Community. Sanctions are determined by the Summit on a case to case basis.

2.3. Energy regulatory policies and institutional frameworks

SADC MS besides being bound by the institution's legal and political agreements are also connected through their shared water resources, energy assets and climate systems. Given the importance of regional management of energy resources for development cooperation, SADC has created a range of instruments in the energy sector that have allowed the region to move onwards from mere cooperation into the desirable regional integration.

2.3.1 Southern African Power Pool

Starting in the 1950's, an energy cooperation project between DRC and Zambia (then known as Northern Rhodesia), merged their electricity grids to create the first sub-Saharan power-trading infrastructure. After the incorporation of more states to this project, the SADC created the Southern African Power Pool (from now on referred to as SAPP) with the signing of this subsidiary organisation constitutive treaty by SADC MS, at the Summit held in Kempton Park, South Africa. SAPP is a subsidiary organisation of the SADC, with the aim of coordinating the planning and operation of the electric power system among member utilities. Decision making rests on SAPP members and all utilities participating in the power pool have equal rights and obligations. Although it is a subsidiary body, SADC Energy Ministers do not have the mandate to implement decisions on the infrastructure operation of SAPP. Today, SAPP counts with 17 members: all SADC MS except for Angola, Malawi and Tanzania which sum a total of 9 members[89], two members are independent transmission companies and the rest are independent power producers (from now on referred to as IPP's). SAPP was SADC's first ambitious strategy to tackle the energy security and energy access concerns of the region through expanded interconnections and transmission capacity. It was also the first formal international power pool outside of North America and Europe[90]. Moreover, the connection between MS electric power utilities encourages economic development by reducing costs and

[88] SADC, op. cit., in footnote 82.

[89] Botswana, the Democratic Republic of the Congo, Lesotho, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe.

[90] SADC, SARDC. *SADC Energy Monitor 2016: Baseline Study of the SADC Energy Sector*. Gaborone, Botswana, 2016, p. 20.

creating a competitive common market for electricity in the region. Altogether, SAPP's mission is "to provide the least cost, environmentally friendly and affordable energy and increase accessibility to rural communities"[91]. *For a map of SAPP's grid see Figure 7 of the Annex.*

SAPP's 2018 operating capacity stood at 60,719 MW, the energy sources were mainly coal and hydropower (with 62% and 21% respectively) only 2% was supplied by solar PV[92]. According to their 2018 annual report, the share of RE in the SAPP installed generation capacity was of 29%[93]. The Southern African Research Development Centre estimated that SAPP countries will require a capacity of at least 96,000 MW by 2027 to meet their electricity needs[94]. To achieve this, a total of 30,646 MW of additional renewable energy capacity is planned to be commissioned for 2022, with hydropower still playing a major role but with an increasing participation of wind and solar energy. The dominance of coal reflects the influence of South Africa in the SADC energy affairs. South Africa is by far the main energy provider to SAPP's joint electrical grid. Unfortunately, its contribution is dominated by fossil fuels, particularly coal, which makes up for approximately 77% of the country's primary energy source and about 60% of its contributions to the SADC region[95].

While several SADC members contribute little or almost none to global GHGs emissions, as they do not rely heavily on fossil fuels for energy like Malawi, Comoros and Swaziland. Most of SADC MS depend heavily on fossil fuels, like South Africa which is the world's 14th largest emitter of GHGs[96]. Additionally, this affects energy security because SADC Member States that mostly rely on coal (like South Africa, Zimbabwe and Botswana) together with, MS that rely mainly on hydropower (such as DRC, Mozambique, Zambia) face considerable climate risks as a result of the changing rainfall patterns. This is because the SADC region is prone to droughts and is characterised by infertile soils, which lack the capacity to retain moisture. This poses a major challenge because coal generation and hydropower need a great deal of water. Therefore, although SAPP has the potential to ensure secure electricity supply for the region, the dominance of South Africa means that national circumstances can alter the region's energy supply, contrary to the notion that regional power trade will make countries more resilient to shocks in their energy systems. Thus, there is still room for improvement in SAPP. In this regard, infrastructural integration must focus on: increasing energy access, development of energy utilities of each member state specially aiming for the integration of Angola, Malawi and Tanzania to the regional power grid and finally, balancing the energy mix across the region in order to truly achieve SAPP's mission.

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91 SAPP. Annual Report 2018. *SAPP Coordination Centre*, Sable Press, Zimbabwe, 2018, p.44

92 Ibid, p.11.

93 Idem

94 SARDC. *SADC ministers to review regional energy programme.* [online] Southern African Research and Development Centre, Zimbabwe, 2015 [Accessed 19 March 2019]. Available at:<https://sadc-energy.sardc.net/index.php?option=com_content&view=article&id=240:sadc-ministers-to-review-regional-energy-programme&catid=37&Itemid=143>

95 SAPP., op. cit., in footnote 91, p.39

96 MCSWEENEY, R, and TIMPERLEY, J. *The Carbon Brief Profile: South Africa.* Carbon Brief Clear on Climate [online] UK, 2018. [Accessed 19 March 2019]. Available at: <https://www.carbonbrief.org/the-carbon-brief-profile-south-africa>

2.3.2. SADC Protocol on Energy

On the other hand, the main legally binding document for all SADC members on energy development is the SADC Protocol on Energy of 1996, which entered into force on April 1998. In its Article 1 it appoints the Ministerial Committee, as the responsible policy body in the overall energy sector and the Secretariat, as provider of technical assistance to the Ministerial Committee. The Committee meets annually, reporting to the SADC Council of Ministers which in turn reports to the Summit. Some of the main SADC principles under the Protocol are the use of energy to support economic growth, development and alleviation of poverty and to ensure that the use of energy is environmentally sound[97]. One of the objectives expressed in Article 3, requires cooperation in energy development and energy pooling to ensure security and reliability of energy supply and the minimisation of costs. As the Protocol was signed a year after the creation of SAPP, it became instrumental for the establishment of the regional power grid. The Protocol also defines the guidelines for sharing of energy data and cooperation between members and non-SADC states and organisations. All in all, the Protocol acknowledges the importance of energy in pursuit of SADC's vision of improving the quality of life throughout the region and provides a framework for cooperation on energy policy. Since the adoption of the Protocol, the organisation has adopted several strategic plans for energy development. Moreover, in order to ensure smooth implementation of regional energy instruments, SADC Secretariat established the Directorate for Infrastructure and Services (from now on referred to as DIS), to coordinate developments and quality of strategic infrastructure in the region. Currently, the most significant policies of the energy sector are:
The 2003 Regional Indicative Strategic Development Plan (RIDSP) revised in 2015, the Regional Energy Access Strategy and Action Plan (REASAP) of 2010, the Regional Infrastructure Development Master Plan (RIDMP) of 2012, and the Renewable Energy and Energy Efficiency Strategy and Action Plan (REEESAP) of 2017.

This paper considers them as the most significant because they are relatively recent therefore they incorporate the current challenges, they apply to all SADC members and they cover the most relevant topics regarding energy's evolution in the region. However, it must be noted that in contrast to the Protocol, the different plans provide recommendations, targets and guidelines which are up to each member state to implement in their most effective way, thus they constitute mechanisms of soft law. The main capacity of these plans is to be a catalyst or facilitator of the exchange of information and best practices within the region.

2.3.3. The Regional Indicative Strategic Development Plan

DIS's activities are identified in this Regional Indicative Strategic Development Plan, which also aligns with the strategic priorities of the SADC Common Agenda. The current RISDP was developed and approved by the Summit in 2003, it established a 15-year period programme, and was effectively implemented from 2005[98]. The 2003 RISDP was the first effort to set specific quantitative targets for infrastructure development of the region, in order

[97] SADC. *Protocol on Energy in the Southern African Development Community Region*. Maseru, Lesotho, 24 August 1996, p.6-7.

[98] SADC, SARDC. *SADC Energy Monitor 2016: Baseline Study of the SADC Energy Sector*. Gaborone, Botswana, 2016, p. 28

to facilitate monitoring and evaluation. The Plan is divided in different sectors of implementation, with energy being part of the sector for "Infrastructure support for regional integration and poverty eradication"[99]. The fundamental objective of the plan is to deepen integration in pursuance of encouraging poverty eradication and the other economic and non-economic development goals[100]. In this sense, energy is able to support regional economic development, trade and investment. More specifically, the Plan also argued for "improving access to affordable energy services to rural communities through rural electrification and development of new and renewable energy sources" through "development of renewable and low cost energy sources including solar, biomass, and wind-generated energy"[101]. When the RISDP was revised in April 2015, it fixed a reduced five-year programme (2015-2020) but the scope and purpose of the Plan remain unchanged from those of the original document.

2.3.4. The Regional Energy Access Strategy and Action Plan (from now on referred to as REASAP)

REASAP was approved by the SADC Energy Ministers in 2010, and will be in force until 2020. It is supported by the European Union Energy Initiative, which has financed similar studies of other African regional economic communities. In accordance with RISDP, REASAP's strategic goal is "harnessing of regional energy resources to ensure, through national and regional action, that all the people of the SADC Region have access to adequate, reliable, least cost, environmentally sustainable energy services"[102]. Its operational goal aims to "half the proportion of people without such access within its first operative phase, and halve it again in successive five year periods, until there there is universal access for all end uses"[103]. This translates into a region overall energy access of 71% by 2025, however, the region's overall energy access in 2016 only reached 48% and 32% in rural areas[104]. In particular, the worst scenarios are found in the overall energy access of DRC which was below 20% and in Malawi which was of 11% with only 4% of electrification in its rural areas. Although until now countries have directed some efforts towards the improvement of rural energy access, the 71% target by 2025 will require even more support for infrastructure implementation, in this case materialised in mini-grid connections and off-grid solutions.
REASAP's ultimate goal of universal electrification is essential for the full development of SADC countries, still the Plan itself acknowledges "it is a challenge for the very long-term because of the massive investment resources which would be required and which are beyond reach[105]". Due to the differing capabilities of the different SADC members, the Plan does not provide with common binding implementing measures, instead it establishes a portfolio of the

[99] SADC, *Revised Regional Indicative Strategic Development Plan, 2015-2020.* Gaborone, Botswana, 2015, p. 110.

[100] Ibid, p.111

[101] Idem

[102] SADC. *SADC Regional Energy Access Strategy and Action Plan 2010*. [online]. SADC Energy Programme with the support of EUEI, Angola, 2010.[Accessed 20 March 2019] Available at: <http://www.euei-pdf.org/sites/default/files/field_publication_file/EUEI_PDF_SADC_Regional_Energy_Access_Strategy_Mar_2010_EN.pdf>

[103] Idem

[104] UNITED NATIONS STATISTICS. *Indicator 7.1.1: Proportion of population with access to electricity.* [online] SDG Indicators database, 2018. [Accessed 20 March 2019]. Available at: <https://unstats.un.org/sdgs/indicators/database.>

[105] SADC., op. cit., in footnote 102, p.4.

least-cost energy options. Thus, the Plan affirms that energy access is primarily a national responsibility, and regionally the SADC is responsible for coordinating these efforts through resource distribution and facilitating the exchange of information and best practices. Member States must deliver a number of primary activities, the first and most important being the adoption and publication of REASAP by their respective Department of Energy, seeking to involve other actors such as energy research institutions, community groups, NGOs and the private sector for implementation. In accordance with the plan recommendations, MS must also adopt appropriate pricing and subsidy policies and strengthen national regulation of their energy sector.

2.3.5. The Regional Infrastructure Development Master Plan (from now on referred to as RIDMP)

The 2012, RIDMP is a 15 year long plan whose aim is to develop cross-border infrastructure in the six priority areas: energy, transport, information and communications technology, meteorology, transboundary water resources, and tourism. For each of these sectors, it outlines indicators and targets for improvement. In the energy sector, the plan addresses four key areas of energy security: 1.Improving access to modern energy services, 2. Tapping the abundant energy resources, 3.Up-scaling financial investment 4.Enhancing environmental sustainability[106]. For this purpose, members are to develop national energy access roadmaps based on REASAP, taking into consideration best practices in the region for rural electrification, including pro-poor tariffs issues[107]. Unfortunately, the majority of SADC MS still have to develop and publish their energy access roadmaps. The plan, also sets a target for 2030, to increase the share of RE in the common grid to 39% and to reach an off-grid share of 7.5%[108]. As noted earlier, SAPP's annual report sets the current share of renewables in the common grid in 29%, therefore, efforts to increase this percentage should push to balance the energy mix of MS in the regional grid. Moreover, to meet the off-grid access target, SADC should aim to install adequate generation and transmission capacity to meet the forecasted demands and to increase access to electricity, based on least cost project options.

2.3.6. The Renewable Energy and Energy Efficiency Strategy and Action Plan (from now on referred to as REEESAP)

Lastly, the recently adopted REEESAP, materialises the institutions efforts of wanting to develop a specific strategy for RE. Finally in 2017 the plan was approved by the Energy Ministers, after several reviews and the incorporation of EE. The plan includes goals for energy access, RE and EE, and it serves as a guide for implementation for the region until the year 2030[109]. On top of this, the Plan provided a framework and encouraged SADC's establishment, in 2018, of a new subsidiary organisation to implement the plan:

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[106] SADC. *Regional Infrastructure Development Master Plan: Energy Sector.* Prepared by Dr Peter P. Zhou in Gaborne, Botswana, 2012 p.8

[107] Ibid, p. 31

[108] Ibid, p.34

[109] SADC. *The SADC region validates a regional plan for a sustainable energy future*. [online] Gaborne, Botswana, press release, 26 October 2016. [Accessed 20 March 2019] Available at: <https://www.gfse.at/fileadmin/files/news/newsletter/SADC_Press_release_06-10-2016.pdf.>

The SADC Centre for Renewable Energy and Energy Efficiency (from now on referred to as SACREEE), is located in Windhoek, Namibia and functions on the recommendations of the Ministers for Energy. SACREEE was established with the technical support of the United Nations Industrial Development Organisation (UNIDO) and with financial assistance from the Austrian Development Agency. The Centre has the responsibility to promote increased access to modern energy services and improve energy security across the region through market-based adoption of RE and EE technologies and services[110]. This materialises through resource mobilisation, policy, quality assurance, capacity building and knowledge management, communication, promoting investments in RE&EE projects and programmes[111]. Once again, the subsidiary organisation depends on MS for implementation and it is only competent to complement and accelerate national efforts. The centre is currently in its first operational phase (2019-2023), its business model for now is based on MS contributions, climate and development funding and fee-for-services. Moreover its Action Plan for Implementation establishes that SACREE shall contribute to achieve the cross cutting objectives of SDG Goal 7, SDG Goal 9 and other interlinked SDGs such as SDG 12 and 13, synchronising its activities to the UNFCCC'S Paris Agreement. SACREEE has already started implementing various programmes like the Entrepreneurship Support Facility, the SADC Industrial Energy Efficiency Programme and the Energy Efficient Lighting and Appliances Project[112], but it is still too early to assess its effectiveness.

At the same time, the private sector and electricity supply industries in the region are coming together, with the increased participation independent power producers and promotion of off-grid solutions. Finally, SADC also aligns its policy instruments to other regional and international documents. SADC energy ministers have endorsed the United Nations' Sustainable Energy for All Initiative and it's 2030 targets, are increasingly reflected in local policy frameworks[113]. By 2018 the 12 mainland SADC MS had joined the initiative but only two states (Angola and Tanzania) had completed Action Agendas and developed an Investment Prospectus[114]. Other relevant international commitments taken into account are the UN SDGs, the AU Agenda 2063 as well as the Programme for Infrastructure Development in Africa (PIDA), which all provide a framework for addressing the infrastructure deficit in Africa through integrated planning for sustainable development at regional and inter-regional levels. Last but not least, the important work of multi-stakeholder organisations such as IRENA is also incorporated in SADC MS. As of mid-2018, 4 SADC MS: Mozambique, Zambia, Eswatini and Tanzania, had undergone Renewable Energy Readiness Assessments supported by IRENA. These assessments have helped countries to identify areas where improvement is needed, and to set realistic targets for renewable energy and energy efficiency implementation[115].

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110 REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 20

111 SACREE. *Objectives and Mandate.* [online] Windhoek, Namibia, 2019 [Accessed 20 March 2019] Available at: <https://www.sacreee.org/content/objectives-and-mandate>

112 REN21., op. cit., in footnote 110.

113 SADC, SARDC. *SADC Energy Monitor 2016: Baseline Study of the SADC Energy Sector*. SADC, SARDC, Gaborone, Harare, 2016, p. 24

114 REN21., op. cit., in footnote 110, p. 16

115 Idem

Together the instruments mentioned above, provide a strong background for progressive policy development in the region and serve as a basis for implementation at the national level. SADC Member States, have already started several national energy strategies and the creation of national agencies to coordinate implementation of these agreed activities, plans and programmes. Increasing RES share in electricity generation together with increasing the population's scope of energy access, are the most common form of national target. *(To see all of the current MS National Renewable Energy Targets and Targets for Energy Access, see figure 5 and figure 8 of the Annex).* However, there still needs to be a lot of work to properly meet these targets and therefore there is a need to improve and promote new mechanisms in order to properly address the current efforts. This paper finds that although energy access, poverty alleviation and ensuring the environmentally respectful use of energy, are strongly addressed in the regionally binding instruments of SADC, namely its Constitutive Treaty and the Protocol on Energy. The Treaty also establishes the obligation to harmonise these efforts through the development and transfer of knowledge and technology in order to fully achieve integration. Yet, energy access remains the primarily responsibility of MS and the above mentioned plans have a soft law nature. This leads to the current situation where MS are free to apply these mechanism in their own way. Thus, as we will see in the next chapter, efforts towards energy access and the promotion of RE are very diverse and there are considerable discrepancies in the achievement of these goals, which should be common regional goals.

3. SOLAR OFF-GRID SOLUTIONS FOR SADC'S RURAL COMMUNITIES

This chapter will analyse the current energy access challenges and application of off-grid solutions for the rural communities of the SADC's population. In order to do a proper analysis, two case-studies will do an analysis of the current situation. First, by comparing the off-grid legal framework adopted in three different SADC MS and then comparing and assessing the actual instalment of the solar stand alone technologies. Altogether, this chapter aims to give an accurate understanding on the kind of challenges and learnings the SADC region must deal with in order to apply a sustainable solar energy solution for remote rural communities. Sustainability of energy systems for rural areas is understood as:

> "the perceived potential for a system or project to endure, build a self perpetuating capacity within a community, and ultimately reach the end of its predefined lifespan or evolve into another beneficial form"[116]

3.1. Access to energy in SADC in rural areas

As mentioned in the previous chapter, the SADC already has in place various strategies and instruments to deal with energy access in the region. The most substantial initiative being the SAPP which constitutes an extension and improvement to the different national electric grids of SADC Members. *To see the maps of the overall grid extension in the SADC Region and the common grid connections achieved through SAPP see Figure 6 and Figure 7 of the Annex.*

[116] LOUIE, H., DAUENHAUER, P., WILSON, M., ZOMERS, A., and MUTALE, J. Eternal light: ingredients for sustainable off-grid energy development. *IEEE Power and Energy Magazine*, vol. 12, 2014, no. 4, p.70.

However, due to the regions' geography and different levels of socio-economic development, there are still many regions where the power grid is unable to reach. This results in an unequal distribution of energy to the population within most of SADC countries. On the one hand, there is a relative small portion of high-income citizens located in SADC urban areas who are able to use grid-supplied high quality energy to serve a wide range of end-uses. On the other hand, population in rural areas in most cases cannot access to the energy supplied by their national grid and thus are dependent on non-electrical energy options, which are mostly inefficient, low intensity and often health-compromising.

Rural energy access poses an overall problem to the whole SADC Region. The most recent data available, confirms this problematic revealing that average electricity access in the region in 2016 was 48%[117]. This means that more than half of SADC's population, which is of 341 million, is affected by limits to or absence of energy access. This consecutively also affects agricultural development, enterprise development, cooking, heating, lighting, community services and transport[118]. Thus population in rural areas is not only poor in terms of energy but also socio-economically. Just by taking a look at both of these figures we can already realise why rural energy access is one of the major challenges of the SADC region.

Up until now, SADC's most common affordable alternative for energy access in off grid regions, has been biomass[119]. Traditional biomass accounted for 44% of the region's final energy consumption as of mid-2018[120]. However, although biomass in some contexts can be considered a RES, this paper considers that the overall current use of biomass in the SADC region does not constitute neither a healthy nor sustainable alternative for the population. Most of the regions' rural population relies on firewood, charcoal and animal waste to meet their cooking and heating energy needs. For lighting and small amounts of electricity to power end uses, such as tv or mobile charging, they use candles, paraffin or kerosene.

Unfortunately, the use of these traditional energy sources has many detrimental consequences for their user's health, development and the environment. Firstly, biomass and other solid fuel's energy used for cooking both inside homes and institutions (for example, schools, offices etc) has obvious negative health impacts. The World Health Organization (WHO), in 2016 found that 174,561 deaths in the SADC region were attributable to household air pollution, as a result of cooking and heating with solid fuels[121]. Regarding lighting and small power applications, the particulate emitted by kerosene-using devices also exceed WHO guidelines: they impair lung function, increase infectious illness, asthma, and cancer risks.

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117 SDG. *Indicator 7.1.1: Proportion of population with access to electricity* [online] SDG Indicators database, 2016 [Accessed on 1 March 2019] Available in: <https://www.sdg.org/datasets/indicator-7-1-1-proportion-of-population-with-access-to-electricity-by-urban-rural-percent>

118 SADC. *SADC Regional Energy Access Strategy and Action Plan 2010*. [online]. SADC Energy Programme with the support of EUEI, Angola, 2010.[Accessed 20 March 2019] Available at: <http://www.euei-pdf.org/sites/default/files/field_publication_file/EUEI_PDF_SADC_Regional_Energy_Access_Strategy_Mar_2010_EN.pdf>

119 SADC Member States remain heavily dependent on traditional biomass with the exception of Mauritius and Seychelles.

120 REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 39

121 WORLD HEALTH ORGANIZATION. *Deaths by country: household air pollution.* [online] Global Health Observatory Data Repository, 2018. [Accessed on 1 April 2019]. Available at: <http://apps.who.int/gho/data/node.main.BODHOUSEHOLDAIRDTHS?lang=en>

Furthermore, UNICEF reported that the primary cause of child poisoning in developing countries is accidental kerosene ingestion (as kerosene is commonly sold in soda bottles), burns are also identified as one of the leading causes of child injury[122].

When analysing the impact to development, we find there is a strong correlation between energy usage and its user's socio-economic development. According to REASAP, population spends more in absolute terms on energy as income rises in both rural and urban locations, and this further improves their socio-economic status. However, poor households specially in rural areas, spend a higher proportion of their monthly income (over four times more) on energy services (i.e. paraffin or kerosene) when compared with the richest households. Fuelwood can be collected free of charge in most rural areas and this is a further incentive not to switch to electricity which has to be paid for[123]. In this case, it specially affects gender issues, as women are the ones bound to collecting and using biomass and the other solid fuels which seriously compromises their time and capacity to undertake other activities. Altogether, the current non-electrical off grid energy options for rural areas, result either too expensive or burdensome for their users socio-economic development.

Finally, the environmental impact of biomass and these other fuels results in local deforestation (caused by excessive harvesting of fuelwood), soil erosion, desertification, poor land-use management and GHG emissions. This is seriously alarming because since 1990, Southern Africa has experienced the highest rate of deforestation in Africa. Moreover, biomass's deforestation causes soils to release a large amounts of carbon. SADC MS carbon emissions due to biomass amount to 54% of the overall emissions of Africa. Overall, carbon emissions from combined deforestation and degradation are over five times larger than those from all other sources[124].

To sum up, rural areas' essential low access and limited use of modern energy services coupled with their dependence on biomass and other solid fuels, does not allow for their socio-economic development and equates with poor health, gender inequality and environmental degradation.

3.2. Potential solutions for rural energy access

As mentioned before, since energy access is primarily a national responsibility, each SADC Member State has applied different strategies to tackle energy access according to their own capabilities. For many years, national strategies for expanded energy access were pursued through extending the national grid. This approach was specially relevant in the SADC region as national grids allowed for regional interconnection (through SAPP), which increases stability and security. However, nowadays for most of MS national utilities grid extension to reach rural communities is an extremely expensive and slow process and in most cases is materially impossible due to rural areas' geography. Therefore, decentralised options are usually the cheapest and quickest way to tackle energy access. An IEA study estimated

122 STROHMEIER, H.. Why sustainable energy matters to children: The critical importance of sustainable energy for children and future generations. *UNICEF Unite for Children,* New York , 2015, p.10

123 SADC. *SADC Regional Energy Access Strategy and Action Plan 2010*. [online]. SADC Energy Programme with the support of EUEI, Angola, 2010.[Accessed 20 March 2019] Available at: <http://www.euei-pdf.org/sites/default/files/field_publication_file/EUEI_PDF_SADC_Regional_Energy_Access_Strategy_Mar_2010_EN.pdf>

124 SADC. *Climate Change Mitigation*.[online]. Gaborone, Botswana, 2012. [Accessed on 5 March 2019] Available in: <https://www.sadc.int/themes/meteorology-climate/climate-change-mitigation/>

that approximately 60% of the new generation required to achieve universal access to electricity in Africa, will need to come from off-grid solutions[125]. Within the decentralised options, the most cost-effective, secure and low-carbon option for rural electrification are distributed renewables for energy access (from now on referred to as DREA). DREA refers to any RE supply system or technology that operates independent of the national grid. This concept encompasses stand-alone power systems (SPS) as well as mini-grids. DREA systems provide energy access and security as they can be applied both in rural off-grid areas but also for urban populations in grid-connected areas where supply is unreliable[126]. Since they are commonly small-scale (average units are 1-100 kW power plants) they represent an affordable alternative for low-income communities.

When analysing the different DREA alternatives for rural communities, we find that mini-grids and stand-alone electricity sources solutions are the most common application. The use of mini-grids has been explored by a number of SADC countries specially in Mozambique, Lesotho, Tanzania, Zambia and Malawi. Technically, mini-grids are stand-alone low-voltage distribution networks connecting end-consumers in a village or neighbourhood[127]. Increasingly mini-grids supply is becoming hybrid in that two or more electricity generating options are used according to the least cost energy resource available. Normally, they combine RE with a diesel generator and backup storage batteries, they can generate from 10 kW to 10 MW. This makes them a reliable alternative, as they are able to supply more energy and throughout the whole day and night. Mini grids are normally implemented in productive areas where there is a combination of households, hospitals, schools, investigation centres, etc. They are ideal where the energy needs of the average consumer exceed 1 kW/h per day and several consumers are close together, also when there is a need for continuous power and a willingness and ability to pay.

Taking into account the above mentioned requirements of mini-grids, this paper considers that mini-grid systems would pose more of a burden rather than an asset for remote rural communities. This is because, as mentioned earlier there is a very strong correlation between rural communities and poverty, hindering their ability to pay for these type of systems. According to the International Fund for Agricultural Development, poverty is most concentrated in regions where agriculture is the mainstay of the economies[128]. In SADC, rural communities depend mainly on subsistence agriculture, unfortunately rain-fed agriculture usually experiences perpetual crop failure, resulting in income uncertainty and irregularities. Moreover, rural remote communities tend to be characterised by a dispersed population distribution which also contravenes mini-grids requirements.

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125 IEA . *Energy Poverty: How to Make Modern Energy Access Universal?* Special early excerpt of the *World Energy Outlook 2010* for the UN General Assembly on the Millennium Development Goals. [online] Paris, 2010 [Accessed 20 March 2019] Available at: <http:// www.un-energy.org/publications/618-energy-poverty-how-to-make-modern-energy-access-universal>

126 REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 53

127 SADC. *SADC Regional Energy Access Strategy and Action Plan 2010*. [online]. SADC Energy Programme with the support of EUEI, Angola, 2010.[Accessed 20 March 2019] Available at: <http://www.euei-pdf.org/sites/default/files/field_publication_file/EUEI_PDF_SADC_Regional_Energy_Access_Strategy_Mar_2010_EN.pdf>

128 IFAD. *Dimensions of Rural Poverty.* [online] Rome, 2013 [Accessed 20 March 2019] Available at: <http:// www.ruralpovertyportal.org/topic>

Since the purpose of this paper is to offer an analysis and a possible solution for energy access in remote rural communities, mini-grids characteristics do not constitute the most effective approach and thus will not be taken into account as a possible solution. Alternatively, the analysis will focus on SPS, which involve small electricity systems to provide electricity to individual appliances. They thus serve the needs of individual customers, while utilising locally available renewable resources[129]. Storage can be included as a battery bank to offer electricity all day long. SPS can be differentiated into pico systems (to power individual appliances such as lights, cellphones or TV), home systems (which allow to power individual households) and productive systems (used to power a small enterprises, clinics, schools, etc.) This papers' position, in agreement with the related literature, holds that SPS are the most cost-effective solution in the case of dispersed populations with low per capita energy consumption[130].

Generally speaking, national energy access strategies for rural areas are very diverse and overall they include both off-grid solutions. The common denominator is that all strategies have either set up or continued their support for the specialised institutions with mandate for elaborating electrification and energy access policies, with a particular focus on rural areas. Additionally, to boost their rural electrification strategies, some MS offer subsidies for the installation of off-grid systems, recognising that rural households will hardly have the financial capacity to pay for the technologies themselves. Countries with specific rural electrification targets include Angola, Botswana, the DRC, Eswatini, Madagascar, Mozambique, Namibia, South Africa, Tanzania, Zambia and Zimbabwe[131]. Due to page restrictions, this paper cannot analyse all the MS electrification strategies and therefore will do a case study analysis of three different countries. The selection of these countries has been done with the purpose to offer an accurate representation of the different scenarios in the region. Taking into account this papers' focus on solar energy and remote rural communities, the countries selected have great solar energy potential and face rural electrification challenges. The selected Member States are Malawi, Namibia and South Africa. Malawi represents the poorest country in SADC, and holds the biggest rural community proportion. Oppositely, South Africa represents the richest Member State but still faces energy access challenges for its rural community. Namibia is in the middle of both, its latest overall electricity access percentage according to REN21 was of 56%, 77% for urban areas and only 29% in rural areas[132]. *For a chart with the electricity access data of all SADC Member States and their 2020/2030 targets see Figure 8 of the Annex.*

3.2.1. Case study analysis.

a) Malawi (energy/electricity access: urban 42%, rural 4%, total 11%)[133]

[129] ALLIANCE FOR RURAL ELECTRIFICATION. *Off-Grid Electricity Systems*. [online]. Belgium, 2014 [Accessed 20 March 2019] Available at: <https://www.ruralelec.org/grid-electricity-systems>

[130] KRITHIK, P. R. Palit, D. Participatory Business models for off-grid electrification. In *Rural Electrification through Decentralised Off-Grid Systems in Developing Countries.* Springer: London, UK, 2013, p. 187.

[131] REN21. SADC Renewable Energy and Energy Efficiency Status Report*. REN21 Secretariat*, Paris, 2018, p. 55

[132] Ibid, p.54

[133] Idem

The country is bordered by Zambia, Tanzania and Mozambique. Is one of the 3 only mainland SADC MS that is not part of SAPP. It has a population of about 18 million people[134]. Politically it has had a stable democratic political system since 2014 and has since then initiated economic and political reforms in public financial management. However, Malawi spends most of its foreign currency reserves on the import of oil and petroleum products, as a consequence is highly vulnerable to oil price shocks. Diversely, the state's vast RES of hydropower and solar energy remains virtually unexploited[135]. Since 83%[136] of Malawi's population lives in rural areas, their only energy sources available are mostly wood and paraffin. The economy remains essentially a subsistence agrarian rural economy, as agriculture and employs 84% of total labour force[137]. This sector relies on rainfall, but climate variability has led to a frequentness of floods and droughts in various regions which result in the loss of crops. Consequently, extreme poverty is widespread setting the country as one of the world's poorest countries. In 2016, the proportion of poor households living below the poverty line of US$1.9 /day stood at 70% of the population[138]. Moreover, Malawi is ranked 173 out of 188 on the United Nations Human Development Index[139]. Its extremely low electrification ratio is considered one of causes of the low average life span, the low literacy rate, inequality and extreme poverty.

Malawi's energy sector is guided and structured by its 2003 National Energy Policy and the Electricity Act which was recently amended in 2016. Moreover, the Energy Regulation Act of 2004 established the Malawi Energy Regulatory Authority (from now on referred to as MERA) the legal entity responsible for the regulation of the overall activities of the energy industry. Within its powers it approves tariffs, and prices of energy sales and services. It must also facilitate increasing access to energy supplies, to minimise the environmental impact of the exploitation, production, transportation, storage, supply and use of energy and in doing so promote the exploitation of renewable energy resources[140]. The restructuring of Malawi's energy market is still ongoing. The main mistaken approach regarding the government's energy access policies, is the heavily subsidised price of electricity which has exacerbated scarcity problems by encouraging an explosion of demand

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134 WORLD BANK. *Malawi - Electricity Access Project (P164331).* [online] International Development Association, Washington, D.C., 2019. [Accessed 20 March 2019] Available at: <http://documents.worldbank.org/curated/en/313871549533419539/pdf/Concept-Project-Information-Document-Integrated-Safeguards-Data-Sheet-Malawi-Electricity-Access-Project-P164331.pdf>

135 Ibid

136 WORLDOMETERS. *Malawi Population (LIVE).* [online] Washington, D.C., 2019. [Accessed 2 April 2019] Available at: <http://www.worldometers.info/world-population/malawi-population/>

137 TAULO., J. L., GONDWE K. J., and SEBITOSI A. B. Energy supply in Malawi: Options and issues. *Journal of Energy Southern Africa,* Cape Town , vol.26, 2015, num.2, p.7.

138 WORLD BANK. *Malawi Economic Monitor – Unleashing the Urban Economy, Macroeconomics and Fiscal Management Global Practice*, Washington, DC, 2017, p.5

139 UNDP. *Human Development Indices and Indicators: 2018 Statistical Update: Malawi*. [online] New York, 2017 [Accessed 2 April 2019] Available at: <http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/MWI.pdf>

140 GOM. *The Energy Regulation Act 2004.* Lilongwe, Malawi Government, Act No. 20 of the Malawi Energy Regulatory Authority. Approved on the 29 April 2004, Part II, paragraph 3. [Accessed 2 April 2019] Available at: <https://www.meramalawi.mw/index.php/legislation>

among population that already has access[141]. Highly subsidised energy implies that consumer's price paid for electricity is below its long-run marginal cost, and as a result the national utility ESCOM is unable to recover its costs which materialises in a poor technical and commercial performance with forced electricity outages and rolling brownouts and low employee productivity[142]. Although subsidising electricity is intended to make it affordable to the poor, the population's total energy access remains at 11%, therefore, the great majority of the poor do not have electricity supply to benefit from this subsidy. Since energy subsidies are not accurately targeted, they do not fulfil their purpose. Instead, the greater beneficiaries from this subsidy are middle and upper-income consumers: the rich end up being subsidised by the poor.

Malawi's Rural Electrification Programme (MAREP) started in 1980, the national utility ESCOM was the responsible for its implementation through donor's and own financing[143]. In 1995, the government took over implementation of the programme through its Department of Energy, which is the actual MERA. Its approach until now involved extending the power grid distribution to the district administration centres, major trading spots and tobacco growing areas. In 2004, MERA approved The Rural Electrification Act 2004 which established the Rural Electrification Management Committee. Primarily, the mandate of the Committee is to ensure energy access to efficient, sustainable and affordable energy for the Malawian's social economic development and to raise funds and administer the Rural Electrification Fund for the benefit of rural electrification in Malawi[144]. The rural energy access strategy can be pursued through grid extension and off-grid electricity supply. The before mentioned 2004 Energy Regulation Act, explains how Malawi intends to finance its rural strategy:

> "In order to promote and fund rural electrification, every licensee (distribution system for supplying electricity to the consumers) shall pay to the Authority a rural electrification levy which shall be part of the tariffs or prices of energy payable by energy customers.
>
> The Authority shall pay the levy referred to in subsection to the Rural Electrification Fund [145]"

The Rural Electrification Act, specifically disposes that the off-grid solutions will be the application of solar home system (from now on referred to as SHS) technologies. The Committee is in charge of monitoring the implementation of the electrification projects, subsequently projects are granted to different concessionaires. All rural electrification lines and equipment installed with funding from the proceeds of the Fund are owned by the Government represented by the Concessionaire of each rural electrification project. To this date, no subsidies are offered to users for the operational and maintenance (from now on

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141 GIRDIS, D., HOSKOTE, M. Malawi: Rural Energy and Institutional Development.- Energy Sector Management Assistance Program. *The International Bank for Reconstruction and Development and the World Bank.* Washington, D.C., 2005, p.2.

142 Ibid, p. 5.

143 DEPARTMENT OF ENERGY AFFAIRS. *Malawi Rural Electrification Programme.* [onlone] Lilongwe, Malawi, 2018. [Accessed 2 April 2019] Available at: <https://energy.gov.mw/index.php/projects/rural-electrification-projects/malawi-rural-electrification-programme>

144 GOM. The Rural Electrification Act 2004. Lilongwe, Malawi Government, Act No. 21 of the Malawi Energy Regulatory Authority. Approved on the 18 March 2004, Part II, paragraph 6. [Accessed 2 April 2019] Available at: <https://www.meramalawi.mw/index.php/legislation>

145 GOM. The Energy Regulation Act 2004., op. cit., in footnote 140, Part III, paragraph 25.

referred to as O&M) costs of the rural SHS, consequently they usually fail after a short period of time due to poor technical capability (poor design, poor installation, lack of independent supervision /certification during project implementation, limited knowledge on O&M, supply of poor quality products, etc.)[146]. Financial innovations such as pay-as-you-go (PAYG) mechanism is applied for SHS which allows users to pay for these systems incrementally (typically 6-21 months), thereby reducing upfront cost as a barrier to adoption[147]. Nevertheless, progress on rural electrification has been very slow, the last information available shows that by 2016 there were only estimated 5.000 SHS installed. This also has to do with Malawi manufacturing capabilities as due to being a poor country, there are no local manufacturers and all systems are being imported, mostly from China. Moreover, only few enterprises are able to import the technologies required, currently there are only four companies importing systems targeted at for off-grid solutions, namely Total, Sunny Money, Zuwa and Green Planet[148].

In 2018, the Government of Malawi updated the 2003 National Energy Policy to align with the Malawi 2020 Vision and the Sustainable Development Goals (SDGs), aiming at intensifying its efforts towards energy access. According to the 2018 National Energy Policy (currently being reviewed by the Cabinet), Malawi aspires to reach 80% electricity connectivity by 2035[149]. The Government has also set a target for 2030 to increase the number of solar home systems installed to 75.000[150]. As part of the implementation modalities for the new National Energy Policy, the government with support from the World Bank created the Electricity Access Project, expected to start on 2019 until 2023, the project will apply off-grid systems that will be developed with support from the private sector through the Public Private Partnership approach.[151] Yet there is not enough data to assess the effectiveness of these preliminary access goals. Despite Malawi still being one of the world least electrified nations, the state is part of regional and global sustainable development initiatives which are ambitiously trying to ensure universal access to energy by 2030. This is beneficial for Malawi because as the world becomes more compromised with SDG it is attracting foreign investment to Malawi of institutions like the United Nations with its SE4All initiative, the World Bank as mentioned above and other on and off-grid interventions such as the USAID Southern Africa Energy Programme, just to name a few.

b) Namibia (energy/electricity access: urban 77%, rural 29%, total 56%)[152]

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146 GOM. *Malawi SEforALL Action Agenda.* Lilongwe, Malawi Government, Approved by the Department of Energy Affairs on June 2017, p.42

147 SAMARAKOON, S. *Energy Justice In Malawi - The Case Of Solar Household Systems*. [online] Blog Post, February 5, 2019 [Accessed 2 April 2019] Available at: <https://www.shanilsamarakoon.com/blogposts/2019/2/5/energy-justice-in-malawi-the-case-of-solar-household-systems>

148 WORLD BANK. *Malawi - Electricity Access Project (P164331).* [online] International Development Association, Washington, D.C., 2019. [Accessed 20 March 2019] Available at: <http://documents.worldbank.org/curated/en/313871549533419539/pdf/Concept-Project-Information-Document-Integrated-Safeguards-Data-Sheet-Malawi-Electricity-Access-Project-P164331.pdf>

149 Ibid

150 GOM. *Malawi SEforALL Action Agenda.,* op. cit., in footnote 146, p.11

151 WORLD BANK.op. cit., in footnote 148.

152 REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 54

Namibia's territory is composed largely by desert, rangelands and its long coastline on the South Atlantic, this heavily influences its population density and economy. The country borders with South Africa, Botswana, and Angola. It has a tiny population of about 2.6 million[153], if we compare it with Malawi, it's surface area is 8 times bigger than Malawi's but Malawi's population is 9 times larger. It is considered an upper-middle-income economy, political stability allowed the country to over half the proportion of Namibians living below the national poverty line since its independence in 1990[154]. However, poverty reduction was not followed by the same efforts into job creation, and therefore the extreme socio-economic inequalities inherited from its apartheid past still persist. As a result, Namibia is one of the most unequal countries in the world which slows the pace of poverty reduction[155].Namibia's economy is sensitive to changes in international fuel prices owing to the importance of its exporting mining industries[156]. The country's natural mineral riches completely drive the economy, but they only benefit the urban rich. Over half of the population (52%)[157] live in the rural areas of this vast country and are dependent on subsistence agriculture and herding for a living. Three decades after independence from South Africa, white Namibians still own the vast majority of commercial farm land[158], which perfectly exemplifies the roots of Namibia's inequality. Namibia's relatively steady economic growth has, thus, not been enough to deal with the country's triple challenge of high poverty, inequality, and unemployment.

The ministry responsible for energy in Namibia is the Ministry of Mines and Energy (MME). Namibia's Energy policy and planning is guided by the 1998 Energy White Paper. The Paper integrates development objectives aiming at achieving social uplifting, economic efficiency and sustainability[159]. In furtherance of the goal of social upliftment, energy access for households is given a prominent place in the policy. The Electricity Act of 2000 paved the way for the introduction of independent power producers (IPPs) to expand domestic generation capacity and the formation of 5 regional electricity distribution companies. It also established the Electricity Control Board (ECB) which is the regulator to mediate between the demand and supply side of the electricity industry[160].

Namibias major energy challenge remains energy access to modern energy services for rural areas. With respect to off grid and rural electrification, The Rural Electricity Distribution

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153 COUNTRYMETERS. *Namibia Population clock (live).* [online] New York, 2019. [Accessed 3 April 2019] Available at: <https://countrymeters.info/en/Namibia>

154 WORLD BANK. *The World Bank In Namibia*. [online] Washington, D.C., 2019. [Accessed 20 March 2019] Available at: <https://www.worldbank.org/en/country/namibia/overview>

155 Ibid

156 IMF. Energy subsidy reform in Sub-Saharan Africa: experiences and lessons. *International Monetary Fund,* Washington, D.C, 2013, p.79

157 TRADING ECONOMICS. *Namibia - Rural population*. [online] New York, 2019 [Accessed 3 April 2019] Available at: <https://tradingeconomics.com/namibia/rural-population-percent-of-total-population-wb-data.html>

158 GLOBAL SECURITY. *Namibian Politics.* [online] Washington, D.C., 2018 [Accessed 3 April 2019] Available at: <https://www.globalsecurity.org/military/world/africa/na-politics.htm>

159 MME. *Energy Policy White Paper.* Developed by the Energy Policy Committee of the Ministry of Mines and Energy, May 1998, Windhoek, Namibia, p.3

160 MME .*The Electricity Act 2000, Act No. No. 2371.* Developed by the Ministry of Mines and Energy, the Act commenced on 12 July 2000, Windhoek, Namibia, p.2

Master Plan (REDMP) and the Off-Grid Energisation Master Plan (from now on referred to as OGEMP) are the key guiding documents. The Rural Electricity Distribution Master Plan was originally introduced in 2000 and it is reviewed and updated every 5 years, due to its methodology of medium to long term targets. The 2010 REDMP prioritises 2,879 rural localities to be electrified through the main grid in the next 20 years[161].

The 2007 OGEMP, covers the energy access for municipal areas, off-grid areas and informal settlements around urban areas, which are not planned to receive electricity by the main grid in the near future. There are approximately 106,554 households planned to be electrified[162]. The OGEMP was developed under the Namibian Renewable Energy Programme and was financed by UNDP, GEF and the Namibian Ministry of Mines and Energy. It provides a framework for off-grid electrification including support of independent renewable energy systems, through the establishment of Energy Shops, which will sell suitable and approved energy products and appliances[163]. With respect to financial mechanisms, the capital costs of the rural electrification programme is administered by the Ministry, funded by NamPower and regional electricity distributors. Off-grid households need to purchase their energy technologies, but consumer credit finance is provided via a OGEMP revolving fund, which makes energy solutions affordable to the even the lowest income households, through different loans at the prime interest rate[164]. Alongside, the Solar Revolving Fund established by MME in 1996, is also a credit facility established especially for communities living in off-grid areas and continues to subsidise stand-alone solar systems for individual household use. Between 2015 and 2017, it financed around 1,600 solar systems (water heaters, pumps and solar home systems)[165].

c) South Africa (energy/electricity access: urban 93%, rural 68%, total 86%)[166]

South Africa's peaceful political transition is considered one of the most extraordinary political feats of the past century[167]. The country's population of 55.9 million people, has achieved to be one of Africa's biggest and most developed nations[168]. The World Bank considers it's an upper-middle-income economy, one of only four in Africa, namely Botswana, Gabon and Mauritius. Commodity prices remain important for South Africa, as the economy was traditionally rooted in the primary sectors due to its mineral resources and favourable agricultural conditions. Since the early 90's, there has been a structural shift and economic growth has been driven mainly by the tertiary sector. Besides, the manufacturing sector is also a large contributor to the country's economic development. Currently, South

[161] GOVERNMENT OF NAMIBIA. *Ministry of Mines and Energy - Rural Electrification Programme.* [online] Windhoek, 2000 [Accessed 3 April 2019] Available at: <http://www.mme.gov.na/directorates/energy/electricity/>

[162] SCHULTZ, R. SCHUMANN, C. *Off-Grid Energisation Master Plan for Namibi Final Report*. Developed by the Government of Namibia with the United Nations Development Programme and the Global Environment Facility, Windhoek, Namibia, January 2007, p.14

[163] Ibid, p.7.

[164] Ibid, p.4.

[165] REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 58

[166] Ibid, p. 54

[167] WORLD BANK. *The World Bank In South Africa.* [online] Washington, D.C., 2019 [Accessed 3 April 2019] Available at: <https://www.worldbank.org/en/country/southafrica/overview>

[168] Idem

Africa is moving towards becoming a knowledge-based economy, with a greater focus on technology, e-commerce, etc[169]. Nevertheless, the country's economic growth is not pro-poor and does not generate sufficient jobs, resulting in enormous challenges regarding unemployment, poverty and inequality. Therefore, similarly to Namibia, the country remains a dual economy, with one of the highest inequality rates in the world. Most of the poor reside in rural areas, which account for approximately 34.7% of the population, according to the World Bank.

South African energy policies have always been linked to the prevailing political situation. After the apartheid, the new democratic government aimed at addressing the inequalities of the past and in order to ensure equal access to basic services for all South Africans, the National Reconstruction and Development Programme was born in 1994. The Program was very effective and between 1994 and 2000, roughly 1.75 million homes had been connected to the national grid, while the proportion of rural household electrification grew from 12% to 42%[170]. Today the energy sector is governed and regulated essentially by the Energy White Paper of 1998 and the National Energy Act of 2008.

The Energy Act, mandates the South African Department of Minerals and Energy (DME) to ensure that diverse energy resources are available, in sustainable quantities and at affordable prices, in support of economic growth and poverty alleviation. This must be done taking into account environmental management requirements that are in line with the National Environmental Management Act, the National Climate Change Response White Paper and the UNFCCC[171].

On the other hand, the White Paper's ultimate goal is access to affordable energy services, it includes two major programmes which are the Integrated National Electrification Programme (from now on referred to as INEP) and the Free Basic Electricity (from now on referred to as FBE).

INEP aims to address physical access to modern and clean energy, in line with the National Development Plan, the government is committed to reach universal access through electrifying all households by 2025. Electrification in rural areas is currently being done through the New Household Electrification Strategy, which delivers off-grid solar home systems. Since April 2002, the Department of Minerals and Energy is responsible for funding INEP. Over 7.2 million households have received electricity so far, thanks to the INEP and its collaboration with the national utility Eskom and licensed municipalities[172]. Within the next three years INEP and its implementing agencies (municipalities, Eskom and non-grid service providers) aim to achieve approximately 700.000 household connections[173].
However, even after being connected to the national grid many poor households still could not use electricity as they were not able to afford it. Thus, in 2003 the government realised that

[169] MEDIA CLUB SOUTH AFRICA. *South Africa's economy: key sectors* [online] Pretoria, 2017 [Accessed 3 April 2019] Available at: <http://mediaclub.co.za/economy/37-economy/economy-bg/111-sa-economy-key-sectors#ixzz5khJbVWMr>

[170] LODGE, T. The RDP: Delivery and Performance. In: *Politics in South Africa: From Mandela to Mbeki*, PHILIP, D. Indiana University Press, Cape Town, 2003, p. 21.

[171] DME. *Annual Performance Plan 2018/19* . Developed by the Department of Energy Republic of South Africa, Pretoria, April 2018, p. 2

[172] Idem

[173] Idem

INEP by itself could not fully benefit all citizens and the FBE Policy was introduced. FBE provides a basic amount of energy for free to poor households, because government pays this subsidy to the municipalities which in turn pay the electricity distributors[174]. Recipients of this policy receive 50 kW/h free of charge every month, sufficient for lighting, black-and-white television, radio and occasional basic cooking[175].

Finally, in Ms. Wlokas review of the Solar Home System Concession Programme in South Africa she included an interview to the Department of Energy's off-grid manager Sebastian Khoza. In the interview he pointed out some of the main benefits and challenges that the rural electrification strategy faces. The main benefit of this decentralised strategy is that local councillors are of crucial influence to the process of creating awareness and convincing rural population about the SHS programme. Some municipalities have even hosted Energy Forum meetings which gather the energy distributors, local authorities and SHS recipients. Secondly, in terms of the electrification roll-out since it requires technical expertise, Eskom collaborates with the municipalities in their planning. On the negative side however, in order for the FBE to reach up to the rural poor, municipalities need to keep their indigent register up to date, which sometimes is not the case. The main problem here as Mr.Khoza explained is that politics influences the commitments of municipalities. Since municipalities are the responsible for paying the government's funding to the energy distributors, this results in financial imbalances. To date, the Department as the managing agent of the programme has not been able to ensure payments through the municipalities to the concession companies [176].

**The overall conclusion and comparison of the three case-studies will be done in the last section of this chapter. The next sections will be dedicated at comparing and assessing the actual instalment of the solar stand alone technologies, in order to give an accurate analysis and conclusion.*

3.3. Solar energy capacity

As the previous sections have demonstrated SADC MS major concern regarding electricity is access for the poor in remote rural areas. Tackling this challenge with solar RE technologies, as this paper aims to demonstrate, is the most cost-effective, quickest and environmental friendly solution. However, in the energy sector, economic concerns often prevail. As Bhattacharyya review explains, the most important indicators for the economic sustainability of electrification solutions are the cost-effectiveness and the reliability of supply[177]. In order to understand the current situation the overall picture of solar energy capacity in the SADC region is the following:

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[174] DME. *Free Basic Electricity Policy*. Developed by the Department of Minerals and Energy. Republic of South Africa, Pretoria, 2005, p. 3.

[175] SADC. *SADC Regional Energy Access Strategy and Action Plan 2010*. [online]. SADC Energy Programme with the support of EUEI, Angola, 2010.[Accessed 20 March 2019] Available at: <http://www.euei-pdf.org/sites/default/files/field_publication_file/EUEI_PDF_SADC_Regional_Energy_Access_Strategy_Mar_2010_EN.pdf>

[176] WLOKAS, H.L. *A Review of the Solar Home System Concession Programme in South Africa.* University of Cape Town, Cape Town, South Africa, 2011,p.9

[177] BHATTACHARYYA, S.C. Energy access programmes and sustainable development: A critical review and analysis. *Energy Sustain. Dev.* 2012, Issue 16, p. 260.

- The region benefits from outstanding solar irradiation approximately 2.500 hours of sunshine a year, which manifests solar power strong reliability. IRENA, in 2014, estimated that SADC's potential to generate electricity from solar irradiation would be of 20,000 terawatt-hours (TWh) per year[178].
- The total installed solar capacity in the SADC region in mid-2018, was 3,102 MW, of which 2,503 MW, was solar PV[179] . South Africa accounts for 97% of this total, a figure that will likely continue to rise[180] . Therefore, still less than 1% of SADC's solar potential is currently being utilised.
- Several MS have planned different investment programmes aimed at increasing solar power generation, mainly South Africa. Solar energy is a major target for renewable energy expansion in five countries: Angola, Eswatini, Mauritius, Mozambique and South Africa[181] . There are still some countries with major solar potential, such as Zambia and the DRC, which are yet to implement any kind of large-scale solar power system.
- Cost-effectiveness of solar photovoltaic panels keeps getting better, thanks to the decline in the cost of the technologies, the radical improvement of battery storage and increase in the energy efficiency of electrical appliances. Although initial investment is still higher than for fossil fuel technologies, the cost savings effects (i.e. fuel saving and the reduction of transmission and distribution investments, especially with decentralised renewable options), far exceed the additional investment costs[182].
- Unfortunatelly, SADC governments often favour fossil fuels over RE as primary energy sources. As most SADC MS are mineral rich and rely on their exporting economies, they are sensitive to international commodity prices. This means they often apply mitigating measures to address the increases in international commodity value and avoid domestic sharp price adjustments. As expressed by REN21 "Renewables remain at a significant disadvantage in terms of government subsidies, for every dollar spent boosting renewables, nearly four dollars are spent to maintain dependence on fossil fuels"[183].

All in all, fossil fuels and biomass still have a predominant position on the final energy consumption of most of SADC's population. Energy access and security concerns are still the main challenges of the region. The arguments above are able to prove the potential of solar power electrification solutions. However, this potential is currently not being exploited as much as it could be. This suggests the need and the concrete opportunity to incentivise decentralised solar power electrification solutions.

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178 IRENA. Analysis of Infrastructure for Renewable Power in Eastern and Southern Africa. *IRENA*, Abu Dhabi, 2015, p. 36

179 REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 45

180 DME. *Independent Power Producers Procurement Programme: an Overview as at 31 December 2016* [online] Johannesburg, 2017 [Accessed 3 April 2019] Available at: <https://www.ipp-projects.co.za/Publications/.>

181 REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 79

182 SADC. Renewable Energy and Energy Efficiency Strategy & Action Plan - REEESAP 2016-2030. *SADC Secretariat,* Gaborne, 2016, p.20

183 Ibid, p.21

3.4. Solar PV off-grid implementation

This section will explain how can solar power energy be used and applied in stand-alone power systems. The sun's radiation is used by solar panels, using photovoltaic conversion technology to convert light into electricity. This is achieved through photovoltaic (PV) modules. As each module supplies small energy amounts, several modules are wired in series creating a "laminate"[184]. The laminate is then amalgamated and put into a protective weatherproof enclosure making the photovoltaic module or solar panel. PV modules are usually of 12 volts with power outputs of between 50 to over 100 watts each, which can be combined into a single array to give the desired power output[185]. Therefore, PV technology is modular, allowing for upscaling or downscaling for the various sizes to meet a range of electricity needs in off-grid regions. Since energy is drawn from the sun, power production is higher during mid-day than the in morning and afternoon, with no production at night. Sun tracking technology is available and can be implemented to improve the PV system's efficiency. This trackers and sensors are an accessory often seen as optional, they can increase output by up to 50%, but add an extra cost making the system more expensive. Additionally, batteries are added so that some of the electrical power produced can charge the battery banks during the day for use during the night when the sun's energy is unavailable. When batteries are added, an inverter must be also be added to convert the direct current (DC) power from the battery into alternating current (AC) since many of our appliances are designed to work with AC.

PV systems in remote rural areas may be used in different ways: Solar Pico Systems (SPSs) is the smallest application producing from 1 to 10 watts which can be used for lightning to replace kerosene lamps. Mid-scale solutions are Solar Home Systems (SHS), they usually have a capacity of a 10 to up to a 250 watts, which can power several uses such as lamps, a radio and TV [186]. SHS for solar cooking still needs improvement as available PV panels today have only achieved an efficiency of 18-19%[187]. However, as Prof. M. Rezwan Khan described with the falling price of the solar PV, solar energy cooking will be able to become effective soon enough. Moreover, he explains that "if the heat loss is contained properly, it is possible to cook with a low power source less than 500W"[188].

Regarding how rural communities may afford these solar systems, there are two separate ways. Firstly, it is each SADC MS obligation to invest and work towards the energy access basic needs of its population. This can be done through various mechanisms which will be further developed in the case analysis. Secondly, rural households already tend to spend a higher fraction of their income than the urban rich, spent on non-renewable off-grid energy

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[184] GOVERNMENT OF THE REPUBLIC OF NAMIBIA. *The National Integrated Resource Plan Review and Update – Final Report Developed for the Ministry of Mines and Energy by the Electricity Control Board.* In consultation with the Hatch Ltd, Windhoek, September 2016, p.49

[185] ALTERNATIVE ENERGY TUTORIALS. *Stand Alone PV System*. [online] March 2019. [Accessed 3 April 2019] Available at: <http://www.alternative-energy-tutorials.com/solar-power/stand-alone-pv-system.html>

[186] LYSEN, E.H. *Pico Solar PV Systems for Remote Homes: A New Generation of Small PV Systems for Lighting and Communication*; Photovoltaic Power Systems Programme, IEA PVPS Task, St. Ursen, Switzerland, 2013.

[187] HARROP, P. *Photovoltaic cooking makes sense* [online] Offgrid Independence, Posted on May 02, 2018 [Accessed 3 April 2019] Available at: <https://www.offgridenergyindependence.com/articles/14202/photovoltaic-cooking-makes-sense>

[188] Idem

sources. Rural families on average spend 10% of their household income for only 4 hours of light at night using kerosene, torches or candles[189]. In Malawi, families spent 12% of their income on lighting prior to solar light ownership but only 5% after, in Tanzania it went from 7% to 1%, and in Zambia from 6% to 2%[190]. Although, initially these technologies have a high cost which is not affordable by rural communities whom tend to be poor, with time the monetary savings from solar solutions would be sufficient to bear the cost. Rural electrification SHS strategies should thus be accompanied by financial aid, in the form of subsidies, credits or loans to allow affordability.

Beyond financial savings, solar PV systems benefit from extra lighting hours and better quality and therefore, can be used to power small enterprises or schools for productive uses. By applying productive solar PV systems, it increases the time available for productive work among rural communities and they can create opportunities for income-generating activities. Productive systems for example can help digital local culture, handicrafts, artisans , rural industry shops, stations for battery charging, agricultural uses (by pumping water for livestock, micro-irrigation) and many more applications.

Following the previous section's methodology, this paper will analyse the solar PV systems applied in the three different MS, to assess its sustainability and effectiveness. By comparing the different solar electrification strategies we can learn from the different scenarios with different needs and capabilities. This analysis aims to understand what would be the most accurate solar energy solution for energy access in the SADC's remote rural areas.

3.4.1. Case study analysis

a) Malawi (energy/electricity access: urban 42%, rural 4%, total 11%)[191]

Solar energy is a vast source in Malawi which could contribute a great amount to fill the gap of energy access needs in Malawi. The country receives about 3.087 hours of sunshine which is estimated to amount in the solar energy potential capacity of 356,284,837 MWh/ year[192]. Contrarily, biomass is the main energy source with 99.4% of energy use in rural areas and 35% in urban centres[193]. The main energy consumers are households, accounting for 83% of the total energy consumption, which means there is considerable potential for stand alone solar home systems in remote rural areas. With only 30% of the rural population planned to be grid-connected by 2030[194], there needs to be an alternative for those communities living too far to get energy access.

The latest data available regarding off-grid installations is from 2016, by then the Rural Electrification Management Committee had achieved to install an estimated 5,000 solar

[189] HARRISON, K., SCOTT, A., and HOGARTH, R. Accelerating access to electricity in Africa with off-grid solar -The impact of solar household solutions. *Overseas Development Institute*, London, 2016, p. 9.

[190] Idem

[191] REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 54

[192] TAULO., J. L., GONDWE K. J., and SEBITOSI A. B. Energy supply in Malawi: Options and issues. *Journal of Energy Southern Africa,* Cape Town , vol.26, 2015, num.2, p.10

[193] REN21., op. cit., in footnote 191, p. 57

[194] Idem

home systems, 2,000 solar water heaters and more than 7 off-grid mini-grids which were supplying electricity to only about 900 people nationwide[195]. Bearing in mind that Malawi's rural off-grid electrification strategy started in 2004 with the Rural Electrification Act, in 12 years the amount of users that gained energy access can be considered quite low, specially when compared with other MS achievements.

Malawi's national RE targets are based on final energy consumption instead of generation and they aim to increase the share renewable energy technologies installed in the country. Specific targets for 2030, aim at the instalment of 75,000 solar home systems, 13,500 mini-grids and 4,500,000 pico solar products[196]. A lot of work needs to be done in order to allow for more amount of population to get energy access. The good news is that these national targets reveal the states's political will to invest in pico solar products and other solar systems, as they become aware of the advantages of this technology for Malawi's large rural population. If we examine the current sales volumes of Malawi's best solar company named Sunny Money, we find that pico solar products are rapidly substituting wick paraffin lamps, for lighting. Pico solar, if used as a substitute for a paraffin or kerosene lamp, can repay itself in three to four months[197]. SolarAid's market research with rural consumers shows that families spend an average of $4 each month on lighting from traditional fuels. The current market price of pico solar products is of $9, discounted price of $7 and a heavily subsidised price would be of $4 or even free. Solar Aid's research on the uptake of solar lamps was 29%, 37%, 69%, 100% respectively according to the above mentioned pricing[198]. Moreover, technological advancements make it possible to further lower the price in the future moving closer to the same cost or even cheaper compared with kerosene and paraffin products. So far, small systems in the form of solar pico system have been the off-grid solution which has received the most investment. This is probably because it represents the most affordable and viable application since it requires less technical and economic capacity for the O&M of the system. While pico solar products have played a useful role in providing Malawian households with an alternative source to kerosene lamps, they are unable to cover the ever-growing energy needs of the population.

To sum up, Malawi is at an electrification and development inflection point, the low amount of SHS installed can be due to the government's weak private investment promotion for local off-grid energy distributors to help the state fund its electrification strategies. Later on in this case analysis, we will see how South Africa's Independent Power Producer Procurement Programme can offer some insights as to how encourage funding for renewable electrification programmes. Moreover, no subsidies are offered to users for the operational O&M costs, which results in short duration of the system due to poor technical capability. Rural electrification strategies must incorporate the communities as a powerful player and thus include within the strategy the transfer of knowledge so that users themselves can carry

[195] Idem

[196] CONREMA. *BIF2 Malawi: Pico Solar Products (PSP): Market Analysis and Strategy.* Blantyre, Malawi, May 2014, p.2.

[197] REN21. SADC Renewable Energy and Energy Efficiency Status Report*. REN21 Secretariat*, Paris, 2018, p. 57

[198] HARRISON K., and ADAMS T. An Evidence Review: How Affordable Is Off-Grid Energy Access In Africa? *Acumen,* 2017, p.21

out the operational and maintenance necessities. In this regard in Malawi there's a basic understanding of how solar panels work, but there is often very little knowledge of the various components and their specifications that are required for a well functioning system. Finally, all the technologies are being imported, mostly from China which doesn't allow for their local economic evolution. Therefore, the state should aim at improving its manufacturing capabilities in order for the local population to be part of the creation, distribution and instalment of these technologies.

b) Namibia (energy/electricity access: urban 77%, rural 29%, total 56%)[199]

Solar energy potential is the most abundant renewable energy source in Namibia. The territory has one of the highest solar radiation regimes in Africa and the world, because sunshine is available all throughout the year with minimal interruptions and most of its land is composed by desert. Namibia has an excellent solar irradiation, which produces energy yields of 3000 kWh/m2 over a large part of the country[200]

The Namibian Government has recognised the importance of having RES as an important part of the country's generation portfolio through its energy legal framework and policies, for example with the establishment of a dedicated Renewable Energy Division. Moreover, Namibia's submission to the UNFCCC 2015 Paris Agreement, with the Intended Nationally Determined Contributions, it plans an energy sector increase in the share of renewables in electricity production from 33% in 2010 to 70% by 2030[201]. Moreover, the government has gone beyond other countries in elaborating their comprehensive Off-grid Energisation Master Plan for Namibia (OGEMP) which uses solar power, in the following 3 areas of implementation:

Firstly, the aim at the electrification of rural public institutions in off-grid areas using solar power in 5 years, institutions aimed at are schools, churches and government buildings. This element of the plan has received major efforts from the government and a sizeable number of rural institutions have received PV solar power. Just in 2013, 5 schools in the Omusati and Omuthiya Regions received "containerised" PV systems, and four more were planned for 2014[202]. This is a remarkable electrification approach since the aiming at local public institution increases the participation and empowerment of rural communities which enhances the social acceptability of solar power solutions.

The second electrification method is the establishment of Energy Shops in each of the 13 recognised Namibian rural areas. Energy shops will be established strategically within a reasonable distance of the targeted communities, in existing enterprises whose core business is mostly technically oriented (selling equipment, building materials, providing installation

[199] REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 54

[200] IRENA. *Renewable data in Namibia* .[online] Abu Dhabi, 2018 [Accessed 3 April 2019] Available at: <https://www.irena.org/EventDocs/Namibia.pdf>

[201] GOVERNMENT OF THE REPUBLIC OF NAMIBIA. *The National Integrated Resource Plan Review and Update – Final Report Developed for the Ministry of Mines and Energy by the Electricity Control Board.* In consultation with the Hatch Ltd, Windhoek, September 2016, p.125

[202] STOCKMAYER, M., MARTONOVA, L., and WETZER, W. Nationally Appropriate Mitigation Action: Rural Development in Namibia through electrification with renewable energies. *UNDP*, 2015, p.49

services, etc)[203]. The shops will sell suitable, approved and compatible energy technologies and appliances to households and businesses of all income levels. For users who lack of all kind of modern energy technologies, the concept of energy basket has been introduced to assist in meeting the varied needs of customers. These Energy Baskets are made up of a wide range of affordable and appropriate energy technologies, compatible fuels, and compatible appliances, with the final basket consisting of a total energy solution[204]. Finally, in order to make sure customers make informed choices, a data sheet will be provided for each basket.

The third initiative is the task of the Solar Revolving Fund, administered by the Renewable Energy Division of the Ministry of Mines and Energy provides loans to households and communities for solar water heaters, solar water pumps and solar home systems at a favourable interest rate of 5 per cent during the loan period of five years[205].

By focusing on energy services rather than electrification, the Namibian strategy has given an increased role to the rural communities which surprisingly is rare in most rural electrification strategies. This approach has many advantages for the sustainability of the solar power systems since the strategy also encourages the involvement, the technical knowledge and economical development of the rural communities. Moreover, this strategy is able to cover all of the household basic needs as it provides for different technologies and appliances with different sizes and adaptability.

c) South Africa (energy/electricity access: urban 93%, rural 68%, total 86%)[206]

South Africa experiences high levels of solar radiation more than 2.500 hours of sunshine per year, with average daily solar radiation of between 4.5 and 6.5kWh/m^2per day[207]. This resource is relatively predictable and evenly distributed, which means that solar radiation harnessing through PV technologies can be used almost anywhere in the country. The government has expended much efforts on harnessing RE power wherever possible as a way of managing energy-related environmental impacts and diversifying its energy mix from the coal-dominated system. Currently, the most relevant RES policies and strategies started with the 2010-30 Integrated Resource Plan (IRP) adopted in 2011. According to the Plan South Africa has the national commitment to transition to a low carbon economy, increasing its RES to 18.800 MW by 2030[208]. In order to fulfil this commitment the government developed the internationally acclaimed Renewable Energy IndependentPower Producer Procurement Programme (from now on referred to as REIPPPP) the first of this kind in the SADC region. REIPPPP is a programme developed to encourage regional and international private investment, to secure electrical energy demand, via RES which will be added to the national

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[203] Idem

[204] SADC. *SADC Regional Energy Access Strategy and Action Plan 2010*. [online]. SADC Energy Programme with the support of EUEI, Angola, 2010.[Accessed 20 March 2019] Available at: <http://www.euei-pdf.org/sites/default/files/field_publication_file/EUEI_PDF_SADC_Regional_Energy_Access_Strategy_Mar_2010_EN.pdf>

[205] REN21., op. cit., in footnote 199, p.52

[206] Ibid, p. 54

[207] SOLA FUTURE ENERGY. *South Africa's solar resource compared to the rest of the world.*[online] SOLA Editor, Johannesburg, Dec 19, 2013 [Accessed 20 March 2019] Available at: <https://www.solafuture.co.za/news/south-africas-solar-resource-compared-to-the-rest-of-the-world/>

[208] INDEPENDENT POWER PRODUCERS. *Renewables Programme.* [online] Johannesburg, 2019 [Accessed 20 March 2019] Available at: <https://www.ipp-renewables.co.za>

grid. IPPs are selected in a multi-stage bidding process comprising of 6 stages, where the main evaluation criteria for the bid selection process is pricing of power per kWh, with a 70% weighting, and also there is a 30% weighting for other factors such as job creation, local content and black economic empowerment[209]. REIPPP has been effective since 2011 which means that the availability of renewable energy products and technical expertise for off-grid applications in South Africa currently relatively high.

Regarding rural communities, under the New Household Electrification Strategy the government aims to electrify some 300,000 households with off-grid solar home system solutions by 2025[210]. The government's strategy is very similar to Malawi's, and gives the right to private companies to establish off-grid energy utilities in the government's designated concession areas. In the same way as the REIPPP, this rural electrification strategy employs concessions as a potential way to attract larger, better organised private companies which already have their own sources of financing[211]. The strategy is aimed specifically, at rural households that are too remote to be connected to the grid. Identification of these villages was done in close collaboration with Eskom and municipal distribution development planning, to ensure that only households that would not be grid-connected for at least five years would receive solar home systems.[212] Under this strategy, six concessionaires are operating in four rural areas, namely Eastern Cape, KwaZulu-Natal, Mpumalanga and Limpopo, the areas were chosen for their remoteness from the grid and low probability of energy access in the short-term[213].

The Department of Minerals and Energy is responsible for implementation, formulating the policy and administering the capital subsidy for the systems and their installation. The solar home system is offered on a fee-for-service basis where customers pay a one-off connection fee for the installation of the solar system. There is also a small monthly service fee that covers lifetime running costs including O&M, replacement of batteries, fee collection and customer support. The government subsidises most of the capital costs of the systems (80%) for rural communities by granting a capital subsidy directly to the concessionaire for each SHS installed. Within the population, those considered poor or indigent receive the free basic energy (FBE) service grant which covers for 100% of solar home system. Municipalities are the ones responsible for providing the energy services and giving out the FBE subsidy to the concessionaires. The Electricity Regulator approves the installation of the systems according to the standards set by South African Bureau of Standards (SABS). With the incorporation of the fee-for-service approach as part of the concessionaire's service, the maintenance is now taken care of by the energy company

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[209] ENERGY INTELLIGENCE. *REIPPP: All you need to know!.* [online] Energy Intelligence, March, 2016 [Accessed 20 March 2019] Available at: <http://www.energyintelligence.co.za/reippp-all-you-need-to-know/>

[210] REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 58

[211] SADC. *SADC Regional Energy Access Strategy and Action Plan 2010*. [online]. SADC Energy Programme with the support of EUEI, Angola, 2010.[Accessed 20 March 2019] Available at: <http://www.euei-pdf.org/sites/default/files/field_publication_file/EUEI_PDF_SADC_Regional_Energy_Access_Strategy_Mar_2010_EN.pdf>

[212] REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 58

[213] SADC. *SADC Regional Energy Access Strategy and Action Plan 2010*. [online]. SADC Energy Programme with the support of EUEI, Angola, 2010.[Accessed 20 March 2019] Available at: <http://www.euei-pdf.org/sites/default/files/field_publication_file/EUEI_PDF_SADC_Regional_Energy_Access_Strategy_Mar_2010_EN.pdf>

distributor, whose staff is educated and trained for this technology. This mechanism creates a scenario where the concessionaire acts just like the traditional national utility in that it provides the electric service in exchange for remuneration, but with operational guarantees. Moreover, people are employed as the concessions are shown to employ more people than an equivalent grid project. For the installation, some concessionaires (i.e. NuRa) employ local consultants, who allow for a greater integrated solution.

In terms of the SHS capabilities, the basic SHS includes a 4 light, 50 Wp solar system with a 100 Ah battery, which delivers approximately 175 Wh per day, or enough to power a black and white television, a 9 V radio and the accompanying lights for three to four hours[214].

The main flaws of South Africa's electrification efforts, is that installation is slowed down by political factors. The major problem delaying roll-out, has been government cutbacks in funding for the programme and delays in awarding new tenders to concessionaires[215]. Which means that the programme 2025 target will take longer to achieve as instalment has fallen short of initial expectations (300.000 SHS). Additionally, the major energy requirement of poor rural households is cooking and unfortunately the SHS systems PV capacity do not allow for regular cooking. Since, energy consumption after energy access always increases, the users demand upgrading to higher-power PV systems rather than the standard 50 Wp. This is fact is not taken into account within the electrification strategy, which focuses on electrification rather than providing the tools for energy access. It must be noted, that some concessionaires did allow for larger systems available on demand, but since each concessions are given the right for energy distribution in their assigned rural area, the PV capacity of the SHS systems depended on the concessionaire assigned in the area. This has resulted in some unsatisfied customers perception, bearing that the solar electrification strategy for rural areas is an inferior technology given only to the poor, which has created an unrepresentative negative image of the technology. Therefore, there is a strong need to harness productive end uses for PV systems which are capable to enhanced social acceptance and affordability.

3.5. Findings

From the very start we can already highlight that although all states are putting efforts towards their common goal of improving energy access for their respective rural communities, there isn't a harmonised approach by SADC Member States. Each State has applied different mechanisms in terms of the institutions responsible, their mandate, financing mechanisms and off-grid technology solutions. From their experiences we can draw on some learnings for the better application of off-grid solution strategies which are the following:

First and most important, institutions play a fundamental role in the effectiveness of the strategy. This is because they are the ones responsible to coordinate, rationalise and bring

[214] Ibid

[215] GNESD. *Off-grid Solar Home System Programme South Africa.* [online] GNESD Energy access knowledge base, Denmark, 2019 [Accessed 20 March 2019] Available at: <https://energy-access.gnesd.org/projects/29-1-sarah-best-sustainable-development-advisors-for-the-international-institute-for-environment-and- development-2011-remote-access-expanding-energy-provision-in-rural-argentina-through-public-private- partnerships-and-renewable-energy-a-case-study-of-the-per.html>

into effect the rural electrification programmes. In this case study, Malawi was the only government with a specialised regulatory institution for rural energy access, namely, the Rural Electrification Management Committee. In the cases of Namibia and South Africa the same institution was responsible for electrification both in rural and urban areas. However, Malawi's institutionalisation can be attributed to the fact that the majority of Malawi's population resides in rural areas and thus this must be reflected in its institutions. Moreover, since Malawi is still one of the least electrified nations, institutions still have a major role to play and in this sense having a specialised regulatory institution is a good approach.

Out of the different electrification strategies, this paper wants to highlight South Africa's decentralised mechanism as a positive mechanism for the sustainability of off-grid solar systems. South Africa's Department of Minerals and Energy utilised different implementing agencies (municipalities, Eskom and non-grid service providers) to its tackle energy access strategy. By doing this it avoided top-down approach by the central government, in order to enhance acceptance of the technologies at a local level and accurately meet the needs of the population. Moreover, the creation of Energy Forum meetings is a very powerful initiative which can help a lot for the sustainability and acceptance of the strategy. Despite the advantages of decentralisation, it may also be problematic as the interview with Mr. Khoza brought into light. Politics uncertainty and the lack of expertise and know-how capacity by local actors can become a barrier to administrate the services. Indeed, numerous studies have shown that the scarcity of expert know-how on RE can affect the effectiveness of off-grid PV systems[216].

On the other hand, Namibia's OGEMP distinct three areas of implementation have proved to be the most complete strategy in terms of fulfilling the energy needs of remote rural communities. The Namibia's strategy implementation focus on public institutions and energy services rather than electrification, has allowed for a prominent role and the required involvement of the rural communities within the strategy. By also incorporating the transfer of knowledge and productive services the Namibian rural electrification strategy has been capable of overcoming the barriers encountered in South Africa's strategy. Since it is highly probable that expert know-how on these new technologies is not available in remote areas, the incorporation of the communities within the process allows for the involvement, the technical knowledge and economic development of users which is essential for the sustainability of electrification strategies. Nevertheless, this is an area where SADC can also help, by creating a common list of recommended quality standards for small standalone systems or the adoption of a regulatory framework for rural electrification efforts based on off-grid systems to achieve better integration and acceptance by the rural communities.

Institutions responsible for electrification strategies must acknowledge that the electric service provider does not understand the needs and conditions of their customers as the electric service is based on the technologies technical requirements, rather than the user's requirements. In turn, remote rural communities in most cases do not understand the technology and the often complicated agreements that go with it. Although, encouraging external and private electric service providers can be beneficial for the financing of the strategy, as proved with the successes of South Africa's REIPPPP. Private distributors will have even less concerns for the needs of the costumers and therefore, the responsible institutions need to address this gap. Otherwise, we will have outcomes like in South Africa

[216] FERON, S,. Rural Electrification Efforts Based on Off-Grid Photovoltaic Systems in the Andean Region: Comparative Assessment of Their Sustainability. *Sustainability*, vol. 8, 2016, issue 12, p.5

where unsatisfied customers created an unrepresentative negative image of the technology and even after electrification fuelwood remained the major cooking fuel in many poor rural areas. Altogether, in order to apply a sustainable solar electrification strategy, it needs to be accurate which implies designing energy solutions according to the socio-cultural reality, which entails meeting the needs of the local community[217].

Regarding the funding of solar electrification strategies, the first thing to bear in mind is that rural communities already have a cheap alternative energy source which is biomass. Moreover, as this paper has demonstrated there is a strong correlation between rural communities and poverty. In this regard PV systems have a higher initial investment compared with traditional biomass, but over time they entail lower O&M costs than the traditional sources. Therefore, low-income rural communities first reaction is to avoid buying these expensive off-grid PV systems, although over the lifetime, they would pay off. These dilemma needs to be addressed by strategies through incorporating consumer credit finance affordable for users and information about the long term economical benefits of these technologies.
The case study analysis has shown that Malawi's Rural Electrification Fund is a good initiative to cover the government's cost of the implementation of technologies since the government could not afford to fund the strategy alone. The tax charged to the tariff paid by on-grid energy consumers and developing a standardised power purchase agreement with Concessionaires encourages private investment for the technologies. However, the financial needs of the communities were not addressed, as Malawi's strategy lacked incentives, such as operation and maintenance subsidies or the productive applications of PV to encourage income generating activities. Similarly, South Africa's highly subsidised approach did not stimulate the economy in rural areas nor include strategies for productive and income generation activities. Since users in this case tend to be poor and their economical development through energy access, falls outside the responsibilities of utilities. The institution responsible, in this case energy ministries, should address the cross-sectoral dimensions of the strategies and work in cooperation with education and economic and financial ministries and organisations active in small and medium-sized enterprises (from now on referred to as SMEs) development to work together in their electrification strategies. Namibia is a good example of the incorporation of cross-sectoral dimension with its focus on the electrification of public institutions and the productive applications of PV through the Energy shop's initiative.

Finally, we will assess the technological solutions given in the different electrification strategies. As mentioned before, the main learning from technology implementation is that investments could achieve greater development benefits, if they are not solely driven by numerical connection targets. Instead they should be integrated in more detailed cross-sectoral local development plans for income generating initiatives through electrification. Such income generating initiatives, have to be in place or have to be developed at the same time to implement the pro-poor energy programmes successfully. This creates a win-win situation as it will secure the affordability and refund of the capital costs of the rural electrification programmes. If we combine it with an institutional decentralised approach, where local

[217] Ibid, p.13

councils, municipalities or power hubs of rural communities are responsible for local energy monitoring, local entities must also focus on facilitating enterprise development.

As seen with the Malawi case study, it is very important to encourage manufacturing capabilities for the local medium and small enterprises which provide services including electrical, electronic and general repairs as they should be the ones providing the solar power systems technologies in the future. This in turn will impulse growth in the energy sector and improve development in the community. Namibia's energy shop initiative allows for reliability of the programme in rural areas, as it is able to meet demands for the availability of spare parts, as well as user know-how to understand the functionalities, use the systems appropriately and exert simple maintenance. Moreover, the overall analysis on rural electrification shows that once population gains access to electricity demand goes up and the variety of end uses for electric machinery increases. As seen in the case of South Africa, customers are willing to upgrade to larger systems. Since solar PV systems are modular, they allow for adaptability and to be upgraded into higher systems. However once users have gained access if they want to upgrade to more powerful PV systems, they will need to have the economical means and the technologies available. This goes to show the importance of the incorporation of economical development strategies and local participation in manufacturing for the sustainability of the rural solar electrification strategies.

4. FINAL CONCLUSIONS AND RECOMMENDED ACTIONS

This final chapter's purpose is to bring back the spotlight to this paper's focal point, namely the SADC. Since this paper intends to demonstrate the institutions fundamental role in the application of sustainable strategies for the energy access of rural communities of the region. It will start with an analysis of what has been done regarding the incorporation of RE in energy systems in the IC, specifically in the EU as it is considered the best international model of a regional integration community. Moreover, the following section will offer two fundamental recommendations considered the most important learnings obtained out of this paper's analysis. Finally the last section will offer the conclusions deduced from what has been developed in the previous chapters in order to organise and highlight the main ideas developed.

4.1. Lessons to be learned of the International Community

There are many international and regional initiatives which seek for the delivery of affordable, environmentally friendly technologies to tackle the energy access dilemma of the SADC region. Mostly they tend to be international organisations with funding capabilities and some kind of motivation for the sustainable socio-economic development initiatives, the USAID Southern Africa Energy Programme, the World Bank's Lighting Africa initiative and the United Nations with its SE4All, are some examples. Nevertheless, as the EU has the greatest level of regional integration it disposes of strong mechanisms to effectively implement their regional initiatives. It is for this reason that this paper will analyse the EU's efforts on the promotion of RES in order to learn from its successes and a possible application in the SADC.

4.1.1. The EU's mechanism to achieve its common objectives

The EU Directive 2009/72/EC, proves a normative advancement for the alleviation of energy poverty and access to energy. In its Article 3.7, it derives the obligation to all EU members to "ensure that there are adequate safeguards to protect vulnerable customers"[218]. The concept of vulnerable customers is described as "referring to energy poverty and, inter alia, to the prohibition of disconnection of electricity to such customers in critical times"[219]. Moreover, this article also places the obligation to "take measures to protect final customers in remote areas", this includes those not connected to the national grid, thereby setting an obligation to provide energy to all potential costumers. Additionally, Article 23 of the directive, favours the promotion of renewables as the solution to the energy access deficit by stating that MS "may require the distribution system operator, when dispatching generating installations, to give priority to generating installations using renewable energy sources or waste or producing combined heat and power"[220]. Moreover, the promotion of renewables in the energy power sector of all EU MS has been reinforced by the Directives 2009/28/EC[221] and 2018/2001/EC[222]. Both of them have been progressively pushing for an ambitious mandatory target which currently establishes to increase the share of RES at least 32% of the overall EU energy mix.

The EU directive constitutes a legal act of the EU institution which requires MS to achieve a particular result without dictating the specific means of achieving that result. Since directives imply collaboration of MS they normally leave member states with a certain amount of freedom as to the exact internal rules to be adopted. Directives differ from EU regulations, since the latter are self-executing and do not require any implementing measures by MS. The creation of the directives text is prepared by the EU Commission after consultation with its own and national experts. The draft is then presented to the EU Parliament and the EU Council composed of relevant ministers, for evaluation and its posterior approval or rejection. Once approved, directives are binding only on the MS whom they are addressed, which can be just one or a group, but most of the times directives tend to be addressed to all MS. The EU success in their level of integration resides in its regulation transposition process, by which MS give force to a directive by passing appropriate implementation measures into their internal domestic law. Moreover, the European Commission carefully monitors that transposition has been appropriately done, in timely manner and correctly implemented in order to achieve the expected results. If a MS fails to fulfil its obligations, the Commission may deliver a reasoned opinion after giving the State concerned an opportunity to submit its observations[223]. If the MS still fails to appropriately

[218] Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC (OJ L 211, 14.8.2009), Art 3.7.

[219] Idem

[220] Ibid, Art 23

[221] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (OJ L 140, 5.6.2009), paragraph 15 recital.

[222] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (OJ L 328, 21.12.2018), paragraph 8 recital.

[223] EUROPA GLOSSARY. *Monitoring the application of Community law.* [online] EU Web Archive, 2018 [Accessed 10 April 2019] Available at: <https://web.archive.org/web/20090116092651/http://europa.eu/scadplus/glossary/community_law_application_en.htm>

implement the directive, even when the MS has transposed a directive in theory but has failed to fulfil its provisions in practice, the Commission may bring the case to the European Court of Justice. Moreover, anyone (i.e. individuals or enterprises) may put forward a complaint with the Commission against a Member State to the European Court of Justice. Finally, each yer the Commission published a report exposing how EU law has been transposed, including infringements and statistics about the achievements.

Although SADC has already implemented a multitude of mechanisms to work in cooperation towards rural energy access and the promotion of RES, as seen in the second chapter of this paper with SADC's various plans and programmes (i.e. RIDSP, REASAP, RIDMP, REEESAP). The only energy specific mechanism with legal binding effect is the SADC Protocol on Energy of 1996. However more than two decades have passed since its creation and thus it cannot incorporate all of the current challenges. Alternatively, in order to be up to date with the current challenges SADC develops its Common Agenda, and the RIDSP and RIDMP, but they constitute soft-law mechanisms and there is no clear transposition mechanisms. As explained in the second chapter of this paper, SADC'S 2012 RIDMP, also sets a target for 2030, to increase the share of RE in the common grid to 39% and to reach an off-grid share of 7.5%[224]. Compared with EU directives, SADC also demonstrates its will to aim for an ambitious target and this must be highlighted. However, as seen throughout this paper's analysis since each state applies different strategies for the implementation of RES promotion and electrification strategies, it results in uneven implementation efforts and achievements.

To use directive-type of mechanism can prove to be a really helpful mechanism for the energy access strategies of the SADC region. This is because the issue of energy access requires a lot of monitoring and involves different dimensions which are subject to constantly change, such as the advancements in RE technologies or the different scopes of electrification of each SADC MS. Directives offer a mechanism where the Commission in charge of creating the directive, has to dialogue with the different national experts in order to come up with a text which includes the different dimensions of each issue, which in this case becomes very relevant. Additionally, directives are not direct regulation as they also allow for some freedom for MS to implement it the best way they can, therefore recognising the MS different levels of economic development and capabilities. Nevertheless, the directives transposition process assure that the objectives will be met by creating domestic obligations. Moreover, the evolutive nature of directives allows for continuous and accurate obligations, since different objectives and dimensions can be incorporated with a new directive, which would then amend and subsequently repeal the previous directives on the same issue. This was the case in the EU with its latest 2018/2001/EC directive which increased the percentage of RE share in the EU energy mix from 20% in the 2009 directive to 32% in 2018. The monitoring aspect of directives is a great advantage as it grants the power to sanction against the non-compliance but it also allows the institution to get an accurate view of the challenges that the different MS can encounter. This in turn is what allows them to set realistic objectives.

[224] SADC. Regional Infrastructure Development Master Plan: Energy Sector. Prepared by Dr Peter P. Zhou in Gaborne, Botswana, 2012 p.34

Finally, SADC already has the infrastructural and legal basis for the incorporation of this type of mechanisms. The equivalent body to the EU Commission in the SADC institution, would be the SADC's Standing Committee of Senior Officials which is the technical advisory committee whose mandate, among others, is to review, and create documents for the SADC Council of Ministers. The directive's draft would then have to be presented to the Council of Ministers and the Summit of Heads of State or Government, for evaluation and approval or rejection. The approval of this directive-type of mechanism would have to be done by the Summit which follows the consensus principle. Moreover, SADC's Tribunal and Summit also have competence to sanction states which fail to fulfil SADC's obligations. By incorporating the directive-type of mechanism, SADC could give stronger force to its targets and incorporate a common monitoring and sanctioning mechanisms in order to better achieve its objectives.

4.2. Recommended initiatives

1. **Energy access cannot be just a primarily responsibility of each SADC Member State, but must be a common SADC responsibility.** This is because as an institution whose main aim is the development of the community of states, the fact that less than half of the community's population has access to modern energy sources must be a common concern. As seen with the successful EU directive model, SADC should aim to have common energy access directive-type of mechanism with binding force in order to fully address this issue.

2. This directive-type mechanism for SADC's energy strategy, will have to incorporate the findings on the third chapter of this paper in order to achieve a sustainable electrification solution for rural communities. Furthermore, this paper finds that the most important guideline for SADC's energy access policies is acknowledging that as a strategy which seeks to benefit the poor it cannot just be restricted to electrification. As proven in this analysis, energy access is inseparable to socio-economic development, with development being a condition of access. Energy access does not only improve development, as once users gain access to energy, they always continuously increase their demand and multiply the different end-uses. This implies that users' socio-economic development must continue rising to sustain their demand and in turn, this has inherent economic benefits for their surrounding community as their energetic end-uses multiply. However, if there is no access to markets people find it hard to generate income to pay for their electricity service.

3. After this papers' analysis, the best approach would be a SADC common directive, where the energy access target is pursued by encouraging the involvement of the rural communities in a way to allow for their socio-economic development. The uptake of this binding common norm, is possible and according to SADC's Constitutive Treaty would have to be approved by the Summit, as it is the highest decision-making body. Moreover, it's approval would not pose a juridical problem as energy access, social and human development and poverty alleviation are all included in all the constitutive legal frameworks with binding legal force and already ratified by all members (SADC Constitutive Treaty and the 1996 Protocol on Energy). The analysis has also shown that

MS have considerable capacity disparities, however, the norm should aim to balance out these disparates, and in doing so it should also aim to harmonise all the different strategies MS have implemented so far. Examples of the common obligations in this directive model could be to include local economic development within energy access solutions, inspired by Namibia's example of energy shops which also includes for the productive application of RE technologies.

4. **Promote environmental protection through RES as to make up for the regions energy security concerns.** As seen throughout this paper there is strong market potential for RES, specially regarding solar energy as its a vast source throughout the whole territory. Still, the region remains extremely dependent on fossil fuels, and less than 1% of SADC's solar potential is currently being used. MS reliance on fossil fuels in most cases is not only for their own energy supply but since most MS are rich in natural mineral resources they also export these commodities. As a result, the state's minerals completely drive the economy making these MS extremely sensitive to global commodity prices. This poses a problem as dependence on global commodities for developing countries constrains their socio-economic development. Therefore there is a need for SADC MS to boost efforts to diversify their economies. In this sense, SADC's efforts towards improving energy access and security first started with SAPP and have been followed by several strategic plans such as the 2012 RIDMP and the 2017 REEESAP. SAPP is the most substantial initiative, however, it is essentially based on two energy sources this being coal and hydropower. This should be also be matter of common concern for SADC since both sources are highly dependent on water in a dry region with recurrent droughts. Moreover, coal cannot be considered a profitable source to supply energy security and access, since it has serious environmental and economic constraints. As mentioned in the analysis, SAPP's purpose is tackling energy security and energy access concerns of the region through expanded interconnections and transmission capacity. However, the reality is that the dominance of coal and hydropower together with South Africa's dominance on energy contributions to the common grid, pose serious challenges to truly achieve SAPP's mission. Therefore, there is a strong need for balancing the energy mix across the region. In order to do so, SADC should aim to work in accordance with the 2030 SDG, the 2063 African Agenda, the Paris Conference and the SE4All policies by encouraging energy access and security with environmentally respective energy sources through the promotion of RE. Within these RES the global trend demonstrates that wind and solar continue to be the most cost-effective technologies with further improvements assured for the future. This occurs within a global context in which institutions like the United Nations and World Bank are ambitiously trying to ensure universal access to energy by 2030, through a myriad of on and off-grid interventions and investment[225].

5. Having said that it therefore makes sense for the SADC region to invest specially in solar energy since the region benefits to one of the best solar irradiation in the world. Therefore, in the same way as the EU has done in its Directive 2018/200, the SADC should also incorporate a directive-type of mechanism to ensure the increasing role of

[225] SHANIL SAMARAKOON. *Energy Justice In Malawi - The Case Of Solar Household Systems.* [online] Blog post of February 5, 2019 [Accessed 20 March 2019] Available at: <https://www.shanilsamarakoon.com/blogposts/2019/2/5/energy-justice-in-malawi-the-case-of-solar-household-systems>

renewables. The Directive should aim at increasing the share of RE in each MS energy system but also in the SAPP common grid. The benefits of this directive would be that MS that for example have major solar potential like Malawi, Zambia and the DRC but still choose to rely mainly on fossil fuels would be obliged to invest in RE. The directive can also include cooperation mechanisms for SAPP, aiming to incorporate the three MS still not part of the common grid (Angola, Malawi and Tanzania) and statistical transfers of renewable energy between MS (as an incentive to exceed their targets).

4.3. Concluding remarks

Altogether, this thesis aims to highlight the important role of the intergovernmental regional institution of the SADC, in harnessing RES for the sustainable rural electrification of remote rural communities of the region. Through the analysis of the legal framework commitments and mandates we have been able to observe that there exists a gap between SADC's targets and its realisation, as the case-studies intended to demonstrate. Therefore, this paper has the intention to help stakeholders related to this issue (i.e. SADC MS, IPP's and heads of rural communities) to identify and address one of the most severe challenges for the social-economic development of a significant portion of the population.

The efforts examined regarding rural electrification strategies demonstrate that ensuring sustainability of off-grid solutions, requires an integrated and multidimensional approach. It is this paper's position that the different dimensions required for the sustainability of off-grid solutions, the institutional, economic, environmental and socio-cultural, are certainly connected and are deeply interdependent. However, within these dimensions, the analysis has demonstrated the importance of paying special attention to the institutional dimension. This is because the institution responsible for energy access in each MS, has the mandate not only to set the regulatory framework but it also has to attribute the different degrees of power to the stakeholders involved, which will allow for different outcomes. Through the case study analysis we can observe that the national institutions regulatory framework, has respected and been written in accordance with SADC dispositions on this regard. In other words, normative transposition has not been a challenge. However, on the practical side, some institutions have preferred to apply different approaches, some gave higher importance to the state's role, others to private actors and in some cases the rural community also had an important role to play. The different approaches mainly depended on the economic development of the different MS, in the sense that Malawi as one of the world's poorest state is in disadvantage economically compared with South Africa. However, for example South Africa's decentralised approach together with its encouragement of IPP's through REIPPPP, created a type of strategy that could work and be beneficial if accordingly applied in Malawi. It is for this reason that this paper encourages a stronger role of the SADC institution in tackling the common problem of energy access, with bolder mechanisms such as the proposed directives in order to achieve a harmonised and powerful strategy. By making energy access and the promotion of RE a common SADC responsibility, the SADC institution would take a prominent role which would have enormous benefits towards achieving a more sustainable electrification strategy for rural communities. Moreover, in order for the strategy to give an accurate solution, this thesis has come up with the following essential conclusions:

I. Modern energy access is a critical foundation for economic development. It constitutes a key enabler for many social developments and outcomes. The current situation of most of the SADC population in rural areas is a limited use of modern energy services, coupled with their dependence on biomass and other solid fuels, which equates with poor health, gender inequality and environmental degradation and does not allow for their socio-economic development. Thus population in rural areas is not only poor in terms of energy but also socio-economically. Moreover, the regional energy access target has been reinforced by the UN SDGs. According to the UN, "Sustainable Development is not possible without sustainable energy, such that the issue has been prioritised by devoting a stand-alone SD goal (No. 7)"[226]

II. Political will is twofold, it can be both an incentive of energy strategies but also a constraint. This can be detrimental for energy access strategies because as White et al. explains, unexpected policy changes can have negative impacts on investments and cause uncertainty[227] . SADC's leading role to set the basis for regulation would decrease the politicisation of strategies. However, MS, IPP's and heads of rural communities would still have a role to play in the strategy. For this reason, is essential that they acknowledge the following notions. Although as this paper has shown, DREA are the most cost-effective, secure and reliable solution, strategies for electrification aimed at rural communities are usually unprofitable (due to high dispersion, low energy demand, difficult access, etc.)[228]. Moreover, since remote rural communities tend to be poor, government funding must be included in the strategy, however this does not imply that the users can meet the repayment rates. Due to the users poverty condition, off-grid electrification strategies will most likely require policy intervention, which means allocating public funds for covering both the initial investment and the O&M of the systems or subsidising private investment in rural electrification[229]. Meaningful improvements will require higher levels of financing and bolder policy commitments, specially regarding the promotion of RE as they still remain at a significant disadvantage with fossil fuels in terms of government subsidies[230] . This means that in order for an off-grid strategy to be successful it is essential to count on the political will of the institutions and the main stakeholders involved in order to promote investment encouragement.

III. Rural communities must be at the core of energy access strategies which should in turn contribute to their economic development. This means that the strategy besides supplying technologies it must also include the transfer of knowledge so that users themselves can carry out the O&M necessities and understand the long-term benefits of the DREA. The Namibian and South African strategies are both good examples of how the transfer of

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[226] SUSTAINABLE DEVELOPMENT GOALS. *Progress of Goal 7 in 2018.* [online] United Nations, 2018 [Accessed 20 March 2019] Available at: <https://sustainabledevelopment.un.org/sdg7>

[227] WHITE,W., LUNNAN, A., NYBAKK, E. and KULISIC, B. The role of governments in renewable energy: The importance of policy consistency. Biomass Bioenergy., 2013, Issue 57, p. 97

[228] FERON, S,. Rural Electrification Efforts Based on Off-Grid Photovoltaic Systems in the Andean Region: Comparative Assessment of Their Sustainability. *Sustainability*, vol. 8, 2016, issue 12, p.9

[229] Ibid, p.11

[230] SADC. Renewable Energy and Energy Efficiency Strategy & Action Plan - REEESAP 2016-2030. *SADC Secretariat,* Gaborne, 2016, p.21

information can be done. This paper argues that stand-alone solar powered systems are the best technological solution in the case of remote rural areas. Nevertheless, the supply of this technologies must include a productive application in order to allow for income-generating activities and contribute to the socio-economic development of its users. In this case Namibia is a better example than South Africa regarding productive applications.

IV. Electrification strategies must incorporate environmental awareness. Bearing in mind the relevance of climate variability in the SADC region, giving energy access to the population can also contribute to resilience building strategies to climate related risks. Moreover, since the power sector is the highest contributor to global GHGs emissions and the current off-grid energy alternatives, namely biomass, have enormous negative impacts for health, deforestation and also GHG emission. Off-grid electrification strategies offer an opportunity to give electricity to a really big portion of SADC's population in a cleaner way. It is for this reason that this paper argues that RES, specially solar power, does not only allow for energy access in remote areas but also improves energy security. In Ms Sara Feron's words, due to their relatively low environmental impact, PV technologies for rural electrification yield long-term benefits in terms of pollution abatement and climate change mitigation[231]. Finally, in order to truly achieve environmental protection and awareness, institutions mush push for the education of civil society's awareness of environmental issues, as their support is essential to achieve these objectives.

[231] FERON, S., op. cit., footnote 228.

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ANNEX

Figure 1[1] :

Primary sources of energy global evolution:

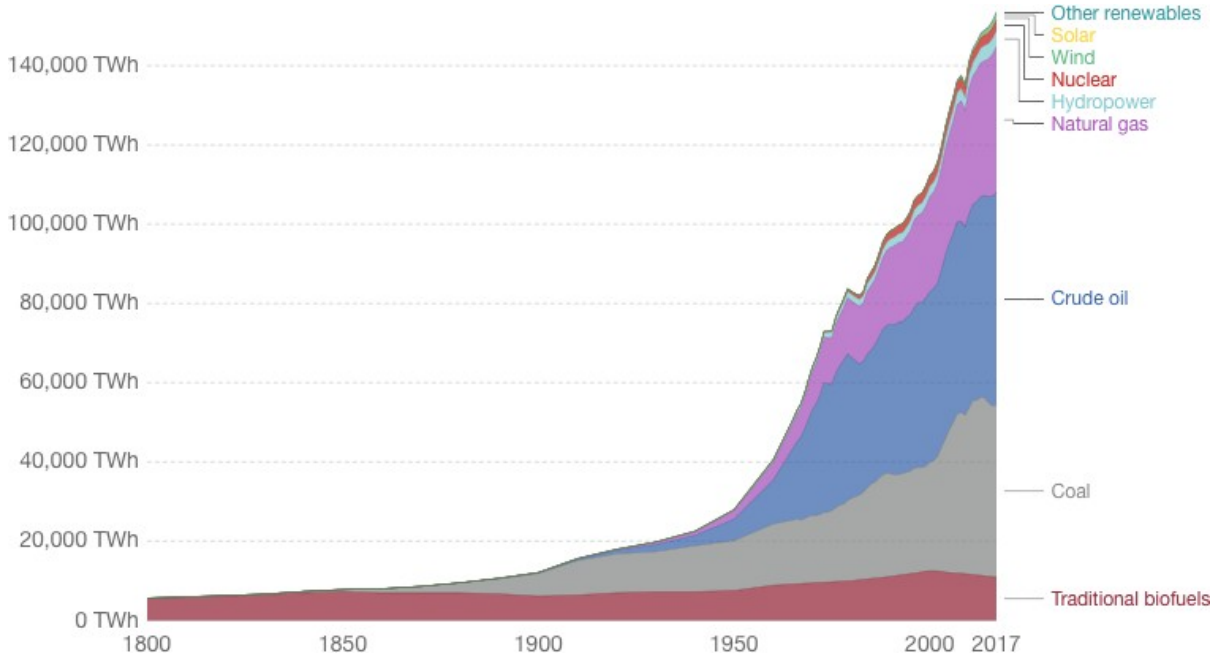

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Figure 2:

Objectives of Efficient Energy policies:

Driver	Typical objectives
Energy security	• Reduce imported energy • Reduce domestic demand to maximise exports • Increase reliability • Control growth in energy demand
Economic development and competitiveness	• Reduce energy intensity • Improve industrial competitiveness • Reduce production costs • More affordable energy customer costs
Climate change	• Contribute to global mitigation and adaptation efforts • Meet international obligations under the United Nations Framework Convention on Climate Change (UNFCCC) • Meet supra-national (*e.g.* European Union) accession requirements or directives
Public health	• Reduce indoor and local pollution

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[1] Data represents primary energy (rather than final energy) consumption. "Other renewables" represents all renewable sources minus solar, wind, and hydropower (i.e. geothermal, wave and tidal, and modern biofuels).

Figure 3:

The 2030 Agenda for Sustainable Development:

UN General Assembly, *Transforming our world : the 2030 Agenda for Sustainable Development*, 21 October 2015, A/RES/70/1

Figure 4:

Geographic overview of the SADC region:

REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p.22-23

Figure 5:

National Renewable Energy Targets of SADC governments of mid-2018:

Angola	Increase in renewable energy capacity of the following amounts by 2025: • Small hydro: 100 MW, with 60 MW for municipalities • Solar: 100 MW, with 10 MW off-grid • Wind: 100 MW • Biomass: 500 MW
Botswana	• 82% access to modern energy services by 2016; 100% access by 2030 • Capacity increases expected from REFIT programme (delayed) • 15% renewable share in final energy consumption by 2036, but may increase to 20% in 2017 Renewable Energy Strategy once approved.
DRC	60% overall energy access (not renewable-specific) by 2025 (up from 9%)
Eswatini	• 60 MW of intermittent resources such as solar PV by 2030 • 50% renewable share in energy consumption by 2030
Lesotho	Targets pending completion of Sustainable Energy Strategy 2018
Madagascar	85% renewable share in electricity generation by 2030
Malawi	By 2025/2030: • 30% access to electricity (up from 9%) • 100% use of efficient cook stoves in off-grid households • 6% renewable share in energy mix (up from 1%) • Biofuels mandate of 20% ethanol and 30% biodiesel
Mauritius	35% renewable share in electricity generation by 2025, including: • Bagasse: 17% • Wind: 8% • Waste-to-energy: 4% • Hydro: 2% • Solar: 2% • Geothermal: 2%
Mozambique	400 MW increase in installed renewable energy capacity by 2024, including: • Wind: 150 MW • Hydro: 100 MW large-scale, 100 MW small-scale • Solar: 30 MW • Biomass: 30 MW
Namibia	70% renewable share in electricity generation by 2030
Seychelles	5% renewable share in electricity generation by 2020; 20% by 2030
South Africa	• 21% renewable share in electricity generation by 2030 • 17.6 GW solar capacity, 37.4 GW wind capacity by 2050 (IRP 2016)
Tanzania	5% renewable share in electricity generation by 2030 (up from less than 1%)
Zambia	200 MW increase in renewable energy capacity by 2020
Zimbabwe	• 1,100 MW increase in renewable energy capacity by 2025; 2,100 MW increase by 2030 (16.5% increase overall) • 2,400 GWh increase in renewable energy generation by 2025; 4,600 GWh increase by 2030 (26.5% increase overall) • Note: targets are conditional on final approval by government.

REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p.78

Figure 6:

Extension of the national electric grids in the SADC Region:

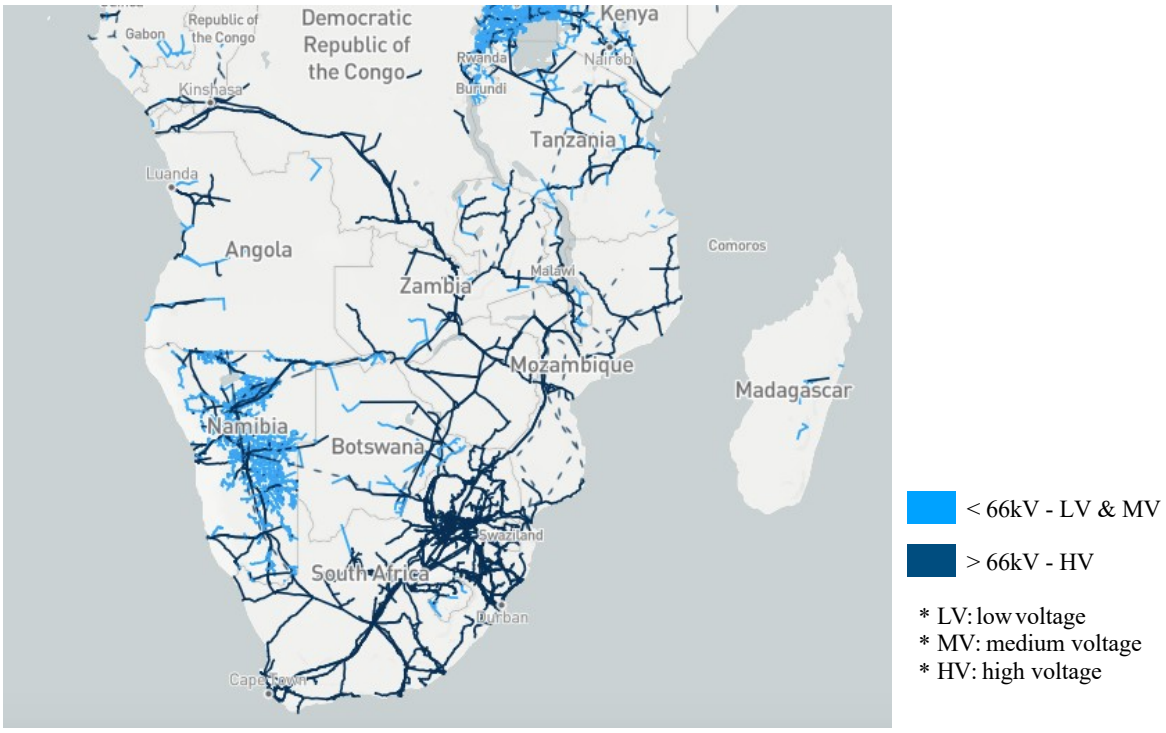

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Figure 7:

Extension of SAPP's common grid :

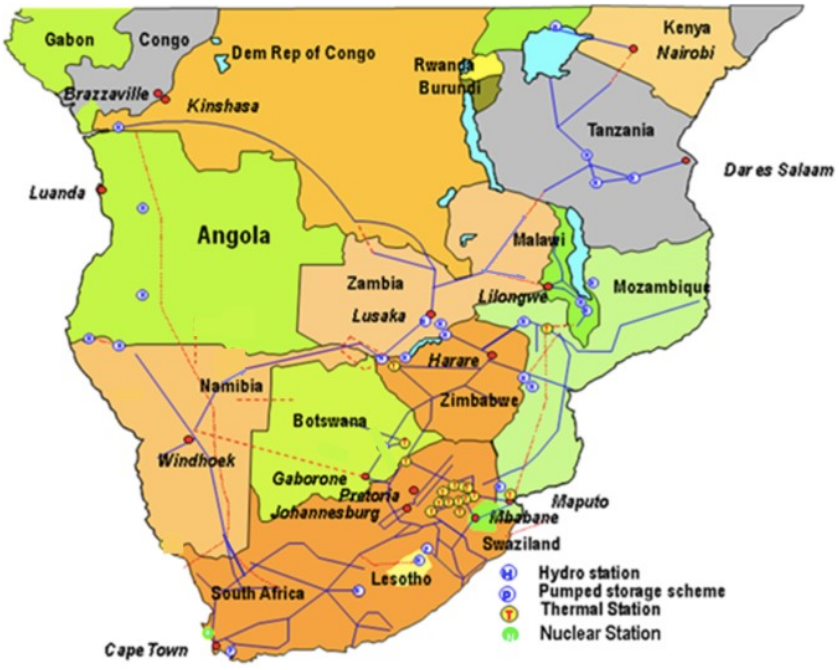

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Figure 8:

Electricity Access in SADC Member States, 2016, and Targets for Energy Access for 2020/2030:

	Energy/electricity access (%) 2016			People without access to electricity in 2016 (millions)	Energy access targets (%)
	Total	Urban	Rural		
Angola	41	69	16	17	100% electricity access by 2030
Botswana	61	78	37	1	100% electricity access by 2030
DRC	17	78	–	68	60% electricity access by 2025
Eswatini	66	83	61	<1	100% electricity access by 2030; 75% by 2018; 85% by 2020
Lesotho	34	66	16	1	40% electricity access by 2020
Madagascar	23	67	17	19	–
Malawi	11	42	4	16	30% electricity access by 2030
Mauritius	100	100	100	–	–
Mozambique	24	65	5	21	100% electricity access by 2030; 30% modern cooking fuels by 2030
Namibia	56	77	29	1	50% modern energy services by 2020; 100% electricity access by 2030
Seychelles	100	100	100	–	–
South Africa	86	93	68	8	100% electricity access by 2025[1]
Tanzania	33	65	17	36	75% electricity access by 2030
Zambia	31.4	67.3	4.4	11	66% electricity access by 2030
Zimbabwe	38	86	16	11	100% electricity access by 2030; 90% by 2030 (urban); 51% by 2030 (rural)
SADC	48	75	32	49	–

REN21. SADC Renewable Energy and Energy Efficiency Status Report. *REN21 Secretariat*, Paris, 2018, p. 5