The potentials of innovative solar initiatives - Combating energy poverty in Sub-Saharan Africa while considering ethical and sustainability challenges.

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ABSTRACT

Many regions in Sub-Saharan Africa face more challenges than ever due to the increasing shortage and demand for electricity. However, since the past decade, small-scale renewable energy options are on the rise which could be the solution to combat energy poverty in even the most rural regions. The biggest benefits are democratized access to electricity, the option for customers to build a credit history, and the possibility to get financial support (Kazeem, 2020). However, because of missing knowledge about the socioeconomic and political environment challenges arise that hinder the uptake of these energy innovations (Chaurey et al., 2012). Therefore, the following research question was investigated, *how can innovative digital and renewable energy initiatives reduce energy poverty in Sub-Saharan Africa while considering the ethical and sustainability tensions and tradeoffs?* To answer the research project a qualitative content analysis was conducted, exploring the following three angles: stakeholder dynamics, consumer communication, opportunities, and challenges, and lastly, solar business models and technology. For this reason, a content analysis was carried out analyzing 18 chosen documents of the following six different stakeholders, governments and UN systems, grid operators and social entrepreneurs, ICT companies, non-profit organizations and ThinkTanks, press and newspapers, and lastly aid agencies and foundations. The findings show that there is a great potential and several benefits these small-scale renewable energy options offer, like for example an affordable, safe, and reliable energy access, mentorship, and training programs, the option to develop a credit history for low-income users, and new partnership possibilities that allow stakeholders to benefit from each other's knowledge. However, to allow these advantages to create a long-term development that considers ethical and sustainable aspects like equal energy rights and fair distribution, and procedural justice, certain challenges need to be worked on. Firstly, the findings showed that there is a need to revise the concept of "universal electricity access" since some stakeholders actually exclude part of the population with this concept definition. Furthermore, there is a need for strengthening and deepening partnerships and making information about the market more easily available. Additionally, key players need to address the missing digital literary of consumers as well as raising awareness about which energy technologies are available and affordable for them. Lastly, to ensure consumer trust and transparency, data practices of platforms need to be communicated clearly to users, and policymakers need to establish privacy policies to protect consumers.

KEYWORDS: *Energy poverty, innovative & renewable energy solutions, Sub-Saharan Africa, Business models, Public-private partnerships*

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1. Introduction

In 2019, it is estimated that almost 770 million people in the world lived without electricity or unreliable and unstable power networks (IEA, 2020). Many regions in Sub-Saharan Africa face more challenges than ever due to the increasing shortage and demand for electricity. Moreover, with the pandemic, prior signs of progress in combating energy poverty might be reversed and studies show that it will impact future electricity efforts (IEA, 2020). Since the last decade, small-scale renewable energy options were developed to solve this issue. For example, off-grid solar energy systems combined with pay-as-you-go mobile-driven offerings enable low-income customers through affordable or follow-up micropayments to get solar panels that can be connected to a platform to manage electricity and payments. The biggest benefits are democratized access to electricity, the option for customers to build a credit history, and the possibility to get financial support (Kazeem, 2020). Furthermore, these platforms enable companies to monitor energy consumption and distribution (Jamasb et al., 2018). The platforms can also generate significant network effects between the different stakeholders and enable them to connect and collaborate (Slavova & Constantinides, 2017). The mobile applications allow providers to record energy flows and manage exchange connections. With the increasing popularity of smart technologies, companies are able to collect vast amounts of personal and transactional data that can be processed and analyzed by Artificial Intelligence procedures (Allam & Dhunny, 2019). This in turn can help create financial access since banks and other financial institutions in Sub-Saharan Africa often require credit histories and certificates of land ownership which hinders poor households to get the chance of being connected to the electricity grid (Butu et al., 2021). The rise of renewable energy technologies is furthermore influenced by the FinTech (financial technologies) sector. Partnerships between the different sectors can help to provide those who need financial support the most with the means and help to get electricity (Akinola, 2020).

But while these innovative models are on the rise, many projects fail because of lacking knowledge about the socioeconomic and political environment (Chaurey et al., 2012). Companies' ideas which were too techno-centric, and solutionism oriented led to failure as these ambitious and philanthropic plans are often too disconnected from reality (Van der Panne, Van Beers, & Kleinknecht, 2003). Additionally, bundling several services from various stakeholders (energy suppliers, financial institutions, etc.) on one platform also creates new risks regarding policies, data collection, and more. Since there is very limited research about these innovations and developments it is important to investigate their risks and challenges. Two other aspects that need to be addressed in this context are platform capitalism, which is the political and economic power of platforms, driven by their digital infrastructure (Srnicek, 2017), and platformization, which is the increasing implementation of applications in several spheres of life (Poell et al., 2019, p.5f.).

Therefore, the following research question is asked to guide this thesis namely, how can innovative digital and renewable energy initiatives reduce energy poverty in Sub-Saharan Africa while considering the ethical and sustainability tensions and tradeoffs?

The following chapter, the literature review, will give an overview of the current Sub-Saharan African situation concerning energy access and pay-as-you-go (PAYG) solar projects, followed by which challenges and tensions arise between key stakeholders and because of technologies. Three main angles will be addressed, starting with stakeholder dynamics.

The first angle addresses stakeholder dynamics and partnerships that are vital for the successful implementation of renewable energy initiatives. The mobile applications allow the providers to record energy flows and manage exchange connections. Within this section, issues in connection to data management and power dynamics between the different stakeholders will be addressed. As mentioned before, without the necessary data policies, questions about who gets to manage the data are essential. Therefore, questions regarding who the stakeholders are and in what kind of power relation they stand to each other are crucial. Findings show that without clarity about who gets to manage the highly sensitive information of users, cases of inequality and disruption of the specific market can emerge. On the other hand, mapping out the stakeholder network is important as it helps to understand how the diverse actors can work together in order to create a networking effect for everyone involved (Pradhan & Agwa-Ejon, 2018). Moreover, the stakeholder dynamics are insofar important as they influence the social acceptance of the renewable energy devices. However, not only customers who tend to base their decision on if they can trust the company, but also investors play a crucial role in this research angle and these, in turn, are connected to other stakeholders, like NGOs, local organizations, and communities who have a say in whether or not a smart technology is successful (Wüstenhagen et al., 2007). Findings show that the focus of renewable energy innovations should not only be based on technological aspects but should also focus on the human dimensions. This is important since a focus and understanding of the people involved helps technologies to ensure a sustainable development and safety (Allam & Dhunny, 2019). In order to investigate this angle, the following sub-question is asked, *who are the stakeholders involved in the new smart renewable initiatives deployed in Sub-Saharan Africa, what are the common grounds as well as tensions involved in such partnerships? Furthermore, who manages the data security and privacy governance and what does this vast data collection/storage mean for end-users as highly sensitive data is required to use the devices?*

The second angle is connected to the previous as it looks in depth at the target audience and how the renewable energy initiatives are marketed to them. Findings from Western countries show that the social acceptance of these technologies is a complex issue. On the one hand, people appreciate the new developments and value innovation that contribute to an eco-friendlier energy production. Research also revealed in European countries that people have mainly positive associations when thinking about solar energy. However, policymakers, companies, and project managers are on the other hand confronted with a completely different reality since many people reject the smart technologies. Social acceptance is crucial for a successful change to renewable electricity production, but local communities pose a threat because they are opposed to broad and large-scale solar panel installations. Furthermore, findings show that energy-related debates about electricity infrastructures are mostly emotionally driven and local residence often hold misguided opinions about technologies that hinder their success (Sütterlin & Siegrist, 2017). These findings might be an indicator of a lack of communication between the energy projects and the residents. One main obstacle is that oftentimes people are skeptical about innovations because project managers are, as mentioned before, too techno-centric, and do not address the residents' fears. Concerns about the smart technologies, how they operate, where the users' data is stored, and by whom, as well as how they can finance these renewable technologies need to be communicated (Potdar, et al., 2018). The second sub-question which will investigate this research angle is, *who is the target audience and how are these initiatives designed to incentivize these users to adopt their products?*

Several spheres of everyday life are now mediated by platforms, like doctor-patient relationships, financial interactions, and even smart home monitoring. Hence, several new challenges emerge that might risk the users' privacy and safety (Srnicek, 2017). The health sector for example got revolutionized by wearable sensors, affordable at low cost. But with this innovation, incidents where smart hospitals and other private health companies exploited the users' data to create profit emerged. While it is essential for a sustainable market development to generate profit, these incidents pose a risk. Although these companies claim that they are beneficial for the larger society, risks like those that violate patients' privacy and personal safety are highly problematic (Srnicek, 2017). What is missing in the case of smart technologies in this regard are data policies and regulations that contribute to a long-term and sustainable smart technology development. Another challenge that comes with data management concerns is that users have no possibility for administrative actions. They cannot control how much, which, and where their data gets shared and spread. This in turn might influence the users' trust in these technologies (Hassan, et al., 2019). Lastly, the platforms' algorithms are insofar problematic as they are not objective. Depending on how they are programmed, they might create a version of what it means to be for example a "good" farmer or application user in general which can lead to discrimination of those who have a different user behavior on the platform and some publics might not even be adequately addressed from the start (Rose & Chilvers, 2018). To investigate the research angle related to PAYG solar companies and the renewable energy technologies, the following and third sub-question will be researched, *how do PAYG solar business models function, what opportunities do they offer, and which privacy challenges arise?*

The methodology chapter will then provide an overview of the data collection and themes that will be used to analyze the chosen companies. In more detail, key themes of the three angels will be looked at concerning common and reoccurring notions, challenges, tensions, etc. Furthermore, they will be organized and mapped out depending on if and how the cases intersect, and if they have major differences or commonalities. The literature that will be used for the content analysis themes was published within the last five years apart from some exceptions that offer relevant findings which are important for the analysis (Wolsink, 2014; Renaud & Van Biljon, 2008; Painuly, 2001). After the methodology section, the results will be presented. Lastly, the discussion followed by the conclusion chapter will give a deeper insight into the meanings, significance, and relevance of the results, what the findings convey, and which limitations and future research opportunities were found.

2. Literature Review

Starting with an overview of the current situation of energy poverty in Africa, the literature review will first discuss the current situation of electricity access in Africa. This section will furthermore explain how different households depending on their family, economic, and geographical region experience electricity access, and what challenges they encounter with traditional on-grid energy providers. Afterward, the first angle of the research, stakeholder identification and which common grounds and tensions of their partnerships are prevalent, will be discussed. Because renewable energy technologies have a multifold stakeholder network, it can influence how the business models of the smart devices are designed and how ethical considerations play a role in this process. Furthermore, the question about who gets to save, store and control user data might also be a challenge and therefore this section will map out all important actors in three main categories, socio-political actors, communications, and community acceptance, and thirdly, market acceptance. The second research angle that the literature review will discuss are the target group characteristics and challenges specifically in the Sub-Saharan African context. Energy projects can fail due to little knowledge about the customers and what their needs are regarding for example financing and platform design. Moreover, this section will consider how innovative renewable energy initiatives are marketed and how stakeholders communicate with their users. Lastly, the third angle, common data, and privacy risks and challenges of smart technologies, will be introduced. This includes how algorithms and new smart devices mediate the everyday life of users and how this impacts not only their security and privacy but also how the technologies interrupt the current electricity market in some Sub-Saharan African countries.

2.1 Energy Poverty in Africa

Few studies have focused on energy poverty of the electricity sector in Sub-Saharan Africa (Kojima et al., 2016; Ye, Koch, & Zhang, 2018). They found out that about one-third of all households between 2008-2016 in 22 Sub-Saharan African countries used electricity at least in some way. Unfortunately, most of the consumers lived in an urban area and were from one of the wealthier regions, suggesting that one of the biggest barriers in this regard is affordability. Especially grid electricity, which is power generated by production stations and electrical substations that further deliver energy from producers to consumers, often does not even reach poor households at the most subsistence level (Ye, Koch, & Zhang, 2018). They are also mostly under-developed electricity systems and have poor power performance which can cause several blackouts throughout the day (Ouedraogo, 2017). Another finding showed that the situation is even worse for female-headed households which are more disadvantaged when poor. Furthermore, the researchers found out that the energy use for cooking was another major indicator for the increased electricity use and power outages as the electricity consumption increased from 57.9% to 73.1% between 2002 and 2011 in South Africa which might be part of meal preparation technology developments. This country experienced an electricity crisis because of this higher demand, but besides several efforts to overcome barriers that constitute the main issues in this regard, not a lot has happened since and energy scarcity is still a problem (Ye, Koch, & Zhang, 2018).

Another issue is that there are fewer investments in renewable energy initiatives in Sub-Sharan Africa compared to other developing countries because of the lack of regulatory frameworks, experience, and governmental divisions (Jamasb, 2006). The Collaborating Centre for Climate & Sustainable Energy Finance of the Frankfurt School published a 2020 energy investment report that revealed that global investments in renewable energy capacities decreased 10% in 2019 compared to 2017. Although solar energy is one sector with the highest investments, it also experiences reduced investments of 3%. During the last decade, China holds the record for the most funding of solar power with a total of $818 billion followed by Europe with investments of $719.4 billion. In comparison, financial funding of solar renewables in South Africa during this time period was only $20.1 billion and from 2018 to 2019 the investments fell by about 76%. One reason the report mentions for decreasing and lower investments in the African region are political and economic concerns (Frankfurt School-UNEP Centre/BNEF, 2020). Painuly (2001) discovered that this issue could be overcome by discussing barriers to find solutions with policymakers. However, Painuly's findings also indicated that some of the major obstacles are social, cultural, and behavioral. The lack of consumer acceptance stems from little knowledge about how to use the platform, cultural characteristics, as well as missing attractiveness and incentives to promote user interests. But most importantly, the new renewable technology is oftentimes seen as something with no use and foreign which causes a higher preference for traditional energy providers. Besides all of these issues, renewable energy innovations are a promising pathway to combat energy poverty in Sub-Saharan Africa. Especially their nature of a more decentralized energy generation away from the public electricity providers could help to empower poorer households (Ikejemba et al., 2016).

2.2 Stakeholder identification and common grounds & tensions of partnerships

Although RETs are usually still small-scale initiatives and not fully expanded and available for the general public, it is important to consider the different relationships between the stakeholders, what tensions, and tradeoffs these partnerships have, and who gets to manage the data. This can be of utmost importance since many of these projects tend to fail because of unfair processes, a lack of trust, or missing approval and incentives for investors to support possibly helpful RETs. Because the smart grids are controlled and monitored by employing ICTs, they authorize energy companies and all other third-party stakeholders that are involved, access to user data, therefore it is highly important to map out all stakeholders involved and their relationships to each other (Aloul et al., 2012). For a renewable energy initiative to be successful it needs acceptance of all stakeholders. However, because there are multifold relationships amongst affected parties in Sub-Saharan Africa when it comes to energy developments, it is often not entirely clear who is involved and what gets managed by whom (Wüstenhagen, et al., 2007). Lastly, it is important to investigate these partnerships since the stakeholder dynamics that have not been prevalent in any other country on this vast scale before, get now "tested" in Sub-Saharan Africa. Once a country has invested and established an energy network, it is unlikely and difficult to change these structures. This can be seen in Europe and the United States where governments and private sector companies have long-established, almost static, relationships and ways of doing things. Because many regions in Africa are still not connected to the grid or cannot even afford it, these countries pose the opportunity to leapfrog developments of a traditional energy system to innovative and renewable energy technologies (Cilliers, 2021).

According to Wüstenhagen, Wolsink, and Bürer (2007), there are three dimensions of stakeholders of renewable energy initiatives acceptance that are used by other scholars to discuss the implementation and success or failure of RETs (Nkoana, 2018; Allam & Dhunny, 2019).

2.2.1 Socio-political actors

The first encompasses the socio-political actors which are the broadest and most general dimension including traditional energy companies, local authorities, governments, and policymakers (Wüstenhagen, et al., 2007). Additionally, aid agencies like the USAID, or the International Renewable Energy Agency (IRENA), as well as telecommunication companies are also highly important since they are deeply involved in the planning and financial phase of renewable energy projects (Khatri-Chhetri, 2019).

Right from the start during the planning phase of renewable energy projects, aid agencies are involved. The USAID for example has furthermore a partnership with the National Renewable Energy Laboratory (NREL). Together they help countries to plan and finally deploy smart grid projects (USAID, 2020). However, the effectiveness of aid agencies is a long-debated issue and there is a general agreement in research that these institutions should be a lot improved. Chronic problems are for example the missing technical assistance since participants of projects are often left with a lack of knowledge on how to maintain the technology or there is no support in the first place because of poor coordination of who is responsible to help. Other issues are that more aid should go to the poorest countries first and that there should be a better selection process on who receives the aid in the first place (Easterly, 2007).

When looking at traditional energy providers, Photo Voltaic (PV) systems in South Africa often fail because one of the major issues regarding the implementation of solar panels is the state-owned energy provider Eskom. The political and technological resistance of the company which is linked to nuclear and vested coal plans hindered several solar projects and initiatives (Kirshner et al., 2019, p. 122). The stakeholder dynamic and relationship between state actors and private investors as well as developers of renewable energy initiatives play a central role and decide how priorities are shaped and determined (Kirshner et al., 2019).

Common tensions that these actors experience with RET companies are missing legislative frameworks that could support and encourage the adoption of renewable energy initiatives, as well as financial mechanisms that could help them to bring electricity to low-income households. Questions about surveillance and data collection need to be considered in governmental support schemes and policies. If these issues would be solved, the RETs' competitiveness with traditional energy competitors would be enhanced, and legislations would support rather than discourage the implementation of these technologies. Moreover, collaborations between different stakeholders could be encouraged which in the long run might result in stronger financial institutions that can help those consumers who need it the most, and the energy infrastructure, in general, would benefit (Shakeel et al., 2017). Telecommunication companies play an important role to offer affordable smart energy devices. Since smart girds are built on the principle of Information and

Communication Technologies, like the pay-as-you-go payment scheme, expansion to telecommunication services is highly beneficial. Specific financial needs of poorer households can be met through mobile device payments which would further lower administrative costs of billing and meter reading (Welsch & Bazilia, 2011).

Chaurey, Krithika, Palit, Rakesh, and Sovacool (2012) found out that Public-private-partnerships (PPPs) are one of the best mechanisms to overcome financial issues and infrastructure problems that could improve access in rural areas. Nevertheless, it is important to mention that the premise of this opportunity is that the goal to support low-income households needs to be prioritized and specifically planned into the project and afterward monitored. Because PPPs usually do not explicitly plan this part when designing a project and treat it as something that will happen automatically, resulting often in inaction and neglect of this demographic (Leigland, 2018).

Identified stakeholders that could contribute to this development are on the one hand from the public sphere like governments and state-owned enterprises and on the other, private sector entities that are local or international like businesses, investors, actors with financial expertise, or nongovernmental organizations (NGOs). Butu, Nsafon, Park, and Huh (2021) also discussed the problem of missing legislative frameworks and PPPs. Additionally, they also see commercial banks as a burden since these institutions have generally a relatively low willingness to fund RETs. This is partly due to difficulties with loan recovery, and a high cost of the initial investment. Another challenge is the governance and administration of land. Raising capital for example in Nigeria can be challenging because land is often the most accepted form of collateral if a household seeks credit. The problematic part is that owned land needs sufficient documentation, and most people in the regions who would like to receive financial support do not have any which means they cannot afford a renewable energy device (Butu et al., 2021). Two further challenges that governments, policymakers, and local authorities need to tackle are security and data privacy. Usually, big data management is not governed and there are no transparent regulations that indicate who gets to store and analyze which data. This is necessary since consumers are already alert about these issues, want to know what will happen with their sensitive information, and this, in turn, impacts the RETs' acceptance (Potdar, 2018).

2.2.2 Communications and Community acceptance

The second dimension of objections concerning renewable energy initiatives encompasses community acceptance. Stakeholders in this sphere are local community-based organizations (CBOs) that can be commonly found in Sub-Sahara Africa. CBOs are individuals who organize them into a group that has one shared goal, namely the purpose of helping poor individuals and households to aggregate much-needed capital for varying purposes. They have the advantage of profound knowledge of consumers in a specific region and can therefore represent and support prospective users of smart energy technologies (Butu et al., 2021). A study in this region about smart farming and CBOs found out that when financial technology companies cooperate with these Community Based Organizations, aggregating financial means is much easier. The companies can rely on the CBOs' information about the individuals and issues like load recovery and credit troubles can be avoided. CBOs also have different means. They are strongly connected to diaspora communities outside Africa and they often have Rotating and Accumulating Savings and Credit Associations (ROSCAs) that facilitate the process of generating financial means. The well-established communities also have a say in what technologies get installed and from what companies (Butu et al., 2021).

In addition to the local community support, mass media supports renewable energy technologies differently, namely, to popularize the products and communicate the innovative technologies to the citizens. A study by Shakeel et al. (2017) in Finland found out that RET companies need to make use of media's commercialization actions to promote their smart technologies because it is highly effective for raising public awareness (Shakeel et al., 2017). But mass media is not only important for the end-user communication, but also to target stakeholders that invest and plan the electricity future in Sub-Saharan Africa. BBC News recently published an article about how investment companies, foundations, and other actors like governments need to get together and change electricity development plans of Africa stated in a report by the International Energy Agency. According to them, fossil fuel plants are still in favor of many governments and without building awareness and shifting financing to renewable energy projects, it will be difficult to plan sustainable and affordable energy networks (McGrath, 2021). The New York Times also wrote about the recent global forecast which presented how many new fossil fuel projects are in planning. The article stated that governments and other institutions still place too much value on fossil fuels and that there is an urgent need for change, not only because of the climate change, but also for the development of the African economy (Sengupta, 2021). Other digital newspapers like Quartz, address a broader target group and generally stress the positive aspects smart meters have and how they can contribute to a sustainable future (Singh, 2019). On the other hand, mass media also discusses challenges of smart metering. The Guardian for example, reported that a supervisor of European Data Protection who functions as a privacy watchdog, warned of the smart devices' algorithms because they collect too much sensitive personal data without safeguards monitoring the process (Doward & Mortimer, 2018). Depending on the mass media company several different opinions are surrounding renewable energy technologies which in turn could influence consumers and other stakeholders.

2.2.3 Market acceptance

Stakeholders in the third dimension can reach from investors to consumers, RET companies, and other smart technology actors. Actors of the market acceptance decide about the willingness to pay for a RET device, which projects get financed, and what cooperations are made (Nkoana, 2018). This section will not focus on the consumer perspective since this topic will be discussed in detail later on.

As mentioned earlier, one advantage of the renewable energy initiatives platforms is that they allow users to transfer money to pay their energy bills. This new development is part of the rise of Sub-Saharan Africa's FinTech (financial technologies) sector which is reshaping the landscape of the financial economy. By enabling users to transfer digital payments from a platform on a mobile phone, laptop, etc. they reduce costs, increase transaction speed and safety, and are also more convenient to use (Akinola, 2020). However, these financial technologies also come with challenges. Although the new technologies can help reduce the ingrained socio-economic imbalances of the traditional banking system, research found out that it can also aggravate the current situation if not regulated properly. Many of the Sub-Saharan African "unbanked" live in rural areas without access to digital devices. In connection with the lack of digital literacy of the users, FinTech can deepen the inequality of customers that do not have the knowledge and means to use mobile phones or a laptop. Moreover, with the high demand for user data, algorithmic biases and data privacy threats need to be addressed (Coetzee, 2019). Furthermore, without proper data safety, customers' trust in the FinTech platforms might be strained, especially because of the higher risk of financial fraud enabled by the application itself (Panos & Wilson, 2020). Since citizens in rural regions in Sub-Saharan Africa already mistrust new technologies because of little to no experience with digital devices, these issues are highly challenging (Coetzee, 2019). An example of these risks is the agricultural finance sector in Kenya, where digital lenders do not only lower credit barriers but also harness data to predict farmers' behaviors, the agricultural value chain, etc., and consequently reinforce inequalities (Iazzolino & Mann, 2019). Therefore, FinTech companies are highly important actors for policymakers since they increasingly have a part in new technology implementations like PV projects. But also RET companies value their partnerships because renewable energy devices can be sold at lower costs which was not possible before.

Private sector investors and foundations also value FinTech services a lot since projects need to have a clear prospect of being successful and meeting the risk-return requirements. Moreover, for foreign investors, it is important that RETs meet global policy requirements, and their cooperation with governmental support is crucial (Nassiry, 2018).

Lastly, RET companies are one of the most central stakeholders in the renewable energy initiative market. With rising sea levels and climate change, their products can solve energy poverty while protecting the environment and reduce the dependency on fossil fuels and oil (Ntanos, 2018). Most importantly, RETs have social impacts on the communities in Sub-Saharan Africa as they try to combat poverty, unemployment, and the resulting inequalities because of financial and societal discrimination. Another advantage is that energy is more reliable than for example energy received from Eskom since this electricity utility has planned power outages. Furthermore, with traditional energy providers, many communities have concerns about the inaccessibility of locally generated electricity which is tied to cultural inequity issues (Nkoana, 2018).

As mentioned earlier, investors and policymakers pay close attention to sustainable and responsible innovation systems, and therefore, RET companies need to pay close attention to meet these desired standards. Moreover, the development of these renewable energy initiatives should not be solely focused on emerging as a “big” smart technology since long-term success is tightly connected to multiple stakeholders and their needs (Rose & Chilvers, 2018).

2.3 Target group characteristics and challenges

Energy is a central part of economic, social, and political systems and determines the development of a society as a whole. But why then do many renewable energy initiatives fail? One of the main issues is that there is limited knowledge about the target group and why they are opposed to RETs. Therefore, it is essential to know the consumers, what challenges they encounter, and how their public perceptions influence the acceptability of energy innovations.

Kizilcec et al. (2021) found out in their case study in Rwanda where they studied pay-as-you-go solar devices and their usage, that the purchasing and usage reasons for RETs are multifold. However, it is striking that 31% of all participants stated that the main purpose of their solar device is to charge smartphones at home, followed by health benefits (22%) and improved living conditions (18%). A possible reason for that is the need for a mobile phone to manage the energy usage and pay bills, but also the increasing participation of smartphone users in developing countries which will be discussed later in the chapter. Surprisingly, the study found out that the price aspect of RETs was on sixth place (15%) which is contrary to the promise of affordability tech companies make. Other purposes that the participants stated were security lighting (11%), education (10%), and listening to the radio (8%) Kizilcec et al. (2021).

One main finding that several authors discuss is that the consumers who need access to infrastructure the most are low-income households in rural areas (Boudet, 2019; Nkoana, 2018; Rose & Chilvers, 2018). The geographical characteristics in combination with cultural and historical differences of specific regions regarding their energy consumption and way of living, constitute varying landscapes that shape the consumers’ needs and acceptance (Wolsink, 2014).

Another often discussed barrier for many households to purchase a RET is affordability. As mentioned earlier, receiving a credit without land or history on a commercial bank account is highly problematic. This means that flexible payment schemes and tariff structures are needed to foster sustainable access to electricity (Welsch et al., 2013).

One of the most discussed issues of successful RET implementation is the consumers' lack of knowledge (Boudet, 2019; Ntanos et al., 2018; Renaud & Van Biljon, 2008; Gerber et al., 2018). Even in Western countries that have well-established electricity infrastructures, only one-third of the people know about smart meters and smart grids. These low levels of knowledge and understanding can cause consumers to reject RETs (Boudet, 2019). However, the educational level can play an essential role too, especially since a lot of people in the rural parts of Sub-Saharan Africa have low educational levels (Ntanos et al., 2018). In hindsight of the digital device literacy, many consumers encounter severe burdens with transferring money to the bank or RET company because they never used a mobile phone or similar before. According to a report of the GSM Association, about 77% of the Sub-Saharan African population had a SIM connection in 2019 which is an increase of 2% only within one year (GSMA Association, 2020). However, another report of the GSMA Association reported that there is a major gender divide. The mobile phone ownership gap between men and women is 15%, but the gender difference of internet use is 41% (GSMA Association, 2019).

But because mobile devices are required to even use renewable energy devices and are of utmost importance for affordability, many households, and individuals fail to do tasks that are considered simple by smart technology companies and investors (Renaud & Van Biljon, 2008). Without the required knowledge about the technology itself, connected devices, and probably the foreign languages the mobile platforms use, access to crucial energy solutions is denied in the long run (Gerber et al., 2018). What might be a solution for this issue is an inclusive platform design. Google for example has created specific research and design methods that they call UX for the Next Billion Users. The main goal is to make digital information universally accessible and to enable citizens of countries that did not have access to a smartphone or the Internet until recently (Google, n.d.). It is essential to tackle accessibility, language, and other related challenges because during the last decade almost three billion new smartphone users from low-income regions now participate in the digital world (Arora, 2019). There was an increase from 9.7 million mobile phone users in 2014 to 21 million in 2020 alone in South Africa which shows how important it is to account for the needs and usage purposes of all these new users (Statista, 2020). Lastly, it is also a question about how well consumers know which, how many, and where their data is collected and stored. Many projects in Western countries failed because people were too afraid of possible consequences due to data leakages, little transparency about the data collection and storage (Véliz & Grunewald, 2018).

Finally, there is also a high correlation between acceptance and the place where RETs are installed. In the case of Sub-Saharan Africa, there is a two-folded sword. On the one hand, renewable energy initiatives are very welcomed, and people usually see them as something positive. On the other hand, energy developments can be seen as something negative, if people in rural communities experience the new electricity infrastructures as something that mainly serves urban areas. This means that there is more resilience of communities in rural areas if tech companies do not adequately compensate them for using land for the renewable energy plant, if the products do not meet specific regional needs, or if people outside the cities have no access to the grid connection compared to urban regions. This goes hand in hand with the emotional connection to traditional energy providers although these are usually unaffordable and unreliable. But people tend to be more attracted by what is well established and known rather than investing money and time in new and not yet known innovations. Particularly the risk of hacking the smart grid or physically manipulating the smart meter is a major disadvantage of RETs (Boudet, 2019). Consequently, the dimension of technological energy justice needs to be addressed. Banerjee et al. (2017) define energy justice as "a global energy system that fairly disseminates both the benefits and costs of energy services, and one that has representative and impartial decision-making" (p.770). If technologies fail to adequately consider the specific users' needs, energy systems can have inherent ethical weaknesses when it comes to providing protection against external safety threats (Banerjee et al., 2017). This problem could also be found in a study in Switzerland where people rated renewable energy initiatives as something valuable and positive, but they were opposed to installing one of their own because they were unsure about the innovation and product itself and rather preferred their traditional energy source (Sütterlin & Siegrist, 2017). Another interesting finding is the phenomenon of the theoretical construct NIMBY (Not In My Backyard). People in western countries tend to reject RET because of protective-place actions. This does not mean that they are opposed to them in general since many think that for example, PVs are a very positive and sustainable way of energy production. However, they have second thoughts because of their own property values, health threats, perceptions of distributive injustice, and procedural injustice (Batel, 2020). Another fear that is connected to the perceived injustices, is social inequality that might arise from technological advancement. If selected individuals in a community invest in a RET, for example for smart farming, other members of the community might be disadvantaged (Pradhan & Agwa-Ejon, 2018).

To overcome the educational issues and the lack of knowledge about the possibilities households in rural areas have when considering investing in a RET, businesses need to engage with their customers and provide training on how to use a mobile device, and what their financial possibilities are. Furthermore, people in these regions need to be trained on how to manage and maintain their RET devices themselves to save on maintenance costs (Welsch et al., 2013). Additionally, because the acceptance of renewable energy initiatives is fully dependent on social cooperation, scholars like Wolsink (2014) advise businesses to focus less on the techno-centric aspect and more on the social side of what the consumers need.

2.4 Opportunities, privacy risks, and challenges of smart technologies

With the African population growing incredibly fast, the increasing demand for electricity, and growing environmental concerns, renewable energy technologies have become more important than ever. One of the greatest advantages of smart technologies that have not been employed in connection with energy devices before this last decade are platforms that operate with Demand Side Management (DMS) algorithms (Lazaroiu & Roscia, 2018). A study by Longe and Ouahada (2018) in Johannesburg, South Africa, found out that these algorithms can minimize consumer-side challenges like financial burdens. Because these algorithms enable not only off-grid operators but also customers to check real-time information about how much electricity is consumed at a certain time, users can monitor and control their own energy usage. Research found out that this way, consumers are more aware of how much they consume and therefore are more conscious about their electricity spending. Additionally, they contribute to a near balance between the energy supply and demand by extracting data from the smart grid which is beneficial to avoid excessive electricity usage in the long term (Longe & Ouahada, 2018). In the past years, renewable energy technologies were also promoted for other benefits like energy justice for all. Banerjee et al. (2017) list three central justice tenets. Energy justice should first off all be based on distributive equity where benefits and ills are distributed fairly between all users. Secondly, RETs can provide procedural justice where stakeholders of all kinds can participate regardless of income, background, or other social demographic characteristics. Lastly, RETs should consider recognition justice which thrives to include the needs and challenges of energy-poor households in the decision-making progress of renewable energy projects, like financial issues, communities opposing to lease or sell land for power plants, etc. (Banerjee et al., 2017). Furthermore, algorithms of smart renewable technologies are seen as essential for planning cities that can keep up with Africa's growing population. Smart electricity devices are integral for planning smart cities in the future since their goal is to promote fair, sustainable, and resilient systems. Access for the poorest household to clean, efficient, and affordable energy is the main promise and key elements for that are smart grids, information, smart metering, and communication technologies (ICT) (Lazaroiu & Roscia, 2018). However, with the implementation of smart technologies in the energy sector also come data and privacy risks and challenges.

Until now, there has been little work done on if and how RETs can contribute to the promise of energy justice. Moreover, with the centrality of data, they often violate privacy rights while mediating the digital infrastructure between groups which gives them an advantage over competitors and a greater political and economic power (Srnicek, 2017). Smart farming technologies for example can lead to mass rural unemployment because platforms of smart technologies define what it means to be a “good” farmer. This means that those who do not fit into the predetermined categories of the algorithm or do not act according to them get discriminated against and have fewer opportunities to acquire seeds, sell products, etc. Moreover, considering that the agricultural sector is getting increasingly consolidated, and farmers already lack power over their own choices, the gathering of big data shifts the power of the decision-making process further away from the farmers to private tech companies that have control over the data (Rose & Chilvers, 2018). Other issues stem from platformization since more and more spheres of peoples' lives are meditated by applications that have not been before. Additionally, several tech companies (Facebook, IBM, Google, etc.) claim to do "social good" by using datafication. Although they state to be beneficial for society, they have one overarching goal, to generate profit. Although Abrams (2016) found out in a study researching the implementation of a solar panel project in Rwanda that it is important to make smart technologies profitable for the long run, how this is done is highly important. The findings showed that the most successful projects were those in which business models were planned hand in hand with the social objectives, like facilitating access to electricity as a critical and essential public utility service (Abrams, 2016). Tech companies, however, are not transparent about the process, how much and what data they collect, who stores and protects the information, or whether the data is used by third parties (Magalhães & Couldry, 2020). Particularly in Sub-Sahara Africa, platform firms exert tremendous bargaining power over who can access the market by pressuring actors into accepting data-sharing protocols and in turn reap profits from it (Iazzolino & Mann, 2019).

The threat and common tensions of privacy protection were discussed by several scholars before (Boudet, 2019; Pradhan & Agwa-Ejon, 2018; Batalla et al., 2017; Gerber et al., 2018; Véliz & Grunewald, 2018; Potdar, et al., 2018). Concerns about data security can be a reason for objections to renewable energy technologies (RET) and the general social acceptance of them (Boudet, 2019). The need of sharing information with network communities can be another threat to possible investors because of missing data protection policies and the misuse of data (Pradhan & Agwa-Ejon, 2018). Another issue poses the interconnectivity of devices that are needed for financial transfers, data gathering, and general use of the devices that risk the user privacy. With IoT (Internet of Things) systems and the multiple connectivities of devices tied with cloud storage and data analysis, specific data protection policies of governments are needed to protect the users. Other challenges that come with missing legislative actions are privacy leakages and especially unauthorized, physical manipulations of devices which might cause the loss of confidentiality of consumers (Batalla et al., 2017). In the case of smart homes, the physical accessibility and openness of networks cause a huge vulnerability as hackers can remotely or on-site access the home systems and control or upload malware on the devices which have further consequences for the users (Nagarkar & Prasad, 2019). Lastly, legislative frameworks for data privacy in Sub-Saharan Africa are needed since unethical data practices of tech companies undermine the trust in businesses and hinder the uptake of potentially helpful energy innovations. Because smart meters that continually monitor, record, and analyze data have complex data policies and data gathering processes, it is oftentimes difficult for end-users to fully understand the consequences of this. Therefore, it is questionable whether informed consent is actually meaningful considering the fact that many users in Sub-Saharan Africa have never used such a RET before (Véliz & Grunewald, 2018).

With the Sub-Saharan African population growing incredibly fast and the urgent need for reliable and affordable energy that (Lazaroiu & Roscia, 2018) meets standards that are feasible for reaching the goals of climate change agreements, renewable energy technologies are indispensable (IRENA, n.d.). However, to successfully implement smart energy device projects, several challenges need to be addressed first. Starting with privacy and security threats, tech companies need to make sure that users can rely on the companies to safely store sensitive data to enhance consumer trust and accelerate the adoption of RETs (Srnicek, 2017). Secondly, challenges and tensions between the multifold stakeholder dynamics need to be addressed (Wüstenhagen, et al., 2007). Not only questions like who gets to manage the data, how the devices are financed, and which regulation will be in place, but also concerns regarding ethical and fair energy justice need to be answered. Because of the vast need of thousands of people in Sub-Saharan Africa for electricity, it is important that the RETs' business models meet the target audience's needs and concerns while establishing a sustainable and long-term profitable product that support the countries' future economic developments (Banerjee et al., 2017). To do so, renewable energy tech companies need to understand their target audience. Failure of previous projects was due to missing understanding of the consumers' needs and issues. Especially the affordability aspect of smart energy devices can be one of the main burdens for low-income households to get an off-grid solar device (Welsch et al., 2013). Moreover, issues regarding how the RET devices are communicated and marketed to the people are under-researched. This ties into the challenge of mobile phone usage to manage energy consumption and pay bills online via for example FinTech applications (Gerber et al., 2018). As mentioned before, millions of new users that did not have a mobile device before are now participating in the digital sphere (Payal, 2019), which means that renewable energy companies need to consider the users' situation and create incentives to promote their devices (Gerber et al., 2018).

To close the current research gap of how innovative digital and renewable energy initiatives can reduce energy poverty in Sub-Saharan Africa while considering the ethical and sustainability tensions and tradeoffs, this research will focus on three main angles describe in this chapter. The following section, the methodology, will describe how the research question will be answered by the content analysis. Furthermore, it will map out several different key stakeholders that have a major impact on how renewable solar energy devices are communicated to the end-users and which role they play for the RETs business models.

3. Research Design & Rationale

This chapter provides an outline of the research method that will be used to answer the research question. Starting with a description of the chosen method, it will continue with a description of the sampling criteria and procedure of the analysis items, followed by the operationalization and the research instruments used.

3.1 Methodology

To answer the research question of this study, two different companies and key-stakeholders of innovative off-grid solar initiatives networks were examined by conducting a qualitative content analysis. As the topic of the research question has not yet been well researched, this method was especially useful since it allows the researcher to gain knowledge about the implicit meanings of the study item without applying preconceived theories of previous studies to the analysis. It furthermore provides insight into how concepts and language are used in a text and how these findings are connected between other case items. Another advantage is the more flexible approach since each company and stakeholder of the network that was studied had very individual characteristics (Kohlbacher, 2006). The main goal of the study was to get a more profound understanding of how the companies' platforms operate, and which role other stakeholders play in the multifold network of different actors that have not cooperated in this specific market before. Furthermore, the challenges, opportunities, and threats of the business models were researched and what the vast collection of sensitive user data means for the customers. Lastly, the analysis examined the different stakeholder relationships, how they communicate with their customers, and which challenges and trade-offs they have to consider in order to contribute to an ethical and sustainable development of innovative digital and renewable energy initiatives. In order to gain better insight into these research angles, relevant documents of diverse stakeholders were analyzed which will be described in the next section.

3.2 Sampling Criteria & Procedure

Purposive sampling was used to intentionally select the two specific companies and relevant key-stakeholders on the topic of renewable solar energy initiatives in Sub-Sahara Africa. These actors were chosen and mapped out according to a stakeholder identification analysis of five smart grid pilot projects in the Netherlands by Obinna et al. (2016). The findings showed that there are seven different key-players, starting with governments. For this category, the Rural Electrification Strategy of the government of Rwanda, an online article of the United Nations Framework Convention on Climate Change, and a feature story of the World Bank called *Lighting Up Africa: Bringing Renewable, Off-Grid Energy to Communities* were chosen since all three stakeholders are important for the chosen companies which will be discussed later. The second stakeholder category analyzed renewable energy technology companies, specifically two annual reports of 2017 AND 2018 FROM NOTS Solar Lamps. Although the second company, Angaza, is not included in this section, since there was no annual report available online, it will be analyzed through other stakeholder documents. Thirdly, documents of Information and Communication Technology companies (ICT) will be examined including FinTech and telecommunication companies. The chosen analysis items were a partnership announcement of NuovoPay and Angaza, followed by another partnership announcement of Mastercard and Angaza, an online post called “Mobile for Development” by the Global System for Mobile Communications (GSMA), and a report called “The Value of Pay-as-you-go Solar for Mobile Operators” also by GSMA, one of the biggest associations representing the interests of mobile network operators. Another stakeholder category form knowledge institutions which was split up in two different groups for this study, namely non-profit organizations, and watchdog agencies and the second category was news articles of press releases of smart solar energy systems. For the first one, an online article of the Electronic Frontier Foundation (EFF), a Think-tank report called “Accelerating access to electricity in Africa with off-grid solar” from Overseas Development Institute (ODI), and an online article by the Non-profit organization World Resources Institute called ““Pay-As-You-Go” Solar Could Electrify Rural Africa” were chosen. For the second category, news articles and press releases, the news article “Mobile power payments and smart meters plug in Tanzanian homes” by Reuter news, another news article with the headline “RWANDA: Nots Solar Lamps builds solar home systems factory” by Afrik21, and an analysis article called “Steamaco: disruptive smart metering for Africa” by power-technology.com, one of the leading news representators of the global energy industry were chosen. The last sector is the development sector and specifically Aid agencies. For this last category two key-players were selected. The aid agencies are represented by an Off-Grid Solar Market Assessment 2019 by USAID, and for the second document, an online news post of the IKEA Foundation was chosen since they founded the first solar plant for a refugee camp on the African continent (IKEA Foundation, n.d.). Since exploring the opinions of end-users would have gone beyond the scope of this thesis and would have required a different methodological instrument, this group was left out (Obinna et al., 2016).

The analysis items had in total 38,820 words, with the word count ranging between 293 and 9,559 words. The documents of these stakeholders were chosen according to their relevance to this research field and the publication date which was not older than five years. Additionally, all of the actors in the categories operate in or address the Sub-Saharan African region directly or indirectly. Except for the article of EFF which was highly important as it addresses the data and privacy risks of smart meters in the United States and a similar item for the Sub-Saharan context for exactly this research topic was not available online. If accessible, analysis items that mentioned or investigated one of the RET companies this research explores were chosen.

Purposive sampling as well as snowball sampling was used to select the analysis documents and companies. Starting with purposive sampling, stakeholder documents of key-players mentioned in previous academic literature formed the basis and start of the document choice. Snowball sampling was used for additional documents that were either linked in the intentionally chosen literature or documents of stakeholders that were mentioned in the analysis items during the purposive sampling research phase (Mayring, 2015).

Moving on to the company selection, NOTS Solar Lamps and Angaza, the criteria were first of all based on the similarities of the offered products. Because there are several innovative digital and renewable energy options, the focus was brought specifically to innovative off-grid solar energy systems in combination with pay-as-you-go mobile-driven offerings in Sub-Saharan Africa. Another characteristic for the selection was that their product is connected to a device or platform with which users can monitor, control, and manage their energy consumption and payment. Lastly, both firms operate at least five years on the market and probably already had to face challenges within the sector. The first company, NOTS Solar Lamps' MUTIMAX Solar System, is exclusively made for low-income African households and enables customers to afford their product through a partnership with BBA Solar Loans Ltd (NOTS Solar Lamps, n.d.). The second provider, Angaza, does not only focus on solar lighting but also other utilities that are all tied together and can be controlled by their platform. They specifically focus on creating relationships between the users and offer flexible payment options (Angaza, n.d.).

The table below summarizes all analysis documents according to the stakeholder category and why the specific document was chosen.

Table 1

Stakeholder Analysis Documents

Stakeholder Category	No.	Document Author	Document Name	Justification of Document Choice
1. Government & UN Systems	1	Republic of Rwanda –Ministry of Infrastructure	Rural Electrification Strategy	This is the official document which specifically discusses the market and current developments of renewable solar energy projects in Rwanda.
	2	UNFCCC – United Nations Framework Convention on Climate Change	Pay-As-You-Go Solar Technology: A Key to Unlocking Energy Access - Kenya and Peru	This article is a summarized assessment of the opportunities and challenges specifically for PAYG solar energy with the important angle of the people in these countries.
	3	The World Bank	Lighting Up Africa	The article sheds light on the consumer side, how they experience the smart technologies and how PAYG solar improved their lives while keeping in mind environmental challenges.
2. Grid Operators, Social entrepreneurship, & RET companies	4	NOTS Solar Lamps	Annual Report 2017	These two documents are the official annual reports from 2017/18 which give profound insight in the success and struggles the company had the previous years.
	5	NOTS Solar Lamps	Annual Report 2018	
	6	Eskom	Eskom and Huawei partner to advance Smart Grid	Since Eskom is one of the main grid operators in the Sub-Saharan African

			innovation	region, this partnership announcement shows the angle of grid connection operators compared to the off-grid reports from NOTS.
3. ICT companies (including FinTech & Telecom)	7	NuovoPay	NuovoPay Partners with Angaza to Make Smartphones More Accessible	This article includes the viewpoint of the second solar company, Angaza, while giving insight on the role of the FinTech companies by NuovoPay.
	8	Mastercard	Mastercard and Angaza Partner to Bring a New Generation of Life-Changing Technology Solutions to Emerging Markets around the World	This article was chose since Mastercard is one of the most well-known credit card institutions and it has a partnership with Angaza, the second PAYG solar company.
	9	GSMA – Mobile for Development	Mobile operators get significant value from pay-as-you-go solar – what's next for these partnerships?	GSMA represents worldwide the interests of all mobile network operators, and these documents specifically address PAYG solar partnerships and what the smart technologies offer to mobile operators.
	10	GSMA – Global System for Mobile Communications	The Value of Pay-as-you-go Solar for Mobile Operators	
4. Non-profit Organizations, ThinkTank & Watchdog Agencies	11	EFF – Electronic Frontier Foundation	Win! Landmark Seventh Circuit Decision Says Fourth Amendment Applies to Smart	This article was chosen since there are hardly non-profit articles and documents which discuss the smart meter data

			Meter Data	security and challenges. Additionally, this analysis item reveals insight in how legal institutions evaluate the opportunities and challenges of smart energy technologies.
	12	ODI – Overseas Development Institute	Accelerating access to electricity in Africa with off-grid solar	The document provides deeper insight into an international non-profit organization which focusses on the people regarding equity, social justice, inclusive growth, and sustainability.
	13	WRI – World Resources Institute	"Pay-As-You-Go" Solar Could Electrify Rural Africa	This article was published in collaboration with several connected stakeholders and therefore offers a perspective of different angles compared in one analysis item.
5. Press & Newspaper	14	Reuters	Mobile power payments and smart meters plug in Tanzanian homes	The newspaper reflects the experience of a female customer before and after she received a PAYG solar device and discusses partnerships of different stakeholders.
	15	Afrik21	RWANDA: Nots Solar Lamps builds solar home systems factory	The article specifically covers news about the first solar company, NOTS solar lamps, and was chosen because of this reason.
	16	Power Technology	Steamaco:	This article was chosen

			disruptive smart metering for Africa	since article about smart metering in African countries are mostly optimistic and discuss less the challenges and how they can be overcome.
6. Aid Agencies & Foundations	17	USAID	Off-Grid Solar Market Assessment Ghana	This aid agency document was one of the most detailed and insightful assessments of the off-grid solar market of an Sub-Saharan African country which discusses many different stakeholder angles and was chosen because of these specific reasons.
	18	IKEA Foundation	Unlocking solar energy to power farms and businesses in Africa	This document was chosen since the IKEA Foundation founded the first solar plant for a refugee camp on the African continent.

Note. For the full referencing list see Appendix A.

3.3 Operationalization

As mentioned earlier the chosen method to investigate the research project is a qualitative content analysis. The first step of the content analysis was collecting the items for the final data set (Mayring, 2015). The 18 chosen documents were accessed and downloaded online. After the selection of the analysis units and a first preliminary overview about the items' topics, inductive category formation was used to establish a coding frame directly out of the text units. During this step, the themes and level of the categories were defined (Mayring, 2015). This was done by considering the three main angles, stakeholder dynamics, user communication and characteristics, and technology/business model which were used as main categories to further refine the themes. Literature of previous research about similar study topics (Muchunku et al., 2018; Baurzhan and Jenkins, 2016; Ulsrud et al., 2018) for example about platformization risks and challenges of renewable energy platforms, bundling services of energy providers, etc. were used to guide and construct categories (Mayring, 2015). After getting familiar with the analysis items and establishing the coding framework, the next step then was to analyze the text units line by line and for each material that fits a category that was previously established, a fitting label was constructed and assigned depending on the category. After several text items were analyzed and a certain point was reached that did not require creating new labels/categories, the whole category system was revised. Interestingly, because almost all stakeholder documents discussed the new partnerships of the emerging renewable Pay-as-you-go (PAYG) solar sector, a specific sub-category was established to further investigate how multifold and specific the key-players relationships are. During the revision and to finalize the analysis, it was important to pay attention to possible overlaps between the categories as well as if their definitions were logical and clear. During this stem the items were revised again, and the labels adjusted if necessary (Mayring, 2015). Below is the table of the final categories, sub-categories, and sub-subcategories including illustrative quotes.

Table 2

Coding Frame Overview

CATEGORY	*SUB-CATEGORY*	*DESCRIPTION*
Stakeholder Dynamics	Stakeholder Partnerships	Including multiple stakeholder partnerships between two or multiple key-players.
	Stakeholder Involvement	Descriptions of actions and how the stakeholders are involved in renewable, innovative solar energy projects.
	Stakeholder Communication & Initiatives	Sub-subcategories indicate how the stakeholders communicate with each other, how they generate funding through communicative strategies, and which different strategies, actions, and goals they have.
	Stakeholder Opportunities & Challenges	Opportunities that arise because of stakeholder partnerships, the values these relationships can or could have, and which challenges they experience regarding funding, limited market knowledge, and issues between the stakeholders.
Consumer Communication, Opportunities, & Challenges	PAYG solar sector-customer interaction	Including consumer characteristics, differences between low-income and upper-income customers regarding the electricity access, challenges like limited knowledge about the PAYG solar products, and digital literacy challenges.
	Communication & smart technology	How users interact with the PAYG solar platform, which benefits and challenges they experience, and the role of digital payment for them.
PAYG solar business model & Technology	Development	The opportunities and challenges of PAYG solar business models as well as digital technologies connected to them, including questions about quality assurance, data collection, the role of

		grid connection, privacy policy, and traditional payment concerning all stakeholders involved.
	Opportunities	Indicators of the benefits and potentials of digital payment options, smart metering, mini-grids, technology directed specifically at end-users and PAYG solar in general.
	Challenges	Including challenges of digital payment options, off-grid solar initiatives, traditional energy systems, alternative energy fuels, and data privacy issues.

Note. This table only displays the main categories and sub-categories. For the final coding frame including the sub-subcategories see Appendix.

4. Results

This chapter will present the results of the qualitative content analysis of key-stakeholder documents described in the previous section. The findings are structured in three main parts. The first one displays the results from the stakeholder dynamics. This includes how multifold their partnerships are, how and in which way different kay-players are involved in the PAYG solar sector, which opportunities and challenges they experience, as well as how they communicate with each other. The second part of the results presents the communication directed towards consumers, how the users are influenced by these renewable energy technologies, and which opportunities and challenges they face. Lastly, the findings of the PAYG solar business model itself and the technology used for the solar devices will be discussed. This includes the development, opportunities, and challenges concerning data privacy, technology use, and how the different stakeholders experience the shift towards these renewable energy initiatives and projects.

4.1 Stakeholder Dynamics

4.1.1 "Universal Electricity Access" Definition

Starting with the definition of electricity access in general, the analysis revealed a difference between stakeholders' understanding of the concept. Newspapers use the term "universal electricity access" more generally without really defining it. For example, Reuters (2017) stated, "With an ambitious target of achieving universal access to electricity by 2030, Kenya, Rwanda, Tanzania, and Uganda are now exploring mini-grids to power rural communities away from the main grid." Private sector companies mostly talk about electricity access for all in a different way by referring to their ambitious goals, as Bart Hartman wrote in the annual report of 2018, "As you can see, we made a lot of progress during the past 1,5 years. This gives me and our team a lot of energy to move forward as fast as possible with providing electricity to African families." ICT companies, and in particular NuovoPay which wrote in their partnership announcement, "Angaza creates the technology that enables businesses to offer life-changing products to anyone, anywhere" (Shete, 2021), implies that it does not matter who or how remote someone lives, everyone is targeted by Angaza and NuovoPay.

These stakeholders do not specifically define universal electricity access, nor did national grid operators or non-governmental organizations. One reason might be that the governments have a specific understanding of "universal electricity access". In particular, USAID cited the definition of the government of Ghana document in their Off-grid Solar-Market Assessment 2019. The Ghana National Electrification Scheme (NES) defines "universal electricity access" as the following:

> The NES defines universal access as an access rate of 90 percent. Here, "access" is defined as the ability to connect to the grid and is applied only to those communities that are greater than 500 households in size, are accessible by road, and are situated within 20 kilometers of existing distribution lines. Villages that do not meet these criteria are not considered in the access rate calculations. (p.2)

According to this definition, ten percent of the whole population are neglected in the NES which questions the concept of "universal access". This contrasts to the definition of Merriam-Webster (n.d.), "including or covering all or a whole collectively or distributively without limit or exception; especially: available equitably to all members of a society.". USAID justifies the definition of the Government of Ghana which they use in their report by concluding that if the strategy would include the whole population, electricity access rates would be much lower and that it is oftentimes difficult to assess Ghana's whole off-grid population (USAID, 2019, p.2). This also raises the question of universal rights considering that the government of Ghana prides itself for the "Implementation of a national uniform tariff [that] is considered to be a matter of social justice, whereby poor, rural consumers should not pay more than their wealthier urban counterparts" (USAID, 2019, p.22). This finding indicates that it is not a question of equality, but rather of equity between low-income and upper-income households. The scholar Price already argued in 1988 that the prices should be considered in terms of the relation to the users' incomes since although prices might seem equal, they create a heavier burden for low-income households compared to richer households and should therefore be priced in relation to the financial means of a household rather than set at a fixed rate for all.

However, it is important to mention that the Government of Rwanda stated specifically in its Rural Electrification Strategy that the end-target is to provide access to the whole population "Ensure that by 2018, 70% of Rwandans have access to electricity and that by 2020, 100% of Rwandans have access to electricity." (Republic of Rwanda, 2016, p.8) Despite this target, the Government of Rwanda did not specify what the "100%" actually means, and since the previous example showed that “universal electricity access” might not apply universally for all citizens, it is questionable if Rwanda’s Rural Electrification Strategy actually targets the whole population.

4.1.2 Electricity Access as an Equal Right?

Another finding showed that the Government of Rwanda and other countries that have similar strategies determines which household and community gets access to which electricity connection. This means that low-income households cannot decide under which category of the electrification plan they fall (there are 5 tiers in the document of the Government of Rwanda in total):

> In order to ensure that “each household will be able to access the most appropriate form of electricity based on their income levels and usage patterns”, this Strategy is broken out into four discrete programmes based on the consumer and technology, … (p.9)

Private sector companies cannot control that either or influence the decision since the governments see themselves as the stakeholder with the key-role in planning and permitting electricity access “… with Government playing a key role in identifying sites and establishing a framework through which these can become financially viable investments.” (p.1) In case of development, there are certain guidelines for communities depending on population size, income, etc. that need to be met to qualify for an upgrade from for example tier 1 (lighting, radio, and phone charging) to tier 2 (lighting, radio, phone charging and basic appliances (TV or fan)). The reasoning for this decision is economic growth to “ensure that as households’ energy needs increase in line with economic growth they can access technologies aligned with these increased needs.” (p.8) This means that the focus is not primarily on the populations’ health or the right to have equal access to electricity, but that the electrification strategy needs to support the economic growth of the country. Furthermore, it is interesting that the government refers to its goal to be “financially viable” considering that it does not need to focus on generating profit as the main driver like private corporations oftentimes do. Therefore, it is questionable why the electrification strategy of the Government of Rwanda does not focus primarily on catering electricity services to a maximum of its population while aligning the goals to the public interests regardless of the financial outcome. Researchers argue that one phenomenon they found in Zimbabwe, southern Arica, was that the electricity sector there is mainly driven by neoliberal tendencies and that accumulating capital is not questioned. Therefore, power scarcity is considered to be inevitable because structural market factors and trends produce electricity shortage which deepens energy poverty and injustice although they should be treated as a human right. Another finding was that this dynamic results in the population's understanding of energy poverty as the effect of a market development that is accepted and endured by them. This raises important ethical questions for policymakers who need to consider the neoliberal tendencies in their policy framework regarding social justice and political-economic implications (Chipango, 2020).

An interesting finding of the analysis was that the annual reports of the private sector, aid agency reports, UN system articles, etc. do not mention this strategy at all although it was mentioned several times. Quite the opposite, they mainly highlight the importance of renewable energy as the main source. In addition to that, the Government of Rwanda plans to extend the grid as far as possible, while focusing on providing grid connection and tier 4 and 5 connections (high power appliances and commercial and industrial energy usage) to “high consumption users” that can pay for their electricity usage by themselves. This points to the possibility that upper-income households are prioritized when it comes to modern and reliable energy access. They even call the Electricity Access Roll-out Programme (EARP) the “power backbone” although their strategy indicates that it will only make up to about 50% of the whole electricity production (the other half is targeted to be renewable energy) as stated below:

> This [EARP] will continue to act as the power backbone, providing power to large users and driving economic growth. (p.2)
> [The] government will continue to roll out the electricity network via EARP, focusing on connecting high consumption users and driving economic growth. (p.9)

This strategy raises multiple questions about if the electrification strategy actually supports inclusivity or if it acts as a political tool. It is also questionable how it would align with the seventh goal of the United Nations’ Sustainable Development Framework “Ensure access to affordable, reliable, sustainable and modern energy for all” (United Nations, n.d.). One motive that might be the reason for the private sector, aid agency reports, UN system articles, etc. to not mention these government strategies is because they speak to a different audience than the government documents. Therefore, mentioning these strategies might cause global funders and philanthropists or institutions with similar ethos to deter to invest in renewable energy projects and loans.

4.1.3 Differences between Stakeholder Expectations

When considering how many stakeholders are involved in the renewable smart energy sector, it is only logical that there are many different agendas. However, in terms of ownership and energy infrastructure planning goals, these differences might be one of the main barriers. Furthermore, the analysis revealed that governments and PAYG solar companies do not specifically talk about these disparate opinions. The governments of Ghana and Rwanda for example, plan on owning and operating the solar grids, especially the mini-grids themselves which hinders the negotiations and planning with private sector companies like NOTS. The private sector on the other hand is euphoric about creating change themselves and contributing to independent electricity access. Bart Hartman, the founder of NOTS stated in the annual report of 2018:

> It was a long (for European standards) and sometimes frustrating process. Though the fact that with this agreement we lay the foundation for improving the livelihood of potentially 125 million African families, makes it easy to forget the less happy moments in the past years. (p.3)

As mentioned before, the report does not specifically mention why the negotiations are “frustrating” and take long, but from what the Government of Rwanda states in its report, and what was discussed in the previous section, it is very likely that the ownership and control of what and where solar projects get installed is due to the government seeing itself as the actor with the key-role in this development. Like USAID wrote in the 2019 assessment report:

> Ghana’s off-grid power sector is characterized by government policies and donor-funded projects that stress government ownership of energy assets. […] These government-driven projects, especially mini-grids, are typically intended to be owned and operated by one of the government-run electricity distribution companies, with private involvement limited to construction. (p.10)

It is worth noting that none of the newspapers and ICT companies mentioned anything about this in their documents. They mainly focus on the partnership with the PAYG solar companies and how valuable these are for them which will be discussed later. Nevertheless, questions about why these ownership and negotiation difficulties arise remain open.

4.1.4 The Need for a Holistic Approach

The analysis revealed that several stakeholders are struggling with current approaches and the Government of Rwanda itself stated in its report that they need a more holistic approach, “In order to meet consumer needs, a more holistic approach to energy access is required” (p.3). What most of the stakeholders mean by that is better cooperation between the stakeholders, including more involved parties in the planning process, and the sharing of information. Especially the latter got mentioned in several analysis documents from various key players. The Government of Rwanda stated that one of the goals was "Support in the dissemination of information" (p.18), the USAID reported in the 2019 market assessment "[…], Power Africa has identified market information gaps and seeks to bridge those gaps […]", and also the IKEA Foundation has the goal to share research results and knowledge. The missing knowledge they are looking for can be derived from several stakeholders that are struggling with where the underserved or unserved markets are, how many citizens are living in certain rural areas, how much mobile phone and internet access penetration these communities have to assess the digital literacy of consumers, etc.

Another big part of the need for a more holistic approach is the shift towards renewable energy projects for productive electricity use. Before the specific plans are discussed it is important to note that PAYG solar companies, newspapers, and platforms did not talk about this specific usage at all. The ICT sector institution GSMA on the other hand, reported in the 2020 report of the value of PAYG Solar that "[…], increased focus in the industry strives to deliver and demonstrate these economic impacts through productive use appliances" (p.19). The goal of these stakeholders is to increase the use of renewable appliances in the agricultural and health sectors. These can be for example solar pumps for farming or electrification programs for healthcare institutions.

4.1.5 A Need for Local Partnerships

One of the reasons why negotiations between governments and PAYG solar companies are so difficult is because governments plan on incorporating local partnerships if private sector companies want to enter the market. Like the government of Rwanda mentioned in its report 2016, "retailing and installing solar home systems represent an excellent opportunity to develop local enterprise and employ Rwandan nationals" (p.12). They see the new partnerships with solar companies as a way to keep some of the earnings and capital in the country which in turn will support the country's economic growth. Although the report of NOTS solar lamps does not specifically state that it is obligated to partner with local enterprises, it does mention the partnerships with companies from Rwanda. One reason why governments insist on this goal is that there are already mostly international PAYG solar companies that dominate the market and because solar systems collect massive amounts of data, the question of ownership and control is pressing, as will be discussed later. One of the main international private sector companies of the off-grid sector in Sub-Saharan Africa is for example ZOLA Electric, with headquarters in San Francisco, California. But also the analysis companies Angaza and NOTS solar lamps do not have their main office in the countries they operate in but the USA and Europe.

One way for the governments to get these companies to cooperate and partner with local entrepreneurs and incorporate the local workforce is to introduce expensive licensing and import tariffs. If companies want to bypass these regulations, they need to provide proof of local cooperation.

4.1.6 PAYG solar company-ICT company partnerships

One of the most highlighted topics during the analysis was that both PAYG solar companies, as well as ICT companies, stress how important a strong and profound partnership between these parties is for them. Although their reasons for this are slightly different, there is no doubt about the benefits these cooperations can have. ICT institutions, for example, mention that one of the main reasons for partnering with the PAYG solar companies is to increase their revenue since they experienced a downward trend of customers using SMS and making traditional calls. PAYG solar companies on the other hand profit from their support regarding digital literacy programs for the population since this is one of their main challenges, smartphone penetration increase, and data usage which is needed to use the digital payment and device platforms. However, questions about who gets to own the data remain somewhat unclear. In the annual report of 2017 from NOTS, Bart Hartman reveals that “there are not many companies that can provide such platform and the ones that can are tough negotiators, especially on the ownership of the platform and data” (p.3). But what the specific outcomes of this negotiation process were, was not mentioned which is interesting since ICT companies see themselves as important for other partners since they have a vast amount of information and data about the users. GSMA wrote 2020 in one of the Digital Development online articles, which was chosen for the analysis, “through our recent study, “The Value of Pay-as-you-go Solar for Mobile Operators,” we have demonstrated through data how valuable those partnerships are”. Nevertheless, there is also no indicator of who gets to manage and own which data.

4.1.7 National Grid Provider-ICT Company Partnerships

Interestingly, it is not only the private sector that is interested in a partnership with ICT institutions, but also national grid providers. Eskom, one of the biggest electricity utility providers in Sub-Saharan Africa, has a partnership with the telecommunications equipment company Huawei to accelerate the digital transformation within the power industry. Worth noting is that in turn, ICT companies do not mention any interest in working with national grid providers in their reports. They only mention and focus on innovative, renewable energy PAYG companies. However, it is easy to see why Huawei might be incredibly beneficial for the digital development of the energy sector since they provide OpenLab facilities with data centers including an advanced hardware and software infrastructure as well as a technical team providing the knowledge and skills. Moreover, Eskom mentioned the advantage that Huawei has a strong presence in Africa which in turn supplements the national grid provider with location-specific ideas and experience.

4.1.8 Implementation of Quality Standards

A threat to sustainable and ethical market development as well as consumer trust are inferior solar products that many stakeholder documents talked about. The analysis showed that they all share the same opinion, that it is important to introduce specific quality standards. Even the private sector is supporting this plan as their consumer awareness campaigns benefit companies of inferior solar products too. Furthermore, consumers who bought these devices and had bad experiences also lose trust in the high-quality renewable energy products which spoil the market overall. Quality frameworks that governments implement are for example from the International Electrotechnical Commission (IEC) or the World Bank and IFC Lighting Global program. The Overseas Development Institute (ODI) which is a Thinktank organization wrote in its 2016 report, "low-quality products, and particularly counterfeits and products which falsely claim a level of quality they do not achieve, defraud consumers and undermine consumer trust in the technology, spoiling the market" (p.9). Interesting to note is that to pull through this strategy, raising consumer awareness about the available quality products and market threatening inferior products is essential. Although the private sector makes efforts to promote its products, the government is seen and sees itself as the main stakeholder to raise consumer awareness for a sustainable market development. What is missing in the analysis documents is that there is no further elaboration about what leads to consumer mistrust despite experiences with inferior products. Is it also because there are trust issues regarding the difference between local and international brands? And what exactly is the relationship between quality perception and consumer trust? Because stakeholders report a knowledge gap of consumers being informed about PAYG solar products, solar companies are focused on their brand image. NOTS solar lamps for example picked a specific brand name for its product called "MULTIMAX" with an orange color and according to the annual report of 2018, it was successful. Another initiative to enhance consumer trust from Fenix International Inc. is the use of sales agents who are from the local area and instill brand loyalty amongst consumers.

4.1.9 Doing Social Good?

Despite assumptions and statements of big Tec companies doing social good, this concept was not used often by the stakeholders. Reuters news states all the benefits of PAYG soar's digital payment development while mentioning the social benefits they create without explaining them.

Another stakeholder who mentions initiatives that would benefit the population and create social benefits is the Government of Rwanda. Unlike the newspaper article, the government specifically states how the renewable energy projects profit its citizens. For example, education and information dissemination that in turn increase the population's health. Other stakeholders too mention the increased health argument. However, they do not talk about doing social good in these specific terms. The language they use is euphoric and they also use environmental argumentations that would benefit the whole population which is why their partnerships are so valuable amongst other reasons (health, increased income, economic growth, etc.) In the case of Aid agency and private sector stakeholders this would make sense since they might try to raise funding and interest in the sector. However, it is still striking how the effects on the health of populations and positive environmental impacts are the proxies for doing good.

4.2 Consumer Communication, Opportunities, and Challenges

4.2.1 Last Mile Distribution?

Terms that were used sixteen times in total and exclusively by ICT companies, as well as aid agencies and foundations, are "last-mile distribution". Consumers are described as living in rural areas or peri-urban areas with unreliable grid access and that most of them are low-income households. Interestingly, these stakeholders talk about this consumer characteristic that often since they are the key players who mention the importance of gathering and analyzing data as Mastercard did in its partnership announcement 2019 with Angaza, "This data gives companies and financial service providers the ability to put underserved populations on a new path to financial inclusion." Another example would be GSMA's online article from 2020, "In closing, the panel was keen to see more done in all areas of strengthening mobile operator and PAYG partnerships – particularly in the areas of data analytics." In contrast to these stakeholders, PAYG solar companies do not talk about their customers in these terms although they also define them as low-income, living in rural areas, and struggling with no or unreliable grid connection. They also need more information about where specifically their customer segment is since "although key institutions [...] are mandated to share information about grid access, they do not often release data" (p.2), as the USAID stated in its 2019 solar market assessment.

4.2.2 Customer Characteristics

Given the fact that it is not always clear for PAYG solar companies who and where specifically their target audience is, the findings showed that there are some shared characteristics across all key-player analysis documents. Firstly, and most obvious was that customers have mainly low incomes and need financial support. Although this is a well-known fact amongst the key players in the PAYG solar sector, it was frequently mentioned throughout all stakeholder documents. One of the main challenges and most often discussed barriers to connect with users is that they are difficult to reach due to their rural location. Additionally, there is a low smartphone and internet access penetration rate which can be an issue as one of the interviewed PAYG companies in the GSMA 2020 solar value assessment reported: “the majority of VITALITE’s rural customers were first-time smartphone users who had previously used a feature phone or never owned a phone before” (p.25). Another challenge are language barriers, although the analysis revealed that solar companies are starting to design their products in the local languages so that customers who do not speak English can interact with the platform. Connected to these issues is one of the most mentioned barriers by all stakeholders, digital literacy. Given the fact that a big customer segment never owned a phone before, it is not surprising that there is a vast need for PAYG solar companies and ICT institutions to fill this knowledge gap by educating the population on how to use a smartphone. Connected to this is the lack of consumer knowledge about what kWh are and what they can buy with the PAYG solar platform. Considering that many of them used alternative fuels like diesel generators or coal before or were never even connected to the grid in the first place, this change is understandably difficult for them in terms of what they buy. A challenge that does not only affect PAYG solar companies, but several other stakeholders is the low awareness of citizens about the renewable solar electricity access innovations. Although this issue is still prevalent according to the analysis, several stakeholders are already finding solutions to this problem and specifically, governments see themselves as one of the main key players to raise consumer awareness. Like the Government of Rwanda stated as one of its new goals in the 2016 Rural Electrification Strategy, “establish the enablers for the market to expand […] and increased consumer awareness” (p.17).

4.2.3 Consumer Integration and Female Mentorship Programs

A very positive finding was that stakeholders increasingly mention the importance of integrating consumers and citizens in strategies through training, mentoring, etc. Especially the government and private sector realize that communicating with consumers is essential for success and that future strategies need to be focused on that as the Government of Rwanda wrote, “To ensure the programmes outlined in this Strategy deliver as much economic benefit as possible, Government will encourage training and capacity development of local staff” (2016, p. 12). But also public utility providers and ICT company partnerships like for example Eskom and Huawei are based on the premise to leverage each other’s close information about consumers and each other’s opportunity to work closely with different citizen’s groups like mentioned in a previous section.

An interesting finding was that mentorship programs and training go a step further and specifically target women and girls. On the upside, female leadership positions increased significantly like USAID mentioned in the 2019 report, “These programs were successful, resulting in a 22 percentage-point increase of women in leadership roles from 22 percent to 44 percent" (p.18). The stakeholders mention specifically the benefits and opportunities of special training programs for female workers. On a more critical note, these mentorships programs seem to be implemented because they increase the chance to receive funding and create a more reliable workforce:

> These programs also helped to facilitate a 30 percent reduction in employee turnover, with women leaving at a 14 percent lower rate than men. These policies helped PEG secure $12.5 million in debt through the 2X Challenge, an initiative of the CDC [...], the Overseas Private Investment Corporation, and five other development finance institutions, to invest in companies with deliberate gender inclusion policies. The 2X funding crowded in a further $7.5 million in debt and $5 million in equity. (USAID, 2019, p.18)

4.2.4 Communication with Customers and Raising Awareness

As mentioned previously, there is a great need for key stakeholders to raise consumer awareness and communicate better with the target population. Findings of the analysis revealed that there are multiple ways how this is done and depending on the stakeholder there are multiple successful options that highlight impacts on consumers' health, the livelihood of communities in general, and the economy.

Offering potential consumers to see and tough the solar lamps in a kiosk before buying them proofed especially successful for solar companies like NOTS Solar Lamps. Consumers oftentimes only know little about the new technologies and therefore appreciate seeing and touching them first. A similar strategy is renting solar products to students and children in schools that can take the products home and show them to their parents who then can experience the benefits firsthand without paying the full price for it. Working with teachers that in turn can give student's parents an honest review is also successful since they are slightly easier to reach through the educational institution and might be a more trustworthy source of information. These are all initiatives that directly communicate with customers but there are also other successful strategies. Working with soap opera stars that promote the solar devices proofed to be a successful way to raising consumer awareness and promoting the brand itself. A strategy that worked well for the Government of Rwanda was communicating through agents that held roadshows which also allowed potential consumers to see and hold the solar products. Press conferences and talk shows at different media houses that were streamed live on the radio and TV are another successful communication tactic. Important to mention is that the government also uses these awareness campaigns to educate consumers on inferior products to counteract market spoilage because of them.

Additionally, these initiatives are used to communicate in a very careful way the electricity strategies and changes since this is a very sensitive topic to discuss with the population and led to unsuccessful projects in the past because citizens might have felt offended and had little trust in the new technologies. Like the 2016 report of ODI stated, “any kind of fuel subsidy reforms is a sensitive issue and needs to be communicated extremely well to win the support of the population” (p.8).

4.3 PAYG Solar Business Models and Technology

4.3.1 Innovative Ways of Communication

Considering all the before mentioned challenges of low smartphone and internet access penetration, PAYG solar companies invented innovative ways on how to keep communicating with customers through technology. One of the great opportunities of PAYG solar business models and their devices is that some can communicate with their consumers even if the internet connection fails via SMS or mail. So regardless of if the platform has an internet connection, PAYG solar companies and consumers can communicate with each other and unlock or pay electricity via SMS, phone call, mail. This in turn highlights the importance of ICT sector-private sector partnerships. Because Western smart solar technologies are oftentimes not applicable in the Sub-Saharan African context, this is a major opportunity, like the online newspaper Power Technology described in an article. “While some European smart meters have been used for energy access projects in Africa, [...] they struggle to cater for the technical demands of working on the continent, with an unreliable infrastructure and internet availability” (2018).

4.3.2 PAYG Solar Business Models Only Advantages?

An interesting finding is that newspapers and press releases do not talk about the disadvantages of PAYG solar business models. Their main focus is on how innovative they are and how many beneficial effects they can have on the Sub-Saharan African population. Although there is a clear upside of these technologies which should not be downplayed, there are still challenges. Other stakeholders like for example non-profit organizations, ThinkTanks, and Watchdog organizations did mention smart metering threats related to data collection and privacy risks. EFF wrote in a news article (2018) online “By contrast, smart meters record consumption much more frequently, often collecting thousands of readings every month. Due to this frequency, smart meters show both the amount of electricity being used inside a home and when that energy is used.” The Government of Rwanda on the other hand sees the technology’s main downside concerning environmental issues. Since the renewable solar devices will make old alternative energy fuels redundant, such as kerosene lamps which would need to be recycled.

4.3.3 Advantages of PAYG Solar Business Models and Technologies

Despite these challenges, almost all stakeholders agree on the beneficial effects these solar devices can have on the population. Microfinance and other new finance models are characteristic for PAYG solar business models and the first step for low-income customers to access to modern, safe, and reliable energy. Another advantage is that these models allow customers to pay in many different ways. Although the main focus is on the pay-as-you-go function, mobile money, and digital payment methods, there are still companies that allow their customers to pay in cash via an agent. If digital payment options are used, mobile money can help to increase the overall revenue even if the installments are only small amounts which in turn benefits the economy in the long run and establishes a credit history. By doing that, customers have a better chance of participating in the market and it is easier for them to receive credit from a local bank. Another advantage that got mentioned in the analysis articles via several consumer statements was that it is much more convenient and saves for them to pay for electricity. PAYG solar business models have one thing in common. Customers do not need to go somewhere, wait a long time in lines, and risk going home in the dark which is especially dangerous for women. They can pay and manage every payment from the comfort of their homes. Additionally, because of the new governmental policies that require local involvement, PAYG solar business models create new jobs since the solar devices need to be produced, monitored, and need maintenance. Lastly, one of the most obvious benefits are environmental benefits that support the goals of a low carbon future. Nevertheless, as mentioned before, governments must monitor and check if PAYG solar companies stick to the rules and engage in recycling alternative fuels that get redundant with the introduction of new technologies.

4.3.4 Data Collection and Privacy Risks

Starting with the most noticeable finding, besides non-governmental organizations, ThinkTanks, and Watchdog organizations, no other stakeholder mentions privacy risks and who gets to collect how much, and which amount of data. EFF discussed in a news article (2016) that "the ever-accelerating pace of technological development carries serious privacy implications and that smart meters are no exception." They also argued that companies cannot expect consumers to know the greater picture of the amount of data collected and what risks this might imply. Furthermore, smart meters collect data every five to thirty minutes and because appliances have certain usage patterns, this sensitive information can give indicators about whom many people live in a household when they are at home, what appliances they are using, and what the people living in the household are doing.

One key player who mentions the importance of consumer privacy protection but did not specifically talk about the threats of data collection or privacy risks are ICT companies. The analysis revealed that interestingly no other stakeholder mentioned the need and opportunities of data management as much as they. It is one of their main arguments to strengthen their relationship with other stakeholders and why they can be important to the industry. Although this has nothing to do with smart meter data, sensitive information about what users do with their phones in connection with PAYG solar platforms still poses risks as discussed in the literature review.

On the other hand, the issue around who gets to manage which data is mentioned by other stakeholders too. Unfortunately, none of the stakeholders talk specifically about who owns the data. NOTS Solar lamps for example, only mentions that “there are not many companies that can provide such platform and the ones that can are tough negotiators, especially on the ownership of the platform and data” (2017, p.3). But besides this information, there are no other indicators of how their partnership agreement looks like.

5. Discussion

To answer the research question, *how can innovative digital and renewable energy initiatives reduce energy poverty in Sub-Saharan Africa while considering the ethical and sustainability tensions and tradeoffs,* a content analysis was conducted. The previous chapter discussed the results from the 18 chosen documents of six different stakeholders, governments and UN systems, grid operators and social entrepreneurs, ICT companies, non-profit organizations and ThinkTanks, press and newspapers, and lastly aid agencies and foundations.

This chapter will discuss each sub-question starting with stakeholder dynamics, then consumers and communication, and finally which role PAYG solar business models and their technology play.

5.1 Stakeholder Dynamics and Partnerships

The first sub-question asked about which different stakeholders are involved and which opportunities and challenges they experience regarding their relationships. Furthermore, it questions data security and privacy governance since smart renewable energy technologies require and store vast amounts of data.

Starting with the definition of “universal electricity access”, the analysis revealed that some stakeholders, like the Government of Ghana, actually exclude ten percent of the whole population from the National Electrification Strategy which questions whether or not there is even something like a “universal” right to electricity. The findings suggest otherwise which means that international politics like the United Nation’s Sustainable Development Goals which set the target for modern, reliable, affordable, and sustainable energy for all (United Nations, n.d.) will be difficult to reach. This finding suggests that stakeholders need to rethink the common grounds and factual definitions like "universal access" that construct a starting point for innovative renewable energy projects. The scholars Stephanidis and Savidis (2001) argue that there are several different connotations stakeholders can have regarding this term. Some use the concept to refer to the inclusion of "special users" to be politically correct, others introduce the term to advert to a “good user-based design” which considers all different needs of potential users. Other definitions are rooted in the US Communications Act of 1934 which was introduced with telephone, radio, and telegraph services to ensure equality regardless of race, religion, sex, or national origin. But because recently we develop into an Information Society globally, "universal access" reappears in terms of a critical quality target. This means that the accessibility challenges go beyond sociodemographic characteristics since many users lack digital literacy which deepens and broadens the accessibility gap. The authors suggest that nowadays stakeholders need to consider several angles of diversity like what the targeted user characteristics are, what is the scope and general nature of the tasks given (e.g., digital literacy), how are smart devices used in various contexts and which effects do they have on the broader propagation into social and business endeavors (Stephanidis & Savidis, 2001). Furthermore, the findings show that many stakeholders describe the PAYG solar customers as mainly a last-mile distribution sector, but if one-tenth is excluded from the market then it might be difficult to consider them as last-mile distribution customers. As discussed in the literature review, energy rights for all citizens regardless of their income and location is essential for successful energy development, otherwise, energy strategies pose significant ethical and sustainable weaknesses to future developments (Banerjee et al., 2017). Considering that ten percent of all citizens of Ghana are neglected in the national electrification strategy would mean that the population has unequal technological and energy rights, and the electrification plan creates a loophole for that.

Additional to the before-mentioned finding, the analysis showed that governments like the one of Rwanda actually decide who gets access to which electricity. Because there are different levels of energy quality, some households do not even have the chance to upgrade their electricity access if they do not meet the formal criteria set by the government. This raises the same question as before, how can everyone have a right to modern and reliable electricity, if the government gets to decide which access type fits best their economic goals?

Connected to the finding that governments plan and decide who gets which electricity access, is that they also see themselves as the main key player when it comes to planning, operating, and owning the solar systems. The results show that there are clearly controverse expectations between the different stakeholders when it comes to this topic since PAYG solar companies would like to own the data themselves, which in turn does not fit with the expectation of ICT companies that have the same goal. Governments on the other hand might be opposed to letting other stakeholders than themselves own and gather data because of reasonable digital colonialism reasons. Researchers argue that the current debate in African countries is because these digital infrastructure poor countries do not have the extensive data protection laws compared to Western countries. This means that with the African landscape and tech companies' goal to establish a presence there, digital colonialism is increasingly the center of debates. Digital colonialism refers to big tech companies from Western countries that own, analyze, and control user data. These companies leverage their power and influence to access before untapped data sources and because of missing data laws, there is a high risk of data exploitation to generate profit. Another angle of the debate is that even if there are policy frameworks that protect user privacy, there is are oftentimes still loopholes, lack of regulation enforcement, and unchecked concentrations of vast data aggregation masses (Coleman, 2018). This dynamic creates a barrier and therefore negotiations take considerably longer and are described as difficult by the involved parties. However, it is important to note that this phenomenon cannot only be found specifically for renewable energy initiatives in the Sub-Saharan context. Studies suggest that digital platforms create their own infrastructures which then raises multiple questions about state power, data policies, regulations, and more which are all linked to who collects, stores, and controls data (Plantin & Punathambekar, 2019). It is therefore not surprising that the different stakeholders are embroiled in difficult negotiations about the ownership and implementation of PAYG solar technologies.

Moving on to the need for a “holistic approach”, results show that stakeholders struggle because they are missing better cooperation and understandings of each other. Specifically, the struggle to access and gather data got mentioned several times due to the actual lack of data, well-shielded information, or too shallow partnerships. Considering how multifold the stakeholders’ relationships are, this finding demonstrates that this might be a barrier that needs to be tackled.

Considering all these results it is not surprising that one main focus of governments is to increase local partnerships since most of the key players are international. Like Tagliapietra (2018) argued, it is not possible to establish a sustainable electricity system in Sub-Saharan Africa with only international organizations and institutions. Domestic stakeholders are an essential part and need to be integrated to create a successful energy access development. An interesting movement that might be another reason for increasing local partnerships is the issue of data ownership and control and the strategy of governments to keep data transfers and ownership within their own country. However, scholars argue that data localization measurements which are used to encumber data transfers across and between national borders are actually dangerous since they can backfire and harm data privacy and security. What is even more important is that localization measures increase the government’s ability to surveil the own population while still risking the data to be transferred across borders. Additionally, data localization would require the governments to build up their own strong fundamental information architectures since the World Wide Web was designed to share information globally. Moreover, building these infrastructures would increase the costs for its users and create additional accessibility burdens (Chander & Lê, 2014).

In order to even collect data, users need to have smartphones, and because in a study in Sub-Saharan Africa 31% of people indicated they use their PAYG solar energy to charge their smartphones (Kizilcec et al., 2021), partnerships between ICT companies and PAYG solar companies are essential. This is supported by one of the findings of the analysis which highlighted these stakeholders' interest in working together and strengthening their partnerships. Although they have varying reasons for this, their contributions are highly important for customers for example to close the gender gap of a 41% difference in internet use (GSMA Association, 2019).

One interesting finding, however, was that ICT companies do not only partner with renewable energy companies but also with national grid providers. The analysis showed that Eskom, one of the state-owned national power suppliers, and Huawei are partnering to accelerate digital transformation. This is contrary to previous findings, which state that Eskom exerts political and technological resistance (Kirshner et al., 2019, p. 122). Although the analysis revealed that other stakeholders do not mention any partnership or relation between these key players, they are working closely together profiting from each other's knowledge and experiences. Something that might influence the partnership and why other stakeholders do not talk about it might be because of Huawei's past controversy regarding the 5G EU market ban and involvement of China. But besides healthy skepticism, which is to a certain degree reasonable, Huawei's ban has nothing to do with espionage but geopolitical reasons about who gets to manage and control user information (Rühlig & Björk, 2020). Furthermore, Huawei is part of a greater knowledge transfer in Kenya and Nigeria as the company provides local engineers with training so they can install and operate on its platform which in turn fuels the local market growth (Tugendhat, 2020). The company's support in establishing key mobile infrastructures and providing equipment in several Sub-Saharan African countries is further aided by the financial support of the Bank of China and the French company BNP Paribas. With the premise to accelerate innovation-driven development and the influence on smartification and renewable energy initiatives, Huawei is leading the way in this tech energy sector on this continent (Hanson et al., 2020). Since the company is also one of the main tech giants in the industry and was wrongly blamed and blacklisted on the US market by US President Donald Trump (Hosain, 2019), the engagement of Huawei displays the larger ties of Sub-Saharan African countries with China as well as a shift in geopolitical power from the US to China in these regions (Hanson et al., 2020).

Research showed that there are several reasons for mistrust in the PAYG solar energy context. It can be because consumers know that FinTech companies and digital payment platforms gather highly sensitive data which might be susceptible to fraud (Panos & Wilson, 2020), or because consumers have little to no experience with digital devices (Coetzee, 2019). Especially the latter was also found in the analysis since many consumers are first-time owners of smartphones and have limited to no digital literacy. A finding that is in line with studies from the literature review is that an important step for governments was to implement quality standards. Because the PAYG solar market is growing and inferior products came into the market, consumers made bad experiences which then resulted in mistrust. This is also problematic since awareness campaigns are expensive and do not only profit companies that meet quality standards but also others.

5.2 Consumer Communication, Opportunities, and Challenges

The second angle of the broader research question asks about who the target audience of PAYG solar businesses is and how the initiatives are designed to incentivize these users to adopt their products.

One of the most mentioned concepts concerning consumer characteristics was “last-mile distribution”. But, because the amount of Sub-Saharan citizens who live without modern, safe, and reliable energy is relatively big, as mentioned in the literature review, it is questionable whether or not the terms “last-mile distribution” are actually correct. Like USAID wrote in its 2019 report, “Given Ghana’s high electrification rate relative to other countries in sub-Saharan Africa, GOGLA estimates that SHS products have penetrated approximately 19 percent of the off-grid market, suggesting that plenty of customers remain to be served” (p.15). This means that there are contradictory expectations about what “last-mile distribution” actually looks like along the previously discussed tern “universal electricity access” where ten percent of Ghana’s population are excluded from the calculations.

Findings that are in line with previous studies (Boudet, 2019; Nkoana, 2018; Rose & Chilvers, 2018), are about customer characteristics. The findings reveal that users live mostly in rural areas, have a low income, and many of them never owned a smartphone before because of low smartphone and internet access penetration (GSMA, 2020, p.25). Other characteristics that were mentioned in the stakeholder documents during the analysis are language barriers, lack of digital literacy, and missing consumer knowledge about what they can buy with their smartphone on the PAYG solar platforms since many only used alternative fuels like kerosene lamps and coal before. It is therefore understandable that consumers need training in all these areas from how to use a smartphone to how much kWh they need to buy for their home. So, to ensure sustainable renewable energy development, PAYG solar projects need to ensure that their customers are supported by agents and other training institutions which many key players actually already work on.

Connected to this finding is that projects have established special mentorship programs for women and girls. The intention behind this training is to enable female users to learn about how the PAYG solar devices work, what they need to do for their maintenance, and what the business models behind these innovative devices are. The findings of the analysis further show that these female mentorship projects are successful with an increase of 22 percent of female leadership positions and a 30 percent lower employee turnover. Considering that there is still a relatively big gender gap in Sub-Saharan Afrika when it comes to female entrepreneurship and that cultural reasons can play an important role in this development, these mentorship projects offer a great way to support women and girls and to offer specific education for them (Ngoasong, 2019). On the other hand, it is questionable whether or not the intentions behind these training projects align with the seemingly positive purpose. The results show that many of these projects are implemented to increase international funding and to create a more reliable workforce, which might indicate that the main reasons for these programs are actually financial ones. Additionally, without addressing the cultural gender differences and gender gaps, these mentorship programs can actually increase women's workload on top of the tasks they need to do for their household. The goal to empower women might then backfire and create even greater burdens for them. Nevertheless, they have an appositive impact on female entrepreneurship and although it would be important to also contribute to cultural changes (Ngoasong, 2019), they offered many women and girls the opportunity to get education on the knowledge behind PAYG solar businesses and devices.

The last finding concerning consumer communication is that stakeholders pay increasing attention to raising consumer awareness. This also means that they found various new ways to communicate with them like offering days where they can see and touch solar products at kiosks or during roadshows. Other projects allow students to rent solar devices and take them home to their parents so they can experience the products firsthand. Additionally, there are cooperations with teachers which promote the devices to parents. Other awareness campaigns are through soap opera stars which function like influencers, but also press conferences and talk shows proofed to be successful. Although the findings show that governments agree in their contracts with PAYG solar companies that they take on the role of raising awareness, it is still important that all stakeholders work together for this since another finding showed that one of the main issues is that there is relatively limited knowledge of Sub-Saharan African citizens about if and what innovative renewable energy options are on the market and how they have access to financial support (McGrath, 2021).

5.3 PAYG Solar Business Models and Technology

The last sub-question which will be answered in this section addresses how PAYG solar business models function, what opportunities they offer, and which privacy challenges arise because of the vast data collection.

One of the main opportunities PAYG solar business models have is that their technology is design in a way that allows the supplier and consumer to communicate even if the internet connection fails. So regardless of whether or not the platform is connected to the internet, there is still the opportunity to communicate via SMS or phone call. On top of that customers do not even need to leave their house for this. Because there is still a 41 percent gender gap of internet access and the internet access rate is still relatively low especially in certain rural areas (GSMA Association, 2019), PAYG solar business models are designed in a way that considers these challenges.

One of the main challenges for many rural and low-income citizens is that they cannot afford modern, sustainable, and reliable energy access (Lazaroiu & Roscia, 2018). This is where one of the innovative energy initiatives' main opportunities comes in because the business models are planned with these financial challenges in mind. Options that customers have are microfinance models or rent-to-own options where customers pay a certain amount of money every month until they own the device. By doing that they mostly use digital payment platforms of FinTech companies that enable customers to establish a credit history which can be used to establish proof of creditworthiness for local banks and financial institutions that do not lend them money otherwise (Iazzolino & Mann, 2019). Another advantage that comes hand in hand with the use of digital payment platforms is the increase in mobile money revenue which supports economic growth and because ICT companies are essential for this development, they are incentivized to support PAYG solar customers as mentioned in the results chapter. But even if customers do not have the option to pay their bills via digital payment platforms because they do not have a smartphone or do not feel comfortable using them, the findings show that PAYG solar business models are designs flexible so that agents can come regularly and collect the weekly or monthly installments in cash. All these benefits contribute to a sustainable energy access development as they offer easy and safe ways for customers to get access to modern electricity without the need to wait in kiosk lines for a long time and risking going how when it is already dark.

However, findings also show that there are disadvantages to PAYG solar business models. One of the greatest risks of these technologies is that smart meters collect vast amounts of data at a high frequency. Because this gives away how many people live in a household, when they are at home, and which appliances they use since these usually have certain usage patterns, the technologies pose a threat to customer data which is highly sensitive. This finding is in line with previous studies that also address the high frequency of data collection and what algorithms might be able to derive from the sensitive information (Coetzee, 2019). It is therefore essential that governments and policymakers find ways that protect customers to contribute to a sustainable energy development that considers ethical questions like how can distributive and procedural energy justice be ensured (Batel, 2020)?

Lastly, there are several open questions regarding data collection and privacy risks. The analysis revealed that although stakeholders like PAYG solar companies and ICT companies mention the issue of data collection and who gets to own and manage the information, they do not reveal anything about how their final partnership negotiations look like in this regard. The findings show that they only mention how difficult it is for PAYG solar companies to arrange the data ownership between the partners and that ICT companies see themselves as key players because of their vast user data collection, however, none of these stakeholders give any insight into who gets to own, manage, and control which data. This finding is in line with previous studies that also discuss the lack of transparency in this context (Magalhães & Couldry, 2020). However, as mentioned before, to ensure distributive and procedural energy justice and to allow customers to know how much and where their data is stored, and what happens to it (Batel, 2020), stakeholders need to communicate these practices better.

6. Conclusion

The purpose of this thesis was to explore how innovative digital and renewable energy initiatives, like PAYG solar business models, can reduce energy poverty in Sub-Saharan Africa while considering ethical and sustainability tensions and tradeoffs. For this reason, a content analysis was carried out analyzing 18 chosen documents of the following six different stakeholders, governments and UN systems, grid operators and social entrepreneurs, ICT companies, non-profit organizations and ThinkTanks, press and newspapers, and lastly aid agencies and foundations. Special attention was paid to the three research angles that were each formulated in sub-questions considering stakeholder dynamics, consumer communication, opportunities, and challenges, and lastly PAYG solar business models and the technology behind them.

The findings show that to establish a sustainable and ethical energy development, it is important to integrate all stakeholders and addresses question like equal energy justice, privacy protection, and procedural fairness. The findings showed that first of all the concept of “universal electricity access” needs to be investigated further. Because governments like the Government of Ghana define this goal in their electrification strategy as accomplished if 90 percent of the population have access to electricity, ten percent of the whole population are left out. Furthermore, the question about whether or not this is really a last-mile distribution needs to be raised since all of these findings indicate that they might be a threat to a sustainable and ethical energy development which ensures the right for modern and clean energy for all and offers fair distribution and procedural justice. However, the results indicate that steps in the right direction are already made since stakeholders already realize the great need for a holistic approach that considers all involved parties which is why governments are eager to incorporate local entrepreneurs and workforces in the process. Another important finding showed that to combat the low smartphone and internet access penetration rates (GSMA, 2020), PAYG solar companies and national grid companies need to deepen their partnerships with ICT companies. Because digital literacy and smartphone ownership are important for customers, so they can pay their energy bills via digital payment platforms, more work needs to be done to enable them to do that. Additionally, challenges regarding consumer mistrust need to be addressed since findings show that inferior PAYG solar products, little consumer experience with digital devices, and low awareness rates can create mistrust in the population. However, the analysis revealed that governments and other stakeholders are already working on this issue by offering training for local workforces and specifically female mentorship programs, as well as implementing quality frameworks to counteract the spread of inferior products. Lastly, stakeholders who collect consumer data need to be more transparent with which and how much data they collect and how they manage information. Additionally, governments and policymakers need to determine ways to protect consumers from privacy threats for a safe development that creates consumer trust and values their sensitive financial and usage data.

This research shows that although there are already several initiatives in place that ensure an ethical and sustainable renewable energy development that supports long-term energy access growth, like training programs, awareness campaigns, and aspirations to deepen and strengthen partnerships, there are still some challenges remaining. Questions like how to define “universal electricity access” to ensure an equal right to modern and reliable energy and how to ensure consumer trust by offering transparency regarding their data still need to be addressed. Nevertheless, the findings showed that renewable energy initiatives have a great potential to combat energy poverty and help Sub-Saharan African citizens to get access to safe, affordable, and reliable electricity.

Because several other stakeholder documents might have been beneficial to the analysis, a limitation of this research is that it does not include all key stakeholders equally and therefore, needs future research to close this gap. Additionally, because it would have gone beyond the scope of this study and therefore poses another limitation, it would be interesting to investigate specifically what consumers experience regarding the renewable topic via for example social media posts. Because this study does not consider privacy policies and legal corpora, future research is needed to investigate how PAYG solar companies operate regarding data collection and privacy policies. Furthermore, more insight is needed on how cultural factors influence the renewable energy initiative development.

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Appendix A – Content Analysis Documents

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Appendix B – Coding Framework

CATEGORY	SUB-CATEGORY	SUB-SUBCATEGORY	ILLUSTRATIVE QUOTE	ARTICLE
STAKEHOLDER DYNAMICS	**Stakeholder Partnerships**	Government-Private Sector Partnership	Mini-grids will be developed by the private sector with Government playing a key role in identifying sites and establishing a framework through which these can become financially viable investments.	1/1
		Government-Private Sector-Development Partner Cooperation	In developing this risk-mitigation facility, MININFRA will engage with both the private sector and development partners.	1/1
		Government-	2. Help to mobilize access to	4/2

		Bank Partnership	finance across the value chain in cooperation with financial institutions and other relevant funding bodies.	
		ICT company-bank partnership	In Uganda, the mobile operator has launched, in collaboration with a national bank, some advanced financial products.	3/4
		Foundation Partnerships	Our partnership with A2EI aims to bridge that gap and make data available to everyone in the sector.	6/2
		Private Sector Partnerships	In January 2017 we entered into LoI's with three Rwandan institutional investors.	1/2
		Public Utility Provider-ICT Company Partnership	Wednesday, 17 May 2017: Eskom today announced a smart grid joint innovation initiative with Huawei at the African Utility Week (AUW) event in Cape Town.	2/3
		ICT Company-Private Sector Partnership	In an era when mobile operators face declining voice revenues, these later trends suggest that PAYG offers a very important new opportunity for mobile operators to diversify their revenue streams.	3/4
		Government-ICT Company-Finance	At the end of 2018, the GoG, in partnership with major financial institutions and	6/1

		Institution Partnership	mobile network operators, completed an interoperability initiative to allow the transfer of funds across mobile money platforms and bank accounts.	
	Stakeholder Involvement	EU: government involvement	› Community-Based Health Planning and Services Initiative. Under this government initiative, the European Union recently supported an effort to construct several new community health clinics and provided off-grid clinics with stand-alone solar battery systems.	6/1
		Foundation involvement	A third project concentrates on designing and installing remotely monitored meters and smart sensors to gather large-scale data.	6/2
		Development Finance Institution involvement	Given that RVO has qualified our SHS activities in Rwanda as a ‘Groenproject Buitenland’ it is attractive for Dutch green banks / funds to invest in the notes.	2/1
		Law enforcement agent involvement	And law enforcement agencies are already trying to get access to data from energy companies without a warrant.	4/1
		Watchdog organization	On appeal, EFF and Privacy International filed an amicus	4/1

involvement	brief urging the Seventh Circuit to reconsider this dangerous ruling. And in its decision, released last week, the Seventh Circuit wisely recognized that smart meters and analog meters are different:	
Citizens group involvement	In this case, a group of citizens called Naperville Smart Meter Awareness challenged Naperville's policy of requiring every home to have a smart meter, objecting on Fourth Amendment and other grounds.	4/1
ICT company involvement	Mobile operators, particularly in emerging markets, are therefore looking for strategic opportunities to drive revenue across other revenue streams such as mobile money and data.	3/3
Aid agency involvement	Power Africa brings together technical experts with stakeholders from the public and private sectors to increase energy access rates in sub-Saharan Africa.	6/1
International Donor involvement	Ghana has an active donor coordination working group that includes representation by all of the major donors working in the on- and off-	6/1

			grid energy sector.	
		Renewable Energy Association involvement	AGSI supports the industry through government advocacy, technical training, and collaboration with donors.	6/1
		Training Institutions, incubators, & accelerators involvement	Program participants complete three- to six-month training courses and become “Power-Sisters” with all-around knowledge about solar power and the business sense behind it.	6/1
	Stakeholder Communication & Initiatives	Funding Initiatives	In 2014 we got the commitment of a successful entrepreneur to invest EUR 0.8 million in the NOTS businesses.	2/1
		Bank financed projects objectives	The banks involved in the country’s renewable energy sector generally are Stanbic Bank, Ecobank Ghana, Fidelity Bank, and CalBank. Even in these cases, loans have high interest rates and short tenors.	6/1
		Aid agency & foundation objectives	The goal of the Power Africa Off-grid Project is to provide support to private off-grid companies and make the markets in sub-Saharan Africa more attractive for investment and operations.	6/1
		Private sector actions	The markets with the highest penetration today have	4/2

			below the line marketing activities that allow consumers to see and touch a solar light before making a purchasing decision.	
		Private sector strategy	IDCOL in turn provides refinancing and grant support, as well as necessary technical assistance, to partner organisations, including microfinance institutions, that install solar home systems, extend credit to end users, and provide after sales service.	4/2
		PAYG solar company progress	Angaza’s software platform serves over 200 distributors of life-changing products across 50 countries.	3/1
		Private sector goal	In 2020 we plan to become active in at least one other African country through a JV with a successful local entrepreneur / enterprise.	2/2
		Government communication strategy	7. Promote consumer awareness for clean and high-quality energy access and challenge any existing prejudices against solar through educational campaigns, including face to face product demonstrations.	4/2
		Government strategy	Fund (FONERWA) the government of Rwanda has established a vehicle to	4/2

			finance enterprises that have an impact on the environment.	
		Government objectives	The Government of Rwanda recognises the vital role that electricity access plays in accelerating economic development through improving health and standards of living.	1/1
	Stakeholder Opportunities & Challenges	National Utility provider Issues	While national utilities have proved unable to serve large populations, over the past few years a new solution has emerged: micro-grids.	5/3
		Investment issues	For implementing our SHSMEB plan we need USD 1.5 – 2.0 mln equity in NOTS Solar Lamps (Rwanda) Ltd (or in NOTS Solar Lamps BV) and about USD 25 mln in a SPV (Sagamba Solar Loans Ltd) for funding SHS loans to consumers.	1/1
		Smart Energy: country & market differences	"In the off-grid context and in Africa – where many countries are looking to privatise their utility sectors – there is a lot more innovation.	5/3
		Private sector challenges	Thus, areas that lack access to these services are especially challenging for PAYGO companies.	6/1
		Stakeholder	I would like to also thank all	1/1

		importance	stakeholders and MININFRA staff that contributed to the development of this strategy and look forward to the continued support in implementing it.	
		Market progress	This shows that PAYG solar can drive a range of mobile money transactions, and therefore makes a very important use case to develop mobile money ecosystems.	3/4
		Market objectives	Although, increased focus in the industry strives to deliver and demonstrate these economic impacts through productive use appliances.	3/4
		Market knowledge gap	Analysis of the existing market in each country will be necessary to determine which specific policy measures are necessary to provide the appropriate enabling environment there (UNEP, 2015).	4/2
CONSUMER COMMUNICATION, OPPORTUNITIES, & CHALLENGES	**PAYG solar sector-customer interaction**	Consumer protection	Adopting and enforcing minimum standards is key to maintaining consumer confidence and supporting market growth.	4/2
		Customer characteristics	Rural consumers, especially women, are particularly prone to this type of financial exclusion, compounding the	6/1

			challenge experienced by SHS companies to offer financed energy products to off-grid customers.	
		Low-income household electricity access characteristics	Because off-grid systems can be scaled to meet demand requirements, they can provide an affordable and flexible way for households to start progressing up the energy ladder, particularly for those on low incomes.	1/1
		Upper-income household electricity access characteristics	This will continue to act as the power backbone, providing power to large users and driving economic growth.	1/1
		Consumer lack of knowledge	As the court explained, the third-party doctrine rests on “the notion that an individual has a reduced expectation of privacy in information knowingly shared with another” and “in this context, a choice to share data imposed by fiat is no choice at all.”	4/1
		Customer education	“That consumer needs a lot of education in order to trust the service and to pay regularly and understand what they are buying.”	5/3
	Communication & smart technology	Consumer benefit of technology	These five pilot mini grids provide 24/7 electricity to about 10,000 beneficiaries	1/3

			for the first time, allowing these fishing communities to use electricity to improve their livelihoods.	
		Traditional technology issues	The farmer had been waiting for a connection to the grid, but because her house is far from the nearest transformer, she decided to go solar.	5/1
		Customer interaction with new payment technology	"Digital payments avoid all the transactions costs of cash collection and customers can easily be reached and served," he added.	5/1
		Consumer benefit of digital payment	"I simply transferred the money from my bank account into my phone to buy electricity," said the 35-year-old mother of three. "It's fast, easy to use, efficient and saves a lot of time and money."	5/1
PAYG SOLAR BUSINESS MODEL & TECHNOLOGY	**Development**	Digital Payment system	In parallel with the negotiations with GoR, we further sharpened our business model and entered into a partnership with ComzAfrica Ltd for developing our SHS Loan Management Platform ('SLMP'), an ICT system with functionalities including: credit assessment, auto-withdrawal, client contracting	2/2

			and default rate management.	
		PAYG solar business model	The PAYG solar model has spread rapidly across developing countries as a means of delivering energy services.	3/4
		Technological development	Advancing technology means that there is an ever-expanding range of ways for households to access electricity: a solar lantern that can also charge a phone or radio; a larger solar home system that can light an entire house and power appliances such as a television; and a grid connection that can power large-scale commercial and industrial use.	1/1
		Technology quality assurance	Standards and Consumer protection will be put in place: Whilst this Strategy seeks to attract a wide range of private companies and a multitude of different products there is a need for certain service levels and standards to be enforced to both protect consumers and mitigate against the risk of inferior products or suppliers.	1/1
		Role of grid connection	Government will continue to roll-out the electricity	1/1

			network via EARP, focusing on connecting high-consumption users and driving economic growth.	
		Data collection	Smart meters collect energy usage data at high frequencies—typically every 5, 15, or 30 minutes—and therefore know exactly how much electricity is being used, and when, in any given household.	4/1
		Privacy policy change	We applaud the Seventh Circuit for recognizing that smart meters pose serious risks to the privacy of all of our homes, and that rotely applying analog-era case law to the digital age simply doesn't work.	4/1
		Traditional payment options	The customer pays in full upfront; therefore, no financing is required.	6/1
	Opportunities	Digital payment system benefits	This study, along with years of evidence from the GSMA Mobile Money programme and the broader GSMA Mobile for Development, show that mobile money can be a crucial engine of growth for both economic developments and the mobile industry.	3/4
		PAYG solar potential	Unlocking solar energy to power farms and businesses	6/2

			in Africa.	
		Private sector benefits of smart metering	Steamaco's smart meter comes with a whole slew of automated marketing features, Leaf adds, that enable utilities to reach and educate their customers.	5/3
		Customer benefits of technology	Companies today can identify the best potential sites and customers using data analytics. Power usage and payments can be controlled with smart metering.	5/3
		Off-grid solar benefits	In recognition of the economic, social, and health benefits that basic access to electricity provides, Government of Rwanda, with the support of development partners, will establish a mechanism to allow low-income households to access modern energy services through a basic solar system.	1/1
		Mini-grid opportunities	Mini-grid systems, where several homes are connected (often with pay as you go systems) are emerging as a key player for cost-effective and reliable electrification of rural areas.	1/3
	Challenges	Digital payment challenges	Mobile operators have found that there are two main hurdles for mobile money adoption: either people do	3/4

			not need it, or they do not know how to use it.	
		Off-grid solar initiatives challenges	Resource constraints to develop these models are another factor.	3/3
		Issues of traditional energy systems	A grid expansion project, while it may provide power to bigger appliances, can take years and significant investment to reach a rural or low-income community.	4/3
		Issues of alternative energy fuels	Diesel generators can produce power when it is needed, but have significant operational costs and complexities associated with the purchase of diesel.	1/1
		Data privacy issues	Due to this frequency, smart meters show both the amount of electricity being used inside a home and when that energy is used.	4/1