Towards energy leapfrogging in sub-Saharan Africa: Exploring strategic investment as a way to increase access to finance among mini-grid energy service companies

by

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Thesis presented in partial fulfilment of the requirements for the degree of Master of Philosophy in Sustainable Development in the Faculty of Economic and Management Sciences at Stellenbosch University

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March 2018

Declaration

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Date: March 2018

Abstract

The aim to extend national grids as an avenue for universal electricity access in sub-Saharan Africa failed extensively over the past few decades. The high cost of extending national grids coupled with low electricity demand and inability to pay in rural areas have resulted in 590 million people remaining without access to electricity, 80% of whom live in rural areas. Mini-grids powered by renewable energy are increasingly seen as viable alternatives by virtue of the technology's lower cost, decentralised and flexible nature and provision of energy services that are on par with that of national grids. The technology especially shows promise in sub-Saharan Africa owing to the vast renewable energy potential in the region. However, a variety of challenges are keeping mini-grid energy service companies (ESCOs) from expanding towards commercial viability. As it stands, mini-grid projects in sub-Saharan Africa are not financially sustainable without the help of grants, which results in an unattractive risk-return profile from an investor's point of view. This study argues that if the sector is to reach a point where debt and equity investors can generate a return, grants need to be complemented with additional funding to enable mini-grid ESCOs to scale up operations, expand their project portfolios and drive down costs. Thus, the main purpose of this study was to explore the potential of strategic investment as a way of attracting additional funding to mini-grid ESCOs. Data was collected by means of in-depth interviews with executive managers of mini-grid ESCOs that are operational in East- and Southern Africa and private sector companies that were identified to exhibit potential for investing strategically in mini-grid ESCOs. The results indicate that there is a need for strategic investments in mini-grid ESCOs. Electric utilities and independent power producers (IPPs) would be more likely to invest, given the closer proximity of mini-grids to their core business. The study contributes to the evolving best practices of viable mini-grid business models, by recommending that mini-grid ESCOs should build competencies in customer relationship management, rural distribution practices and the extrapolation of rural households' uptake of electricity and electricity dependent products and services from consumption data to commercial applications. Indeed, the study shows that potential strategic investors attach value to these focus areas, with the implication that when mini-grid ESCOs can demonstrate these competencies successfully, the probability of successfully attracting strategic investment would increase. Considering these implications, the study offers a

contribution to the development of pathways to attract investment to mini-grid ESCOs, the achievement of which will facilitate energy leapfrogging in the region.

Opsomming

Die poging om nasionale krag netwerke te verleng ten doel van universele toegang tot elektrisiteit in sub-Sahara Afrika het grootliks misluk oor die afgelope paar dekades. Die hoë koste met betrekking tot die verlenging van nasionale krag netwerke tesame met die klein vraag na krag en beperkte vermoë om te betaal in landelike gebiede het daarheen gelei dat 590 miljoen mense in die streek steeds nie toegang tot elektrisiteit het nie. 80% van hierdie bevolking woon in landelike gebiede. Mikro krag netwerke wat krag opwek deur middel van hernubare energie bronne word toenemend gesien as lewensvatbare alternatiewe as gevolg van laer kostes, die gedesentraliseerde en buigsame aard van die tegnologie en die vermoë van die tegnologie om krag te bied wat op dieselfde vlak van gehalte is as nasionale krag netwerke. Die tegnologie lyk veral belowend in sub-Sahara Afrika, gegewe groot hernubare energie potensiaal in die streek. Daar is egter 'n verskeidenheid van uitdagings wat keer dat die mikro krag netwerk sektor in sub-Sahara Afrika uitbrei tot kommersiële lewensvatbaarheid. Die stand van sake is dat mikro krag netwerk projekte in sub-Sahara Afrika tans nie sonder die hulp van skenkings finansieël volhoubaar is nie, wat lei na 'n onaantreklike risiko-opbrengs profiel vanaf die oogpunt van 'n belegger. Vir die sektor om 'n punt te bereik waar leners en ekwiteit beleggers 'n opbrengs kan verkry, word addisionele bevondsing bykomend tot skenkings benodig. Dit sal dan mikro krag netwerk ontwikkelaars in staat stel om hul bedrywighede te vergroot, projek portefeuljes uit te brei en kosts af te dwing. Die hoof doel van hierdie studie was om die potensiaal te eksploreer van strategiese beleggings as 'n manier om addisionele bevondsing te lok na mikro krag network maatskappye. Data was versamel deur in-diepte onderhoude te voer met uitvoerende bestuurders van mikro krag netwerk maatskappye wat aktief is in Oos- en Suider-Afrika asook privaat sektor maatskappye wat potensiaal toon om strategies te belê in mikro krag netwerk maatskappye. Die resultate dui aan dat daar 'n behoefte vir strategiese beleggings in die mikro krag netwerk sektor is. Dit wil blyk asof onafhanklike kragverskaffers die meeste potensiaal toon om strategies te belê in mini krag netwerk maatskappye as gevolg van die nabyheid van mikro krag netwerke aan hul kern area van besigheid. Die studie maak 'n bydrae tot die ontwikkelende beste praktyke van lewensvatbare mikro krag network besigheidsmodelle, deur voor te stel dat mikro krag netwerk maatskappye kundighed moet bou in kliënt verhouding bestuur, landelike verspreiding praktyke en die uitbou van huishoudings se aanneming van

elektrisiteit en elektrisiteit-gebaseerde produkte en dienste vanaf verbruiksdata na kommersiële toepassings. Die studie toon dat potensiële strategiese beleggers waarde heg aan hierdie fokus areas, met die implikasie dat wanneer mikro krag netwerk maatskappye hierdie kundigheid suksesvol kan demonstreer, die waarskynlikheid van suksesvolle aantrekking van strategiese belegging sal verhoog. In hierdie wyse maak die studie 'n bydrae tot die ontwikkeling van strategieë vir die aantrekking van beleggings na die mikro-krag netwerk sektor, sodat 'n energie sprong gefasiliteer kan word in die streek.

Acknowledgements

First and foremost, I am eternally grateful for the guidance and strength that I receive from the Heavens in the clouds, the wind, the earth and in all ubiquity. I would also like to thank the following people for their unwavering support throughout this year, without which this research would not have seen the light:

My father, Pieter, for helping me to flesh out research ideas during those challenging beginning phases and those regular fireside chats about mini-grids. My mother, Narine, for always showing me the light when I can't find it. The two of you have continuously supported me throughout my studies and instilled the values of perseverance and hard work in me and for that I am grateful. My sister, Carina, for your love and support. My partner-in-crime, Nadia, for always being willing to help out and your love and support.

Prof. Josephine Musango and Prof. Alan Brent, my industrious supervisors, for your valuable assistance throughout the research process. Nicolas Rolland, for introducing me to mini-grids and enabling me to see how it can change the narrative of rural electrification in sub-Saharan Africa. The uMAMA team, without whom this would have been a lonesome journey. My classmates and the SI staff, it has been an honour undertaking this journey with you. You have inspired me in so many ways.

All the interviewees who will remain anonymous, your insights and contributions are highly appreciated.

Finally, I would also like to thank Stellenbosch University for the financial assistance in support of this study.

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List of Acronyms and Abbreviations

€	Euro
$	United States Dollar
AC	Alternating current
ACORE	American Council on Renewable Energy
CO_2	Carbon dioxide
CSI	Corporate social investment
CSR	Corporate social responsibility
DC	Direct current
EPC	Engineering, procurement and construction
ESCOs	Energy service companies
GIZ	German Agency for International Cooperation
GW	Gigawatt
Hz	Hertz
IEA	International Energy Agency
IPP(s)	Independent power producer(s)
IRENA	International Renewable Energy Agency
IRR	Internal rate of return
ISP(s)	Internet service provider(s)
kW	Kilowatt
kWh	Kilowatt-hour
LCOE	Levelised cost of electricity
LPG	Liquid petroleum gas
MIA	Microgrid Investment Accelerator
MNO(s)	Mobile network operator(s)
MW	Megawatt
NGO	Non-governmental organisation
NPV	Net present value
PV	Photovoltaic
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RETs	Renewable energy technologies

ROA	Real options analysis
T&D	Transmission and distribution
UN	United Nations
V	Volt
W	Watt
Wp	Watt-peak

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Definition of Concepts

Electric utility

An electric utility is a privately- or publicly held company that is involved with the generation, transmission and distribution (T&D) of electricity to end users. Electric utilities can be active in both generation and T&D, or specialise in either of the two. If an electric utility is responsible for both, the company is typically referred to as a vertically integrated utility.

Electricity distribution

Electricity distribution entails the delivery of electricity over relatively short distances with the use of low voltage lines between a local substation and end-users.

Electricity transmission

Electricity transmission refers to the delivery of electricity over large distances with the use of high voltage lines, typically from utility scale power plants to local substations.

Energy leapfrogging

Energy leapfrogging is a form of technology leapfrogging, whereby technology leapfrogging theory is applied to the context of energy technologies. As such, energy leapfrogging is described as the deployment of state of the art energy technologies in areas where the dominant prior technology from developed areas have not been deployed.

Energy service company (ESCO)

An ESCO can be involved with a range of energy supply and management activities, such as engineering, procurement and construction (EPC), energy financing and monitoring of performance (Morgado 2014). Vine (2005) concurs and defines an ESCO as a company that is involved with developing, installing or financing energy projects.

Independent power producer (IPP)

An IPP is a private company that owns and operates facilities for the generation of electricity. IPPs generate profit by selling electricity to electric utility companies.

Mini-grid

A mini-grid is a decentralised renewable energy technology (RET) that provides electricity from a centralised point of generation in a town or village. In most cases, a mini-grid supplies 220 Volt (V) 50 Hertz (Hz) three phase or single-phase alternate current (AC) electricity with a low-tension distribution network to customers (Chaurey & Kandpal 2010). A mini-grid can either be designed to be completely based on renewable energy sources, backed up with battery storage or a source of dispatchable renewable energy, such as a biomass gasifier, or it can be designed as a hybrid between renewable energy sources and a diesel genset (Chaurey & Kandpal 2010).

Risk-return profile

A risk-return profile is defined as an assessment of the potential financial return against the risk of financial loss of an investment (Hofstrand 2013).

Strategic investment

Strategic investors comprise organisations that are not investing solely for a direct financial return, but for new markets and know-how that could be obtained through the investment (Economy Watch 2010; Privco 2016). A strategic investment does not merely involve a financial transaction, but involves a range of engagements between two companies including, but not limited to, supply agreements, technology sharing agreements, and research collaboration (Economy Watch 2010).

CHAPTER 1: INTRODUCTION

1.1 Introduction

The sub-Saharan Africa population amounts to approximately 1 billion people (World Bank 2016). Of this population, 590 million people still lack access to electricity, as reported by the International Energy Agency (IEA) (2017). Moreover, 80% of the population without electricity live in rural areas (IEA 2017). The deployment of national grids over long distances to electrify rural areas has proven to be ineffective as the demand for electricity in rural areas is insufficient to recoup the cost of installing transmission and distribution (T&D) infrastructure (Szabó, Bódis, Huld & Moner-Girona 2011; Williams, Jaramillo, Taneja & Ustun 2015). As a result, decentralised solutions are increasingly viewed as superior in the energy poverty crisis, because they eliminate the cost of T&D over long distances by bringing generation in proximity to the load (Chaurey & Kandpal 2010; Tenenbaum, Graecen, Siyambalapitiya & Knuckles 2014).

This research is concerned with renewable energy mini-grids as a decentralised solution for rural electrification in sub-Saharan Africa. The study explored the potential of strategic investment in increasing access to finance for mini-grid energy service companies (ESCOs) in sub-Saharan Africa, with the purpose of scaling up the commercial mini-grid sector in the region and in turn facilitating energy leapfrogging. Surveyed mini-grid ESCOs were operational in East- and Southern Africa as these ESCOs are more established, being the longest operating ESCOs with more experience to draw from during interviewing (Blodgett, Moder, Kickham & Leaf 2016; Duby 2017; Duby & Engelmeier 2017). Their unique insights, gained from a pioneering process of rural mini-grid business model development enabled the researcher to justify the relevance of the findings of this study for mini-grid ESCOs that will follow in the path created by these first movers. The comparability between rural energy project landscapes (Williams et al. 2015; Knuckles 2016; Duby & Engelmeier 2017) and the widespread presence of renewable energy technology value chains across the wider region (Duby 2017), further facilitates the relevance of the findings drawn from the pioneering ESCOs in East and Southern Africa to ESCOs that are looking to establish or expand operations elsewhere in sub-Saharan Africa.

This introductory chapter provides the context in which the study was conducted. The chapter opens by providing the background for the study, in the process referring to broad trends and statistics that point to the importance of the research focus along with the rationale of the study. This is followed by the more specific discussion around the problem statement and research objectives. The scope and limitations of the study are then discussed. The chapter concludes with the chapter outline of the study.

1.2 Background

A variety of indicators and trends form the context in which the focal point of this study is located. Together, they inform and justify the focal point of the study, and are discussed next.

1.2.1 Decentralised renewable energy for rural electrification

The IEA and World Bank (2014) report that only 30% of the global non-electrified population can feasibly be electrified with the expansion of national grids. 70% of the global non-electrified population will be best served with decentralised options, comprised of mini-grids and stand-alone off-grid systems (IEA & World Bank 2014). Of this share, 65% is to be electrified with mini-grids and 35% with stand-alone off-grid systems (IEA & World Bank 2014). With regards to sub-Saharan Africa specifically, the forecast model developed by the IEA (2014) projects that by 2040, 315 million people in rural areas will have received access to electricity. Of this population, the IEA (2014) projects that 80 million people will receive access to electricity by means of stand-alone off-grid systems, while 140 million people are projected to receive access to electricity by means of mini-grids. The remainder, 95 million people, will be electrified through grid extension (IEA 2014). Connecting 140 million people to mini-grids would require the installation of between 100 000 and 200 000 mini-grids, depending on the number of households and businesses connected to each mini-grid (IEA 2014). This translates to a requirement of developing between 4000 and 8000 mini-grids per year for the next 25 years (Africa Progress Panel 2017).

As the costs of renewable energy technologies (RETs) continue to fall, in particular photovoltaic (PV) systems, there is growing consensus among scholars and practitioners that a large portion of prospective off-grid and mini-grid systems in sub-Saharan Africa will generate electricity from RETs (Szabó et al. 2011; Glemarec 2012;

World Bank 2016). Furthermore, the IEA (2014) projects that PV technology will account for the majority of off-grid and mini-grid electricity generation in sub-Saharan Africa by 2040, as illustrated in Figure 1.1.

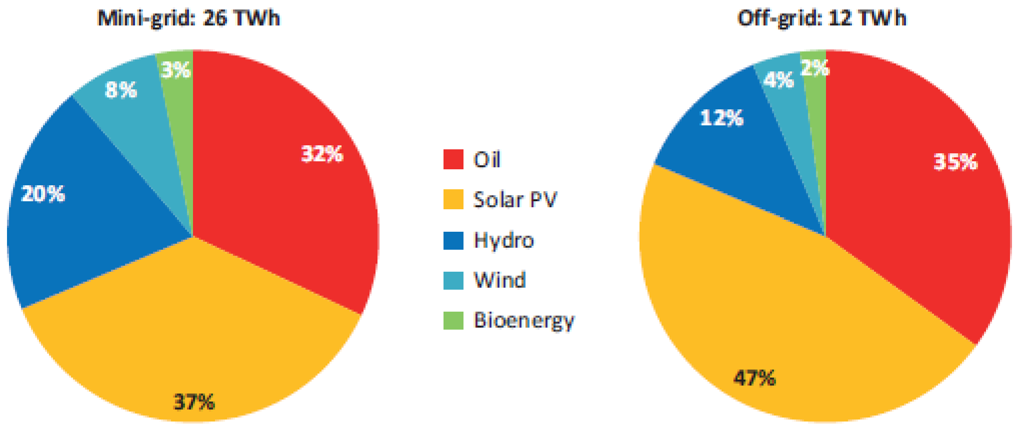

Figure 1.1: Electricity generation technology mix in mini-grid and off-grid systems in sub-Saharan Africa by 2040
Source: IEA (2014)

1.2.2 The emerging market opportunity for mini-grids

The International Renewable Energy Agency (IRENA) (2016a) notes that the cost decline of RETs, in particular PV modules, is enabling mini-grids to be a viable option for rural electrification, which brings the sector as a whole closer to commercial viability. As of 2017, there were approximately 150 commercial mini-grids operating in sub-Saharan Africa, which are expected to increase to 7000 by 2021 (Duby & Engelmeier 2017).

In addition, the potential for commercially viable renewable energy mini-grid projects in sub-Saharan Africa is also emerging by virtue of declining costs of batteries and inverters, the emergence of smart metering, mobile money payment software and geographical information systems, governments' calls for private sector investment in rural electrification and increased support among scholars and practitioners for mini-grid ESCOs to charge cost reflective tariffs (Tenenbaum et al. 2014; Williams et al. 2015; Bardouille & Shepherd 2016; IRENA 2016b). The latter is particularly relevant considering that non-electrified households in sub-Saharan Africa already pay $10 billion per year cumulatively on traditional forms of energy, such as firewood, charcoal, candles and kerosene; as estimated by the Africa Progress Panel (2015). Converted into equivalent cost terms, the Africa Progress Panel (2015) estimates an equivalent of $10 per kilowatt-hour (kWh) spent on lighting among these households. Even worse, when converted to equivalent cost terms, non-electrified rural households in sub-Saharan Africa pay around €20-€80/kWh for mobile phone charging (Franz, Peterschmidt, Rohrer & Kondev 2014). Furthermore, households have to spend these amounts on energy while earning less than $2.50 per day on average (Africa Progress Panel 2015). While cost-reflective tariffs vary across projects, they are well below the figures that households spend on these traditional forms of energy, taking into consideration 2016/2017 tariffs, which are comprised of the levelised cost of electricity (LCOE) of the delivered electricity plus a profit margin (Leaf 2015; Blodgett et al. 2016). In 2015, Chattopadhyay, Bazilian and Lilienthal (2015) reported that the LCOE of rural mini-grids amounts to roughly $0.5-0.6/kWh. This concurs with the researcher's calculations, which was completed in 2016 to determine the LCOE of a solar PV mini-grid backed up by battery storage (Troost 2016). These calculations point to a LCOE of $0.57/kWh. Hence, mini-grid ESCOs can generate a return, while providing electricity for rural households at a more affordable price than what is currently being paid for traditional forms of energy. This leads to the acknowledgement that rural households do have the ability to pay cost reflective tariffs in cases where a higher amount is being paid for kerosene, dry-cell batteries and other traditional forms of energy (Economic Consulting Associates & Practical Action Southern Africa 2013; Tenenbaum et al. 2014; Blodgett et al. 2016). Indeed, insights from mini-grid projects in Kenya indicate that customers are willing to pay up to $4/kWh (Blodgett et al. 2016; Duby & Engelmeier 2017).

It must be emphasised, however, that the amount of traditional energy services that are bought are typically small, so while households are paying high amounts per kWh, they are in effect not spending much money in total due to limited uses for energy (IEA 2014). When extrapolating this observation to mini-grid electricity, it would seem that the aim should be to continue to drive down costs so as to enable households to buy larger sums of kilowatt hours.

With $10 billion spent each year on traditional forms of energy by rural households across sub-Saharan Africa (Africa Progress Panel 2015), a considerable market opportunity arises when these forms of energy are replaced with the provision of electricity. Early stage commercial mini-grid pilot projects, located particularly in East- and Southern Africa, have been operational since 2010 with knowledge and best practices being developed accordingly (Hornor & Van Gerven 2015; Blodgett et al. 2016; De Pascale 2016; Powergen Renewable Energy 2016).

Experiences with successful as well as failed projects are increasingly enabling these mini-grid ESCOs to ascend the learning curve. This is facilitating the emergence of commercially viable business models, much of which is centred around the provision of productive power to commercial customers (Duby & Engelmeier 2017). In contrast to basic direct current (DC) electricity solely suitable for household use, mini-grids provide alternating current (AC) grid quality power, which is not only sufficient for household use, but also for productive activities (Zomers 2014; Williams et al. 2015; Knuckles 2016). Productive power is primarily suited for commercial customers, commonly referred to as anchor customers, due to their relatively large energy demand and subsequent importance for revenue flows. These customers require productive AC power to function and typically include small retail businesses, mobile telecom towers, mills, or mines (Blodgett et al. 2016). The energy demand of such customers is more than households, and as such, they buy more electricity, which compensates for households' lower levels of consumption. Insights from the field subsequently indicate that mini-grids with less commercial customers are less profitable (Blodgett et al. 2016). In this way, the provision of productive power to anchor clients drives down costs, increases the profitability of a mini-grid project and, in turn, the attractiveness of the risk-return profile (Schnitzer, Lounsbury, Carvallo, Deshmukh, Apt & Kammen 2014; Williams et al. 2015; Blodgett et al. 2016).

Furthermore, electrifying commercial customers is advantageous for both the local community and the mini-grid ESCO. The provision of productive power enables the emergence of business opportunities and job creation in rural areas and in turn localised economic development (Knuckles 2016). The benefits of economic development that emanates from the consumption of productive power stretch even further to include the perception among the rural population that economic opportunity can also be found in rural areas and not only urban areas (Blodgett et al. 2016). Indeed, this could suggest an alternative approach to the growing urbanisation problem that sub-Saharan African cities face as less people leave rural villages and towns for cities (Williams et al. 2015).

1.2.3 Financing barriers to reducing costs and scaling up the sector

While a commercial market for rural mini-grids can be a reality in the near future, there are significant challenges preventing this from being achieved, of which a lack of investment into the sector is particularly noteworthy (Schmidt, Blum & Wakeling 2013; Energy Access Practitioner Network 2015; Williams et al. 2015; Raisch 2016; Odarno, Sawe, Swai, Katyega & Lee 2017). To reiterate, the Africa Progress Panel (2017) reports that 4000 to 8000 mini-grids would have to be developed per year over the next 25 years to electrify 140 million people by 2040 as projected by the IEA. However, compared to current estimates of mini-grid investments, a much larger amount of investments will be required to build 4000 to 8000 mini-grids per year. There is no precise reported number of required investments to build 4000 to 8000 mini-grids per year. However, the IEA (2014) reports that in total, $61.5 billion in capital investment in mini-grids and off-grid systems is required for its 2040 electrification scenario, which is a continent-wide electrification rate of about 70%. As was mentioned earlier, 65% of this off-grid electrification activity would take place by means of mini-grids. As such, a rough estimate would indicate that $40 billion of mini-grids investments will be required up to 2040, which translates to $1.7 billion per year. However, this significantly exceeds current estimates of investments in mini-grids in sub-Saharan Africa (Africa Progress Panel 2017). It follows that a flood of investments in mini-grids will be required over the next 25 years (Africa Progress Panel 2017), indicating a large market opportunity.

The lack of investments in the mini-grid sector is typically attributed to an unattractive risk-return profile, leading to the reluctance among investors (Schmidt et al. 2013; Williams et al. 2015). To account for the risk of investing in renewable energy projects in emerging sub-Saharan African markets, characterised with little track record and policy uncertainty, international private investors are seeking minimum returns of around 16% to 17% (Donnelly 2015). While this is true for utility-scale projects, a mini-grid project with its higher LCOE and novelty, have to provide returns of between 18% and 20% at the minimum to attract investors (Raisch 2016; Rolland 2016), which is currently not achievable without grants or subsidies (Gaudchau, Gerlach, Wasgindt & Breyer 2013; Raisch 2016). In sub-Saharan Africa, grants and subsidies are required for at least 30% of funding requirements for a mini-grid project to break even (African Development Bank 2016). As such, without grants and subsidies, mini-grid projects are in most cases not financially sustainable, and as a result both established and emerging ESCOs are unable to attract commercial debt and equity finance. Thus, when providing grants, donors, whether they are private or public entities, are in effect supporting the industry to progress to a point where debt and equity finance can be attracted successfully (Bardouille & Muench 2014; George 2014).

However, it has been reported that grants alone are not enough to bring the mini-grid sector to a point of profitability (Williams et al. 2015). Additional funding is required to propel the sector into the commercially profitable stage (Gómez 2013; World Economic Forum & PriceWaterhouse Coopers 2013; Williams et al. 2015). Furthermore, grants are not always the preferred type of funding among mini-grid ESCOs, as they tend to be inflexible and the transaction costs associated with applying are high (George 2014; African Development Bank 2016). The inflexibility of grants is particularly unsuitable for mini-grid ESCOs because their financing needs can quickly change due to unforeseen problems and delays, which is characteristic of the rural electrification and energy access space in sub-Saharan Africa (African Development Bank 2016).

Going forward, there is thus a need for commercial funding such as debt and equity finance (Wüstenhagen & Menichetti 2012). However, debt finance is still unrealistic at this stage, given the risk-averse nature of commercial banks, and African commercial banks' lack of experience in financing small-scale renewable energy projects (African Development Bank 2016; Steurer, Manatsgruber & Jouégo 2016). On the other hand, equity finance can potentially be attracted, but if the investor's goal is short term financial return, the investment is contingent on the premise that the project (in the case of project equity) or the company (in the case of corporate equity) provides sufficient returns for the investor, which, as mentioned, is not yet possible without the help of grants.

The concern of this study is thus not to investigate how donor funding can be replaced, but how it can be complemented with additional private sector funding so that mini-grid ESCOs can expand faster to a point where commercial equity investors and commercial banks will be inclined to invest.

1.2.4 A potential new wave of investments for scaling up the sector

Given that equity finance with the goal of short term financial return and debt finance are unrealistic in the current pre-commercial stage and grant funding having its limitations, this study sought to ascertain whether other investors, who might not be overly concerned with the prevailing unattractive risk-return profile and have a strategic approach to the market, can be attracted to mini-grid ESCOs. This study argues that such investors could be strategic investors, which are defined as organisations that are not investing solely for a direct financial return, but to get a foothold in new markets and for a particular set of desired knowledge or experience possessed by the target company (Economy Watch 2010; Privco 2016). Indeed, as Duby and Engelmeier (2017) note, the emergence of viable mini-grid business models is creating commercially attractive opportunities for early stage or strategic investors. In the case of mini-grid ESCOs in East- and Southern Africa, strategic investments have already taken place, notably from electric utility companies such as E-ON, Engie, Caterpillar and Total (African Development Bank 2016; Duby & Engelmeier 2017), which indicates that mini-grid ESCOs are beginning to create the perception among investors that there is potential for commercial viability (African Development Bank 2016). Thus, the study sought to determine whether an increase of investments could come from electric utility companies or other renewable energy players looking to gain access to emerging energy markets.

In addition to electric utility companies and renewable energy investors looking to gain access to emerging energy markets, this study argues that private sector companies offering electricity dependent products and services could also serve as strategic investors. Companies offering these products and services could have an interest in rural areas being electrified as non-electrified areas could represent a latent market for a range of electricity dependent follow on products and services (Bardouille & Muench 2014). Thus, this study additionally sought to identify the types of private sector companies that are not operational in the energy sector but that offer electricity dependent products and services and have potential to become strategic investors in the mini-grid sector. It is argued that a win-win partnership could be developed between mini-grid ESCOs and these potential strategic investors, as the latter could benefit from latent markets being unlocked through electrification and the local practical knowledge of mini-grid ESCOs by virtue of their physical presence in last-mile rural areas and customer relationships. Access to such knowledge is hard to come by, as distribution channels are frequently cited as a major constraint to deliver products and services to rural communities (Knuckles 2016; Orlandi, Tyabji, Chase, Wilshere & Vickers 2016) and little is known about the consumption preferences of rural households and small businesses (Schillebeeckx, Parik, Bansal & George 2012; Williams et al. 2015). Strategic investors looking to gain access to such distribution channels could thus partner with mini-grid ESCOs with their already established operations. These could serve as channels through which electricity dependent follow-on products and services can be distributed (Bardouille & Muench 2014).

1.3 Rationale for the study

Considering that mini-grid ESCOs in sub-Saharan Africa find it difficult to access financing, this study is deemed relevant because it aimed at exploring strategic investment as an avenue to increasing investments in mini-grid ESCOs. The study broadens and complements the discussion surrounding financing of mini-grid ESCOs given that the literature does not seem to address the possibility of additional sources of investments other than traditional debt and equity for short term financial return and currently deployed grants. In doing so, the following stakeholders may benefit from the study:

i. Mini-grid ESCOs, who struggle to attract financing, may benefit from the study’s findings pertaining to potential strategic investor’s perceptions of the value that mini-grid ESCOs offer. Knowledge of the aspects to which potential strategic investors attach value could enable the development of business models that are in accordance with these perceptions of value.

ii. Potential strategic investors may be interested in the diversification opportunity that mini-grid ESCOs present and to this end they may benefit from findings pertaining to the strategic value that mini-grid ESCOs can offer them.

iii. Energy ministries and rural electrification agencies, through being informed of the potential of strategic investment in mini-grid ESCOs, may realise the hurdle that unfavourable energy policies pose to investment in mini-grids and ultimately rural electrification.

iv. The 590 million people that continue to live without access to electricity in sub-Saharan Africa, to which the essence of this study is dedicated, would hopefully be the ultimate benefactors of the positive chain of events that this study hopes to contribute to, which is to increase investment in mini-grids so that more projects can be deployed for the purpose of delivering productive electricity services.

1.4 Problem statement

Mini-grid ESCOs in sub-Saharan Africa exhibit potential to scale up in the pursuit for commercial viability. However, as the preliminary investigation of this study has shown, a lack of access to finance is a significant challenge to mini-grid deployment. Hence, scholars are calling for more academic work that explores solutions to unlocking private sector investment in rural electrification (Schmidt et al. 2013; Williams et al. 2015). This study sought to answer that call with a specific focus on private sector investment in mini-grids for rural electrification. Mini-grids were selected as the focus owing to the leapfrogging potential of the technology, which manifests in the provision of AC grid quality power generated with renewable energy sources in a decentralised fashion.

The preliminary investigation of this study further indicated that while there is a growing body of literature on the technical and policy aspects of mini-grids, academic work focused on developing additional sources of private sector investment for mini-grids is limited. Some studies set out to develop best practices for financially sustainable mini-grids (Azimoh, Klintenberg, Wallin, Karlsson & Mbohwa 2016; Kirchoff, Kebir, Neumann, Heller & Strunz 2016; Knuckles 2016; Azimoh, Klintenberg, Mbohwa & Wallin 2017), while others were concerned with developing new finance and risk management approaches to lower the risk of investing in mini-grids and other small-scale renewable energy projects (Gershenson, Tilleard, Cusack, Cooper, Monk & Kammen 2015; Raisch 2016; Steurer et al. 2016; Wagemann &

Manetsgruber 2016). However, little work has been done to explore whether investments can be attracted via additional avenues, within the context of the unattractive risk-return profile that characterises mini-grid projects in sub-Saharan Africa (Schmidt et al. 2013; Williams et al. 2015). This study fills this gap by suggesting that strategic investments could play a role in channelling finance to ESCOs and explores this notion accordingly. In exploring the potential of strategic investments, the study responds to the call by scholars for academic work that explores solutions to unlocking private sector investment in rural electrification (Schmidt et al. 2013; Williams et al. 2015).

1.5 Research objectives

The primary objective of this study was to explore the potential of strategic investment as a way to attract additional funding to mini-grid ESCOs in sub-Saharan Africa. This primary objective was comprised of the following specific objectives:

1. To determine the need for potential strategic investment in mini-grid ESCOs;
2. To identify types of private sector companies that could invest strategically in mini-grid ESCOs; and
3. To explore the potential of strategic investment in mini-grid ESCOs from private sector companies identified in objective two.

1.6 Scope and limitations of the study

The scope of the study was limited to renewable energy mini-grids, which implies that in terms of decentralised renewable energy options, solar home systems were not considered in the study. Secondly, this study did not analyse policy and regulation that affect mini-grid deployment in detail, as the scope would have been too broad if considered in conjunction with an exploration of strategic investment potential. Thirdly, the geographic scope of this study was relatively broad. As was stated at the beginning of this chapter, surveyed mini-grid ESCOs were operational in East- and Southern Africa as these ESCOs are more established, being the longest operating ESCOs with more experience to draw from during interviewing (Blodgett, Moder, Kickham & Leaf 2016; Duby 2017; Duby & Engelmeier 2017). The similarity between the issues faced by rural mini-grid ESCOs in sub-Saharan Africa (Williams et al. 2015; Duby 2017;

Duby & Engelmeier 2017) facilitates the relevance of the findings drawn from this study to other mini-grid ESCOs in sub-Saharan Africa that are aiming to attract funding.

The cross-national scope was required because insufficient data would have been yielded from surveying mini-grid ESCOs in a single country, given that there are not enough established mini-grid ESCOs in a single country to enable a domestic survey that would yield sufficient data. Hence, the region-wide scope, while broad, was required.

1.7 Research strategy

Figure 1.2 illustrates the steps taken to develop a comprehension of the research problem, and to achieve the research objectives, so as to describe the potential of strategic investments in mini-grid ESCOs in sub-Saharan Africa.

The first step in this process constituted the literature review, which focused on the most relevant themes for the study, namely: the position of mini-grids in rural electrification, energy leapfrogging, and the role of financial capital in technological change. The literature review further informed the chosen research methods, as well as the questions to be included in the semi-structured interviews. Questions were also identified through discussions with experts in the field.

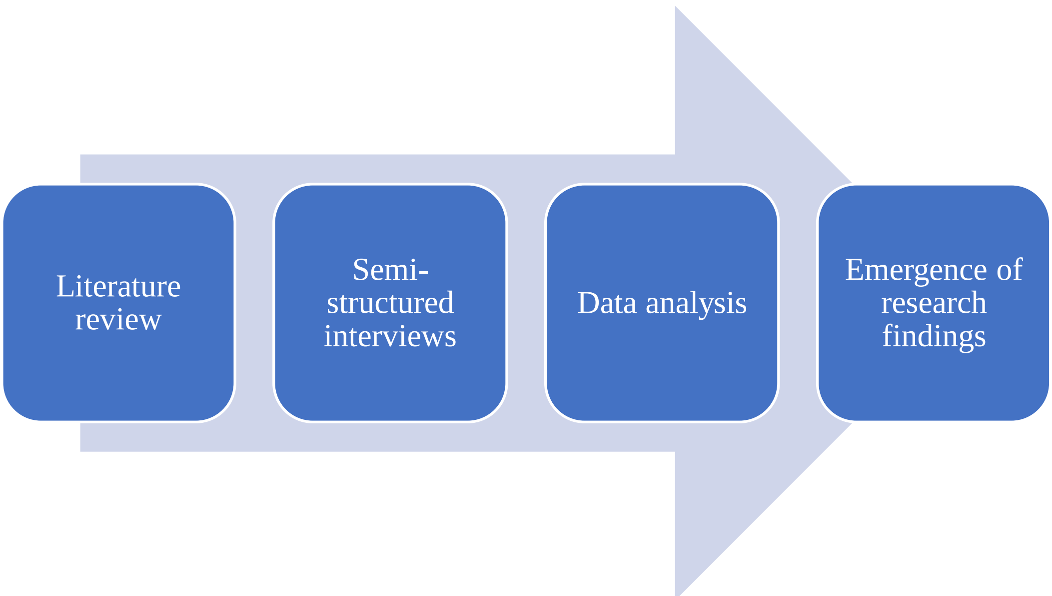

Figure 1.2: Research strategy of the study

The second step of the research strategy constituted primary data collection by means of semi-structured interviews with representatives of well-established mini-grid ESCOs and potential strategic investors. The interviews were conducted either face to face, or, by means of Skype.

The final step involved the analysis of data for findings to emerge under each respective research objective.

1.8 Chapter outline

Chapter 1 has provided the introduction to the thesis, which consisted of background information, the rationale for the study, problem statement and the scope and limitations of the study.

Chapter 2 comprises the literature review. The chapter opens with a review of renewable energy mini-grids in the context of rural electrification. The chapter continues with a review of leapfrogging applied to the energy context. Finally, in keeping with the potential for strategic investments to scale up mini-grid ESCOs, the chapter provides a review of the literature on the role of financial capital in technological change, with specific reference to the determinants of renewable energy investment, the nature of strategic investment and conceptualisations of investments in mini-grids.

Chapter 3 provides the research design, methodology and methods used in this study. The chapter elaborates on the appropriateness of a qualitative approach and sets out the steps taken in designing the research study. This is followed by a discussion of in-depth interviews as the qualitative method. The chapter closes with a note on validity and reliability and how data analysis was conducted.

Chapter 4 reports the results of the study. The results are organised according to each research objective.

Chapter 5 is dedicated to the conclusions and recommendations of the study. The goal of the chapter is to discuss the implications and relevance of the results to practice and academia. The chapter closes with a discussion on the possibilities for future research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In 2015, the United Nations (UN) released a report entitled *Transforming our World: The 2030 Agenda for Sustainable Development*, which comprises a collection of 17 goals that set out the global pathway for sustainable development up to 2030 (UN General Assembly 2015). One of these goals is to *"ensure access to affordable, reliable, sustainable and modern energy for all"* (UN General Assembly 2015:21). Access to energy is thus crucial to achieving sustainable development (Camacho 2015; Urmee & Md 2016) and is regarded as a pillar of human wellbeing and critical to achieving socio-economic development (Bhattacharyya 2012; Chaurey, Krithika, Palit, Rakesh & Sovacool 2012; Eder, Mutsaerts & Sriwannawit 2015).

Yet, approximately 590 million people and 10 million small businesses across sub-Saharan Africa remain without access to electricity, which is stifling socio-economic development in the region (African Development Bank 2014; Bhattacharyya 2012; Sokona, Mulugetta & Gujba 2012; IEA 2014; IEA 2017). Furthermore, 80% of the population without access to electricity live in rural areas (IEA 2017). Those who do not have access to electricity are forced to use dirty, hazardous and expensive forms of energy to meet their energy needs, which causes a range of negative health and environmental consequences (Adkins, Oppelstrup & Modi 2012). Thus, rural electrification is an imperative.

With the goal of providing a theoretical framework for this study, the first theme of this literature review constituted the position of mini-grids in rural electrification. The potential deployment of renewable energy mini-grids in sub-Saharan Africa would signify the adoption of a decentralised, renewable energy-based generation and distribution model, by leapfrogging over the traditional centralised, fossil fuel-based electricity generation and transmission model. It follows that a theoretical underpinning of the deployment of mini-grids in sub-Saharan Africa further required a discussion of energy leapfrogging theory as the second theme of the literature review.

The final theme of the chapter flowed chronologically from the energy leapfrogging discussion. The literature provides extensive support for the argument that the deployment of financial capital in the form of investments is a critical enabler for energy leapfrogging to take place (Gallagher 2006; Chen, Farinelli and Johansson 2010). Thus, given that energy leapfrogging essentially entails technological change, it seemed plausible that the final theme of the literature review should be the role of financial capital in technological change. To elaborate on this theme within the context of mini-grid deployment, the literature on the determinants of renewable energy investment, strategic investment and investments in rural mini-grids were then reviewed.

2.2 Mini-grids in the context of rural electrification

Access to electricity continues to elude rural areas. 78% of the world's non-electrified population live in rural areas and 80% of the non-electrified population in sub-Saharan Africa also live in rural areas (IEA & World Bank 2014; IEA 2017). Since the 1950s, the centralised model, comprising national grid extension, was the dominant approach to rural electrification (Szabó et al. 2011; Zomers 2014). The extension of the national grid is traditionally undertaken by a governmental institution, such as the state-owned national utility or a rural electrification agency (Tenenbaum et al. 2014). However, due to a weak techno-economic fit between national grid extension and rural electrification, sub-Saharan African governments made little progress in electrifying rural areas by means of national grids over the past few decades.

Rural areas are located far away from urban areas, which is where the grid tends to be centralised. The extension of the grid from urban to rural areas thus leads to far higher connection costs in rural areas than in urban areas (Haanyika 2008). It follows that the longer the distance between the nearest grid and the household, the higher the cost of connection will be. For example, in South Africa, as of 2017, connecting an urban household to the grid costs approximately R21 000 ($1620) but a rural connection will cost anything between R30 000 ($2317) and R50 000 ($3860) (Aitken 2017). Similarly, recent data indicates that on average, the cost of connecting a household located more than 70 metres from a low-voltage line in sub-Saharan Africa can fluctuate between $1100 and $2000, with costs decreasing for households that are closer to a line

(Golumbeanu & Barnes 2013; Williams et al. 2015; Lee, Brewer, Christiano, Meyo, Miguel, Podolsky, Rosa & Wolfram 2016). Coupled with the high cost of connection is the low population density, limited ability to pay and low demand for electricity in rural areas, which significantly decreases the probability of recouping the investment made in extending the grid (Yadoo & Cruickshank 2010; Szabó et al. 2011; Williams et al. 2015).

It follows that electrification rates naturally increase in areas with higher population densities and where people have the ability to pay, which is characteristic of urban areas as opposed to rural areas (Sokona et al. 2012). As such, the electrification rate in most rural areas in sub-Saharan Africa have remained virtually the same under the dominance of the grid-extension approach to rural electrification. In fact, in many sub-Saharan African countries, population growth in rural areas is outpacing the arrival of new connections, which in effect leads to an increase of the population without access to electricity (Crousillat, Hamilton & Antmann 2010; Williams et al. 2015). While it is acknowledged that urbanisation is accelerating in countries in the region, it is important to note that the decline in the demand for new connections in rural areas that comes with the migration from rural areas is offset by continual rural population growth (Crousillat, Hamilton & Antmann 2010).

It is thus imperative that the rural electrification narrative should be changed in sub-Saharan Africa and it follows that a shift towards a decentralised approach to rural electrification is required. The decentralised approach to rural electrification constitutes the deployment of stand-alone off-grid systems and mini-grids (Chaurey & Kandpal 2010; Williams et al. 2015; Levin & Thomas 2016; Mandelli, Barbieri, Mereu & Colombo 2016). The former, stand-alone off grid systems, can refer to pico-solar systems, solar home systems or diesel generators (Mentis, Welsch, Nerini, Broad, Howells, Bazilian & Rogner 2015; Lee et al. 2016). Traditionally, diesel generators used to be the more common technology but recently solar-based technologies comprising pico-solar systems and solar home systems are becoming increasingly common by virtue of rising diesel costs, declining costs of PV modules and solar lanterns and innovative customer payment models such as lease-to-own and prepaid schemes deployed by solar home system and pico-solar suppliers (Szabó et al. 2011; Sokona et al. 2012; Bhattacharyya 2013; Levin & Thomas 2016). Pico-solar systems typically range in size between 0.1 Watt (W) and 10W and can provide basic energy services such as lighting and charging of mobile devices (Levin & Thomas 2016; Ngoepe, Henriksen, Power, Panulo, Modungwa, Scholtz & Gulati 2016). The second stand-alone off-grid system, solar home systems, typically range in size between 8 and 200 watt-peak (Wp) and supply DC electricity for the purpose of lighting, charging of mobile devices and in some instances powering fans, televisions and refrigerators (Chaurey & Kandpal 2010; Williams et al. 2015). In most cases, solar home systems also have battery storage and are fitted with a charge controller in order to monitor and control the energy flow between the PV module, battery bank and load (Chaurey & Kandpal 2010). While pico-solar systems and solar home systems are effective in providing electricity for basic household needs, they are not well suited to provide the full range of energy services that households and communities require to power higher wattage appliances and income generating activities needed to move out of energy poverty (Chaurey & Kandpal 2010; Williams et al. 2015; Lee et al. 2016).

Since the 1950s, the diesel generator, the third type of stand-alone off-grid system, has been the conventional solution to decentralised electrification (Szabó et al. 2011). While the use of diesel generators comes at an environmental cost due to considerable carbon dioxide (CO_2) emissions, these systems were more successful than grid extension programs in bringing electricity to rural areas (Zerriffi 2007). Stand-alone diesel generators vary in size, with Rahman, Paatero and Lahdelma (2013) reporting a range between 1 and 25 kilowatt (kW). They typically have lower upfront capital costs than solar home systems, but regularly required maintenance coupled with the gradual oil price increases and the gradual removal of diesel subsidies across sub-Saharan Africa, have increased operating expenses substantially (Szabó et al. 2011; Olatomiwa, Mekhilef, Huda & Sanusi 2015).

Within the decentralised approach to electrification, mini-grids constitute the second group of technologies. Mini-grids typically supply 220V 50Hz single phase or three phase AC electricity with the use of a low-tension distribution network (Chaurey & Kandpal 2010), but DC mini-grids are also increasingly common. Mini-grids can vary in size from a few kilowatts to a few megawatts. Scholars often use a range of terms interchangeably to describe mini-grids (Schnitzer et al. 2014), but sometimes differentiate between these terms to delineate the size and configuration of mini-grids

(IEA & World Bank 2015; IRENA 2016a). IRENA (2016a) groups pico-grids and nano-grids together to describe smaller systems that only supply single phase DC electricity, while micro-grids and mini-grids are grouped together to describe systems that supply single-phase or three-phase AC electricity. However, given that these terms are mostly used interchangeably and that the term mini-grid is most often used to describe the technology, mini-grid is the term that will henceforth be used in this study.

Mini-grids can generate electricity from a variety of technologies including PV arrays, biomass combustion systems, wind turbines, hydro systems and diesel generators (Brent & Rogers 2010; Chaurey & Kandpal 2010; Williams et al. 2015). Furthermore, hybrid mini-grids, which combine at least two energy generation technologies, are also common (Brent & Rogers 2010; Olatomiwa et al. 2015; Knuckles 2016). When a mini-grid is hybridised, it will usually take the form of a combination between a diesel generator and a RET such as a PV array. Mini-grids that are powered by 100% renewable energy can either be configured on the basis of dispatchable renewable energy such as hydro or biomass or on the basis of intermittent renewable energy sources, such as solar (Odarno et al. 2017). Intermittent sources are, however, typically backed up by battery storage to provide backup during night time and cloudy days (Khalid, Ahmadi, Savkin & Agelidis 2016). However, due to the high cost of battery storage, battery-backed mini-grids tend to be smaller in size (Brent & Rogers 2010; Bardouille & Muench 2014; Blodgett et al. 2016). DC mini-grids powered by solar PV are also increasingly regarded as a viable mini-grid configuration. DC mini-grids are cheaper and more efficient than AC mini-grids as an inverter is not needed, resulting in less losses incurred in power conversion (Dragičević, Lu, Vasquez & Gerrero 2016). However, the lack of AC power means that the powering of income generating activities is limited. Furthermore, as soon as a requirement arises for lengthy reticulation, the cost of a DC mini-grid can surpass an AC mini-grid.

Mini-grids are by no means a new technology. Along with the use of stand-alone diesel generators to electrify rural areas in sub-Saharan Africa over the past few decades, diesel-based mini-grids were also deployed by governments. Today there are still many diesel mini-grids operating in sub-Saharan Africa, as Figure 2.1 indicates. National government agencies continue to operate these projects (Duby & Engelmeier 2017).

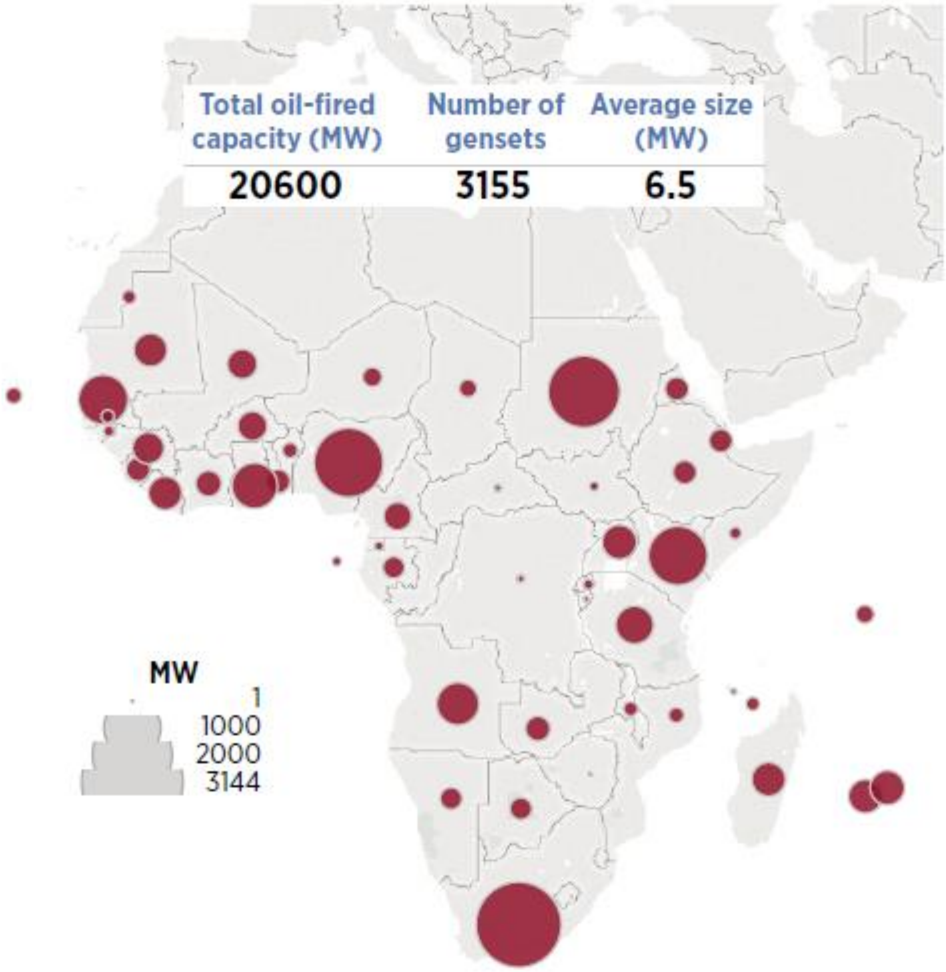

Figure 2.1: Existing diesel mini-grid capacity in sub-Saharan Africa
Source: IRENA (2016a)

South Africa, Nigeria, Sudan, Kenya and Senegal rank as the countries with the largest diesel mini-grid capacity (IRENA 2016a). Across the continent, the average size of these systems is 6.5 megawatt (MW) (IRENA 2016a). Scholars and development institutions have pointed out that prospective mini-grid activity in sub-Saharan Africa will not only entail the development of new renewable energy mini-grids but also the retrofitting of current diesel mini-grids with RETs, in particular PV arrays (Tenenbaum et al. 2014; Blechinger, Papadis, Baart, Telep, Simonsen 2016). The large capacity of diesel mini-grids in the region thus offers a significant opportunity for mini-grid ESCOs to deliver these retrofitting services. Considering all electricity generation technologies, the installed capacity of mini-grids of varying sizes in sub-Saharan Africa stands at 1.2 gigawatt (GW) (Africa Progress Panel 2017).

In summary, given that 80% of the 590 million-large energy poor population of sub-Saharan Africa live in rural areas far away from the national grid, decentralised RETs offer the most potential in electrifying these areas. Considering the distinction between solar home systems and mini-grids, it is argued that the latter is better suited to comprehensively eradicate modern energy poverty by virtue of the technology's ability to provide the full gamut of energy services required to power income generating activities and high-wattage appliances. Indeed, mini-grids constitute a real leapfrogging opportunity, which leads to the next theme of this literature review, namely energy leapfrogging.

2.3 Energy leapfrogging

Energy leapfrogging emanates from the broader theory of technology leapfrogging, which was coined by Soete (1985) and is defined as: *"the diffusion of state of the art technology in a region where the dominant technology from more developed areas has not been diffused"* (Fong 2009:3707). Energy leapfrogging is thus typically seen as the application of technology leapfrogging theory to the context of energy technologies, which can be described as the deployment of state of the art energy technologies in areas where the incumbent technology from developed areas have not been deployed. Gallagher (2006) describes energy leapfrogging by stating that developing countries can leapfrog the resource- and carbon intensive process of energy infrastructure development previously undertaken by developed countries by transitioning directly to adoption of advanced state of the art technologies. Gallagher (2006) also notes that developing countries can even jump further ahead to become a leader in the field of the particular technology. The resource and carbon intensity described here is typically associated with the centralised approach to electrification, comprising the extension of national grids that transmit electricity generated by fossil fuels (Fox 2016). As such, developing countries that have underdeveloped national grids can leapfrog the centralised approach to electrification and transition directly to a low-carbon decentralised approach, which entails the adoption of decentralised RETs (Levin & Thomas 2016). In this way, leapfrogging to decentralised RETs is evident of how *"leapfrog solutions enable people to skip centralised inflexible dirty industrialisation and go straight to local flexible clean solutions"* Fox (2016:36).

Fox (2016:36) adds that technologies that enable decentralised production, distribution and consumption *"enable prosperity to be highly distributed."* In the same way that mobile devices facilitated decentralised telecommunications through leapfrogging landlines and transitioning directly to mobile telecom towers, decentralised RETs can leapfrog the national grid and directly facilitate the provision of decentralised renewable energy (Fong 2009; Szabó, Bódis, Huld & Moner-Girona 2013; Fox 2016). Decentralised RETs, being leapfrog solutions, can overcome the conventional trade-off between distribution and efficiency which has characterised the industrialisation of developed countries (Fox 2016). As Figure 2.2 shows, the conventional paradigm pertaining to the pursuit of efficiency sees efficiency as only achievable through centralised economies of scale (Fox 2016), such as a national electricity grid.

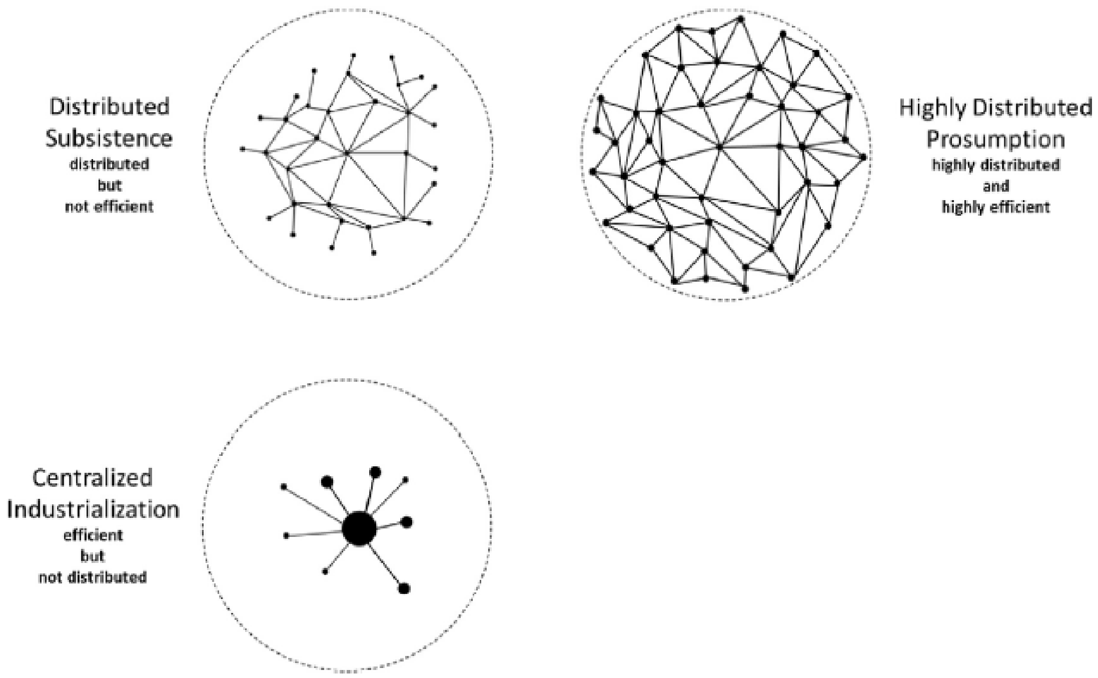

Figure 2.2: Distribution-efficiency trade-off compared to distributed efficiency

Source: Fox (2016)

In this way, Figure 2.2 expresses a trade-off between decentralisation and efficiency through the notions of *"distributed subsistence"* and *"centralized industrialization"* (Fox 2016:37). However, leapfrog solutions challenge this preconception by achieving efficiency in a decentralised manner, which is expressed in Figure 2.4 with the notion of *"highly distributed prosumption"* (Fox 2016:37). Ryan (2009) adds that the shift to decentralisation and the realisation of distributed efficiency are two important design principles for the organisation of a sustainable economy. In this light, distributed efficiency places emphasis on the value of "*smaller productive units*" and "*local and regional resources*" (Ryan 2009:350), which are characteristic of renewable energy mini-grids.

Fox (2016) observes that centralised industrialisation, through the centralisation of infrastructure and other resources, typically leads to the absence of important infrastructures such as electricity in geographical areas that fall outside of the periphery of the centralised infrastructures. The fact that 80% of the non-electrified population in sub-Saharan Africa lives in rural areas is an example of the lack of services in such areas (IEA 2017). This also illustrates the notion that centralisation is best achieved in urban areas, characterised with high population density and concentration of economic activity. As such, decentralisation is indeed essential for the purpose of implementing electricity infrastructure in dispersed locations and, in turn, to foster socio-economic development and prosperity in these locations, given the correlation between energy consumption and economic growth (Kammen & Kirubi 2008; Sokona et al. 2012). To this end, many scholars argue that developing countries have the opportunity to bring electricity to rural areas by leapfrogging the conventional path of centralised fossil fuel-based grid expansion to the deployment of decentralised RETs (Murphy 2001; Sokona et al. 2012; Szabó et al. 2013; Amankwah-Amoah 2015; Fox 2016; Levin & Thomas 2016; Mandelli et al. 2016). In addition to the benefit of accelerated electrification, Murphy (2001) notes that energy leapfrogging is beneficial in the sense that it also facilitates environmentally friendly industrialisation, considering that the environmental degradation caused by carbon intensive energy technologies is avoided when state of the art low carbon energy technologies are adopted. In this way, industrialisation can effectively be decoupled from environmental pollution and greenhouse gas emissions (Swilling & Annecke 2012).

Developing countries are by essence well positioned to adopt state of the art technologies as they are typically not heavily constrained by a pre-existing, locked-in technological paradigm with associated vested interests that resist the adoption of these technologies (Fong 2009; Verbong & Geels 2010; Swilling 2013). Still, there are typically many challenges facing the facilitation of energy leapfrogging in developing countries. In order to facilitate energy leapfrogging, extensive investments of financial capital are required (Gallagher 2006; Chen et al. 2010). However, at the same time, inefficient capital markets in developing countries often prevent the inflow of foreign direct investment (Van Benthem 2015). Additionally, Fong (2009) notes that investment in a novel technology will most likely have a long payback time period due to the infancy characteristics of an underdeveloped market pertaining to the particular technology, which is typically the case in developing countries. In addition to investments, a variety of prerequisites are required to facilitate technology leapfrogging of energy technologies in developing regions (Fong 2009), much of which is not always present in these locations due to "*un-strategic and inconsistent policies*" and "*weak domestic technological capabilities"* Gallagher (2009:384). These prerequisites are elaborated upon in Table 2.1.

Table 2.1: Infrastructural prerequisites for technology leapfrogging

Prerequisites	Examples
Market demand and competition	Competitive pricing Demand for the product or service and the ability to pay for it Foreign direct investment
Institutional capacity	Creating an enabling regulatory and policy environment for the attraction of investment Political, economic and social stability
Human competencies	Development of skills required for technology transfer to take place
Diverse stakeholders	Establishment of strategic links among involved actors Regional and international collaboration
Physical infrastructure	Transportation network

Source: Adapted from Fong (2009)

These prerequisites are often non-negotiable, because the focus of technology leapfrogging is not mere use of technology, but rather the development of capabilities required for the technology to be successfully diffused in the developing region. In this light, Murphy (2001:174) makes a distinction between technology "*adoption"* and technology *"absorption,"* where the former refers to mere use of the technology and the latter refers to the development of technical, organisational and institutional knowledge and skills that allow enterprises and individuals to use the technology efficiently.

2.3.1 Number of energy needs met as a criterion for energy leapfrogging

However, even though decentralised RETs in general are often cited as the goal to which developing countries should strive to in their pursuit for energy leapfrogging, it is important to be critical of the extent to which different decentralised RETs actually constitute leapfrog solutions. The fundamental characteristic that all decentralised RETs have in common is that they supply electricity generated from renewable energy sources in a decentralised fashion. However, differences do exist with regards to the number of energy needs that different decentralised RETs meet. It is argued here that an energy technology should only be regarded as a leapfrog solution if it provides energy services that are on par with the incumbent technology, in this case the national grid. This view is promoted in this study, given that the value of energy leapfrogging would be jeopardised if a technology that provide inferior services compared to the incumbent technology is adopted.

In this light, it is important to critically discuss which decentralised RETs in actual fact qualify as technologies that can enable energy leapfrogging. For this purpose, a distinction is made between mini-grids and stand-alone off-grid systems, such as solar home systems and pico-solar products. While some scholars argue that solar home systems constitute a leapfrog solution over the centralised model of national grid extension (Levin & Thomas 2012; Appies 2016), it is important to note that the quality of power derived from solar home systems is inferior to that of a national grid given that less energy needs are met (IEA & World Bank 2014; Williams et al. 2015; Knuckles 2016; Lee et al. 2016). This is because of the limited applications of DC power and the inability of the power provided by solar home systems and pico-solar products to scale with demand (Lee et al. 2016). Thus, proceeding with an electrification mandate with the conviction that solar home systems is a substitute for grid power is dangerous for the prospect of lifting non-electrified communities out of energy poverty and, in turn, socio-economic poverty. It seems easy to argue that a decentralised RET constitutes a leapfrog solution only because it is decentralised and clean. Instead, it is reiterated here that the criterion of service quality that the technology provides be emphasised. It follows that renewable energy mini-grids are better examples of leapfrog solutions with consideration of the service quality criterion, given that these technologies are decentralised and provide clean energy that is on the level of quality than that of a national grid. Furthermore, mini-grids are also a manifestation of *"highly distributed prosumption,"* a form of network development, as depicted in Figure 2.4. In this way, mini-grids provide the basis of an AC smart grid future for sub-Saharan Africa and in so doing enables the regional power sector to converge with the model of the future global power sector (Powergen Renewable Energy 2016). In this model, several authors have illustrated that AC mini-grids can become nodes in a larger country- or continent-wide AC smart grid (Adil & Ko 2016; Khalid et al. 2016), and thus current AC mini-grid development can act as the building blocks for such a future.

That is not to say, however, that solar home systems have no use in the pursuit of electrifying non-electrified communities. Solar home systems are effective in providing previously non-electrified households their first experience with electricity. After having experience with basic electricity from solar home systems, evidence shows that households aspire to own higher wattage appliances and become dissatisfied with solar home systems due to the inability of such systems to power these appliances (Lee et al. 2016). Indeed, evidence also shows that early adopters of mini-grid electricity in rural villages tend to be households that already own a solar home system, while households with no experience of any form of electricity tend to be sceptical towards the mini-grid (Duby & Engelmeier 2017). Furthermore, once households with no experience of electricity are made aware of the benefits that early adopters accrue from the mini-grid, the uptake of mini-grid electricity accelerates rapidly (Duby & Engelmeier 2017). Thus, in effect, solar home systems create a need for mini-grid electrification, and hence it is argued that previously non-electrified households in most cases need the stepping stone of a solar home system to consume mini-grid electricity. This discussion thus points to a necessary distinction between energy leapfrogging and an incremental step-up in the type of electricity consumed.

In summary, developing countries with low electrification rates are uniquely positioned to leapfrog over the centralised model of electrification and transition directly to the adoption of renewable energy mini-grids. However, as was reiterated in this section, developing countries might not always be able to financially afford to leapfrog to such state of the art technologies (Chen et al. 2010). This points to the importance of mobilising financial capital in the pursuit for energy leapfrogging (Gallagher 2006). In this case, private sector investment is of particular importance, considering that the goal of this study is to respond to the need for exploring ways of unlocking private sector investment in rural electrification. It follows that the next theme of the literature review, the role of financial capital in technological change, flows from this observation. In addition, seeing that the lack of investment is a fundamental challenge to converting the leapfrogging potential of renewable energy mini-grids into a reality, there is a requirement to fully understand the role of financial capital in this regard. Thus, the review of the role of financial capital in technological change will be complemented by an application to the case of strategic investments in mini-grids.

2.4 The role of financial capital in technological change

This section aims to create a theoretical underpinning of the role of financial capital in enabling the diffusion of new technologies. The discussion continues with the application of the theory to the context of renewable energy investment and more specifically strategic- and mini-grid investments.

The role of financial capital in technological change has been extensively investigated, notably by Carlota Perez (Perez 2002; Perez 2007; Perez 2009). Contrary to financial capital, productive capital manifests as established investments in physical capital, as well as intangible assets, such as: knowledge and experience in the incumbent technology, and established networks between incumbent firms and their suppliers and customers (Perez 2007). Financial capital, however, is not bound to these constraints. It is mobile and takes the form of early monetary investments characteristic of venture capital and other early stage risk investments (Perez 2002; Perez 2007; Perez 2009). The latter, in turn, typically manifests in corporate venturing activities of large firms seeking to capitalise on new technologies and new markets for strategic purposes (Jackson 2011; Wüstenhagen & Menichetti 2012). In turn, the strategic intent behind such activities is motivated by long-term financial return prospects.

Perez (2007) further notes that entrepreneurs that are active in the development and diffusion of new technologies often only have technical capabilities and a strong motivation, with little financial resources of their own. To attract finance, they need to form partnerships with the providers of financial capital (Perez 2007), which, as Figure 2.3 indicates, typically takes the form of grants and equity in the initial stages (Wüstenhagen & Menichetti 2012).

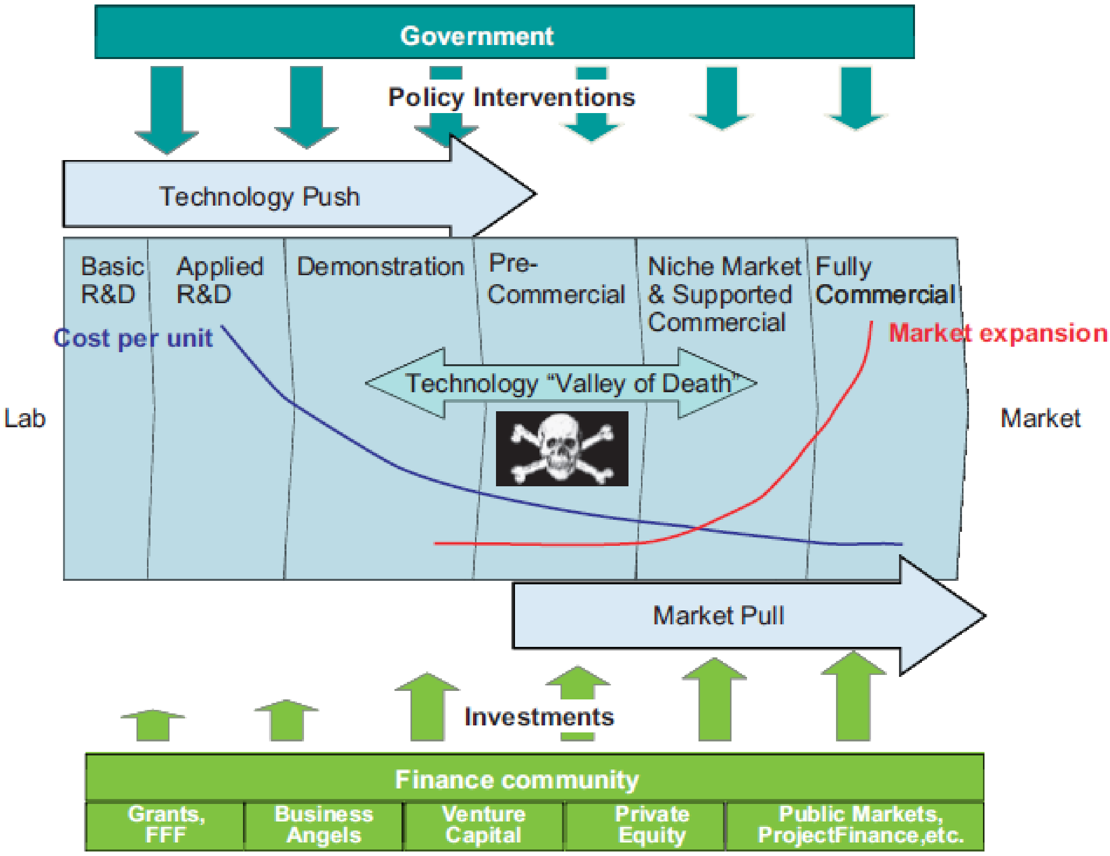

Figure 2.3: Investment requirements for technology diffusion

Source: Wüstenhagen & Menichetti (2012)

When these initial alliances are formed, it typically signals the start of a new cycle of technological change and advancement (Perez 2007). In cases where technological innovations such as renewable energy mini-grids disrupt the status quo, financial capital reinforces this process, or, as Perez (2007:9) summarises, "*financial capital becomes the routine breaker against incumbent production capital.*" However, it is argued here that technological innovations do not necessarily have to compete against established technology in order for financial capital to play an instrumental role. Indeed, financial capital is also instrumental in facilitating the deployment of new technologies in unmet markets where prior technology is not present. This is typically the case in the deployment of leapfrog technologies.

In the context of decentralised RETs, in particular renewable energy mini-grids, many have reported the lack of access to finance among ESCOs that are active in rural electrification in sub-Saharan Africa (Tenenbaum et al. 2014; George 2014; Sinn 2014; Williams et al. 2015). It is also well known that ESCOs are in need of finance to scale up operations (George 2014; Energy Access Practitioner Network 2015; Williams et al. 2015). Thus, it is argued here that financial capital is of crucial importance to the deployment of renewable energy mini-grids and other decentralised RETs in the region. In turn, it can be deduced that the lack of access to finance is a major reason for why the technology diffusion process of renewable energy mini-grids is occurring at a slow rate (Williams et al. 2015; Raisch 2016; Azimoh et al. 2017). This observation connects back to the leapfrogging discussion, in the sense that investment of financial capital in a leapfrog technology such as renewable energy mini-grids is critically important in enabling technology leapfrogging to take place. Following on from Newell (2015), it is argued here that the deployment of financial capital to RETs is a critical determinant of the successful diffusion of RETs in general and in turn the fostering of decarbonised economies.

With the role of financial capital in technological change introduced, it would be plausible to delve deeper into the manifestations of financial capital in the process of technological change and diffusion with an application to the advancement of rural mini-grids. In this light, it is argued that renewable energy mini-grids signify a technological innovation by virtue of new developments in energy storage, metering, cloud based monitoring, and remote payment. In the same vein, it is argued that entrepreneurs, as they are depicted by Perez (2007), manifest as mini-grid ESCOs while financial capital, in the form of venture capital or early stage private equity as discussed by Perez (2007), manifest as potential strategic investments from private sector companies that could have an interest in the electrification of rural areas by means of mini-grids.

2.4.1 Determinants of renewable energy investment

It is widely argued that investment is a function of a decision made on the basis of perceived risk and return (Williams et al. 2015; Raisch 2016). In addition to risk and return, the determinants of investment, in particular renewable energy investment, comprise several non-financial cognitive aspects (see Figure 2.4). These elements will be discussed accordingly in the following sections.

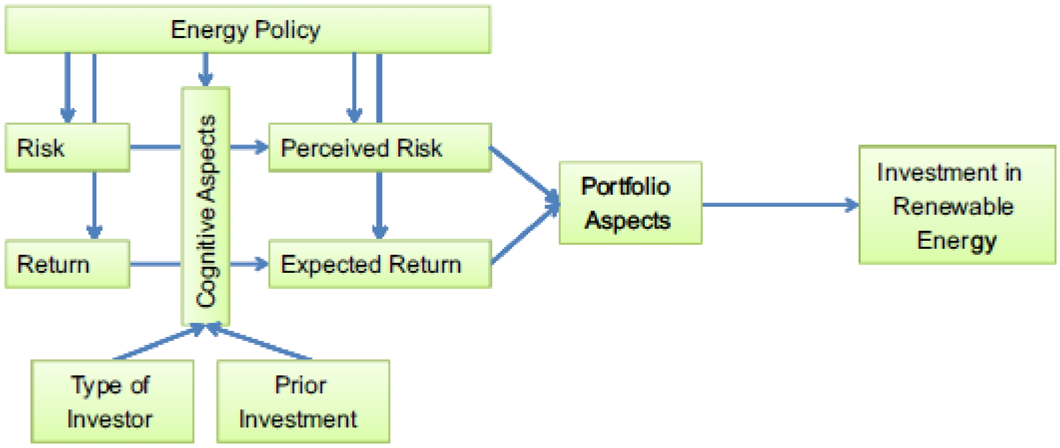

Figure 2.4: Determinants of renewable energy investment

Source: Wüstenhagen & Menichetti (2012)

2.4.1.1 Risk and return

The total risk of a given investment is comprised of systematic risk and unsystematic risk. Systematic risk refers to market-wide risk that affects the company in which the investor is considering investing in. Unsystematic risk refers to firm-specific risk of the company in which the investor is considering investing in. The impact of unsystematic risk is typically negligible in cases when the investor holds a portfolio of investments, given that the unsystematic risk of the respective investments can be averaged out by virtue of diversification.

Systematic risk, however, can potentially have a more noticeable impact on the decision to invest, regardless of whether the prospective investment is made in isolation or as part of a portfolio. Systematic risk is typically measured with the use of a beta analysis, which indicates the extent to which the returns of a company or a security is influenced by market fluctuations (Donovan & Nuñez 2012). A company or security with a high beta value is typically volatile, which implies a potential high rate of return coupled with higher risk (Donovan & Nuñez 2012). A high beta value contributes to a high equity cost of capital, for which investors ought to be rewarded through higher returns (Sadorsky 2012). A beta value of 1 is considered to be neutral, while a value of higher than one indicates relatively high volatility and conversely, a value of lower than 1 indicates relatively low volatility. Renewable energy companies typically have a beta value of 2, but this could have changed among renewable energy companies operating in more established markets with established technologies (Donovan & Nuñez 2012). Taken further, it is argued here that renewable energy companies operating in emerging markets such as sub-Saharan Africa could indeed still have a beta value of close to 2, due to the lack of track record that these markets have.

Expected return of an investment is calculated with the use of financial calculations such as net present value (NPV) and internal rate of return (IRR) and are commonly used in the renewable energy sector (Sadorsky 2012; Tenenbaum et al. 2014). The IRR is a measure of financial viability that is calculated on the basis of the cash flow of a project or company (Tenenbaum et al. 2014). In financial terms, the IRR is described as the discount rate that brings the NPV equal to zero (Santos, Soares, Mendes & Ferreira 2014). The NPV is the sum of the present values of all cash flows of the project (Santos et al. 2014). A positive NPV suggests that a project's cash inflows will exceed its outflows, which in turn indicates that the project and the investment therein will be profitable (Volschenk 2013). Thus, investors that consider an investment will firstly have to study the IRR and NPV of the company or project to come up with an estimation of what the returns would look like over the short, medium and long term.

2.4.1.2 Cognitive aspects in renewable energy investment decision-making

In the context of economic decision-making, it is acknowledged here that humans are in essence irrational beings, which was initially pointed out by Simon (1955) and to which contemporary heterodox and behavioural economic models concur (Lee 2012). Moreover, it is virtually impossible to have access to all the time and information required to make a fully informed and rational decision (Simon 1955; Preiser & Cilliers 2010). The theory of bounded rationality points to these constraints, which contain time limitations, information limitations and computational or cognitive limitations in humans (Simon 1955; Gigerenzer 2001). These limitations ultimately affect and limit the objectivity and rationality with which decisions are made. Thus, in the same way that it is possible for financial markets to deviate from quantitative neo-classical economic models, so too is it possible for investment decisions to deviate from quantitative risk-return analyses (Wüstenhagen & Menichetti 2012).

Furthermore, investment decisions are also influenced by past experience, a phenomenon referred to as path dependency (Goldstone 1998; Wüstenhagen & Menichetti 2012). Path dependency results from a range of so called "*stabilising mechanisms"* such as *"vested interests, sunk investments and stable beliefs"* (Verbong & Geels 2010:1215). In cases where investments into new sectors are required, path dependency particularly fulfils an influential role, as it is the *"lock-in"* of the path dependency that must be overcome for investment to flow into the new sector and for the transition to take place (Verbong & Geels 2010; Swilling 2013).

Extending the premise that investor's perceptions of risk and return are influenced by cognitive aspects, Masini and Menichetti (2013) propose a conceptual framework that emphasises the non-financial factors that affect renewable energy investment decision making (see Figure 2.5). While a priori beliefs can develop from a wide range of personal experiences, the framework makes special mention of a priori beliefs about the technical adequacy of the related RET as well as policy stability and effectiveness (Masini & Menichetti 2013). Secondly, institutional pressure relates to the institutional isomorphism phenomenon, which comprises *"the tendency of decision makers to conform to the rules and the norms prevailing in their institutional environment"* (Masini & Menichetti 2013:515). Masini and Menichetti (2013) add that institutional isomorphism also applies to renewable energy investors, as investors facing similar institutional pressures will deploy similar investment strategies.

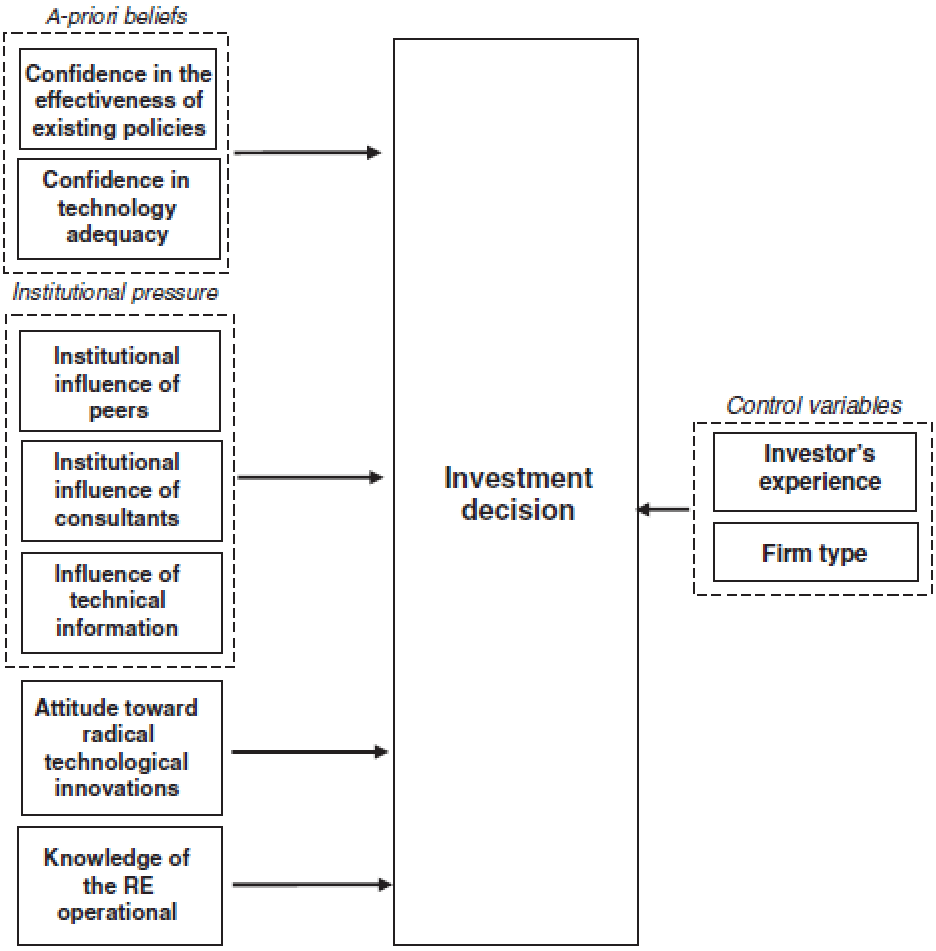

Figure 2.5: Non-financial factors affecting renewable energy investment decisions
Source: Masini and Menichetti (2013)

When investigating the different applications of institutional isomorphism to the case of renewable energy investors, it becomes evident that pressures do not only come from formal institutions, but also informal institutions. Formal institutions can include any public institutions such as an energy ministry or private institutions such as investment firms or consulting firms while informal institutions refer to values, norms and legal frameworks underpinning socio-economic activity (Casson, Giusta & Kambhampati 2010; Smith 2010). In the renewable energy context, these institutional pressures typically manifest in the kinds of investments that other energy investors are making as well as advice from consultants and access to techno-economic information originating from reports and due diligence activities (Masini & Menichetti 2013). The implication for investments in novel sectors such as mini-grids is that it is particularly difficult to get investors to invest in such sectors due to it not being the norm.

Masini and Menichetti (2013) further note that an investor's attitudes towards new technologies, characterised with uncertainty and relatively high risk, also influence the decision to invest. Given that many RETs, in particular decentralised RETs, still carry a great deal of technology uncertainty along with the potential to provide returns in the long term, attitudes to new and often unproven technologies are particularly important.

Lastly, knowledge of the operational context of the RET of concern is also an important factor that influences renewable energy investment decision making (Masini & Menichetti 2013). In this sense, operational context can take the form of industry dynamics. A lack of knowledge of the operational context would increase perceived uncertainty levels of the particular investment (Masini & Menichetti 2013). This would particularly have an effect on risk- and uncertainty-sensitive investors.

When it is accepted that renewable energy investors are influenced by the above-mentioned non-financial cognitive factors, the focus moves towards how perceptions of risk and return can be managed, which is inherently a policy concern (Wüstenhagen & Menichetti 2012). Indeed, in addition to increasing returns or decreasing risk, it ought to be the goal of policymakers to facilitate a positive perception among renewable energy investors by, for example, ensuring a stable policy and regulatory environment (Wüstenhagen & Menichetti 2012).

2.4.1.3 Portfolio aspects

Further consideration should also be given to the role that portfolio aspects play in renewable energy investment decision-making. Portfolio diversification, coined by Markowitz (1952), entails the reduction of risk by combining diverse assets (Wüstenhagen & Menichetti 2012). Investors typically diversify their investments into a portfolio so as to average out and ultimately reduce the impact of firm specific risk of the respective companies and securities in which they invest. As such, it must be noted that portfolio diversification will not have an effect on the potential impact of systematic risk on the portfolio, which implies that it is impossible to diversify systematic risk. Still, an investor can reduce the total risk of an investment by reducing the firm specific risk component of the equation.

Investment in RETs could well represent portfolio diversification when viewed from the perspective of incumbent fossil fuel energy companies looking to diversify their portfolio of investments. The attractive premise of portfolio diversification is that the aggregate risk-return profile of two investments can be superior to that of a single investment (Wüstenhagen & Menichetti 2012; Masini & Menichetti 2013). From this perspective, it can be argued that investors tend to consider portfolio aspects before investing by analysing a prospective investment in light of the investor's prior investments. With regards to determinants of renewable energy investment, it can then be argued that the decision to invest will depend on the investor's impression of whether the investment will improve the aggregate risk-return profile in light of the investor's prior investments. Masini and Menichetti (2013) add that while portfolio diversification between fossil fuel energy projects and renewable energy projects is well documented, it is important to also emphasise the value of portfolio diversification between different renewable energy projects.

2.4.2 Strategic investment

While investments are often made for the purpose of short term financial return, the motivation for investing can also include longer term strategic benefits. Strategic investments involve the deployment of financial capital for the purpose of these longer term strategic considerations (Carr, Mitchell & Kolehmainen 2010; Jackson 2011). A firm might see a particular technology or company as having potential or being positioned to radically change the status quo of a particular industry in the future and as such the firm might want to buy into this potential through an investment. Investing strategically can thus create a first-mover advantage for a company if the technology or company in which it invested becomes successful, especially in the context of new markets that emerge from technological innovation (Chevalier-Roignant, Flath, Huchzermeier & Trigeorgis 2011).

Strategic investments are typically substantial investments characterised with relatively high levels of risk, outcomes that are difficult to quantify and long-term impact (Milgrom & Roberts 1992; Alkaraan & Northcott 2013). These investments, when providing a return, typically provide benefits to the entire company making the investment and not only the operating unit making the decision to invest (Milgrom & Roberts 1992; Henriques & Sadorsky 2011). They can take the form of a variety of transactions, including a larger firm buying an equity stake in a smaller firm, mergers and acquisitions, the introduction of new product offerings, the implementation of new manufacturing processes and the adoption of new technology (Milgrom & Roberts 1992; Alkaraan & Northcott 2013). The term *corporate venturing* is also commonly associated with strategic investment, which can take place externally where a firm purchase an equity stake in a smaller firm or internally, where the firm creates its own spin-off venture in the particular industry that exhibits potential for future growth. (Economy Watch 2010; Jackson 2011).

Thus, the characteristic that all these transactions have in common is that they are not conducted for the purpose of immediate financial return, but rather for the strategic consideration of achieving knowledge of a technology, company or industry that exhibit potential to deliver financial return in the long term or to provide a stepping stone that can be used by the firm making the investment to develop competitive advantage.

2.4.2.1 Strategic investment decision-making

When strategic investors make decisions regarding investment opportunities, a wide range of factors influence the decision-making process. Firstly, financial analysis forms an important part of investment decision making, even in strategic investment (Alkaraan 2016). Financial analysis in investment decision-making constitutes quantitative tools that assist in appraising investment opportunities and is also commonly referred to as a collection of capital budgeting techniques (Carr et al. 2010; Chevalier-Roignant et al. 2011). It must be noted, however, that traditional capital budgeting techniques tend to favour short-term and direct financial investments that are easily quantified and are as such biased against long-term strategic investments (Alkaraan & Northcott 2006). In this light, Chevalier-Roignant et al. (2011:639) note that these techniques can be referred to as *"static."* Nevertheless, these techniques, comprising, NPV, IRR, net profit margin and return on equity analyses are still commonly used (Alkaraan & Northcott 2006; Alkaraan & Northcott 2013). In response to these shortcomings, scholars have expressed the need for financial analysis techniques that are more suitable for strategic investments (Alkaraan & Northcott 2006).

Scholars have proposed an alternative technique in the form of what is referred to as real options analysis (ROA) (Chevalier-Roignant et al. 2011; Santos et al. 2014). As opposed to the conventional techniques, Chevalier-Roignant et al. (2011:639) further suggest that the ROA technique can be referred to as being "*dynamic*" in the sense that it incorporates a wider range of exogenous factors. Santos et al. (2014) add that the ROA technique incorporates uncertainty into the equation, which is particularly suitable for strategic investments in general and energy investments specifically due to the uncertainty involved in these investments. Furthermore, ROA techniques emphasise the value of flexibility in investments (Alkaraan & Northcott 2006). Flexibility in this regard refers to options to "*expand, defer, downsize or abandon a major capital investment project,*" which is valuable considering that *"they allow a firm to respond to strategic and competitive opportunities rather than remaining locked into a fixed course of action"* (Alkaraan & Northcott 2006:153). ROA can make use of a variety of techniques including but not limited to the Black-Scholes model, the binominal tree and the Monte Carlo simulation (Chevalier-Roignant et al. 2011; Sadorsky 2012; Santos et al. 2014). These are complex financial mathematical equations and an analysis of these are not appropriate for an interdisciplinary study such as this one and are thus only mentioned here to provide a review of financial analysis in strategic investment decision making as a part of the theoretical underpinning of strategic investment.

Secondly, the strategic investment decision making process is influenced by a range of contextual factors. Strategic investments are typically made by companies who are looking to create or enter new markets, have a strong financial position and operate under an entrepreneurial corporate strategy and management style (Carr et al. 2010; Jackson 2011). In summary, these companies have a strong strategic orientation and can be plotted on the upper end of the "*market orientation*" axis of the strategic investment decision making contextual framework developed by Carr et al. (2010:171) (see Figure 2.6). *"Market creators"* encapsulate these characteristics to the utmost extent, while *"refocusers,"* even though they display similar characteristics to *"market creators,"* might have more financial constraints and as such gravitate slightly more to investments that provide shorter term financial return to deliver on shareholder expectations (Carr et al. 2010:171). On the lower end of the vertical axis, "*value creators"* are concerned with internal efficiency and creating value for direct customers and shareholders. It follows that "*value creators*" and "*refocusers*" both have a balanced approach to financial and strategic considerations when investing (Carr et al. 2010:171).

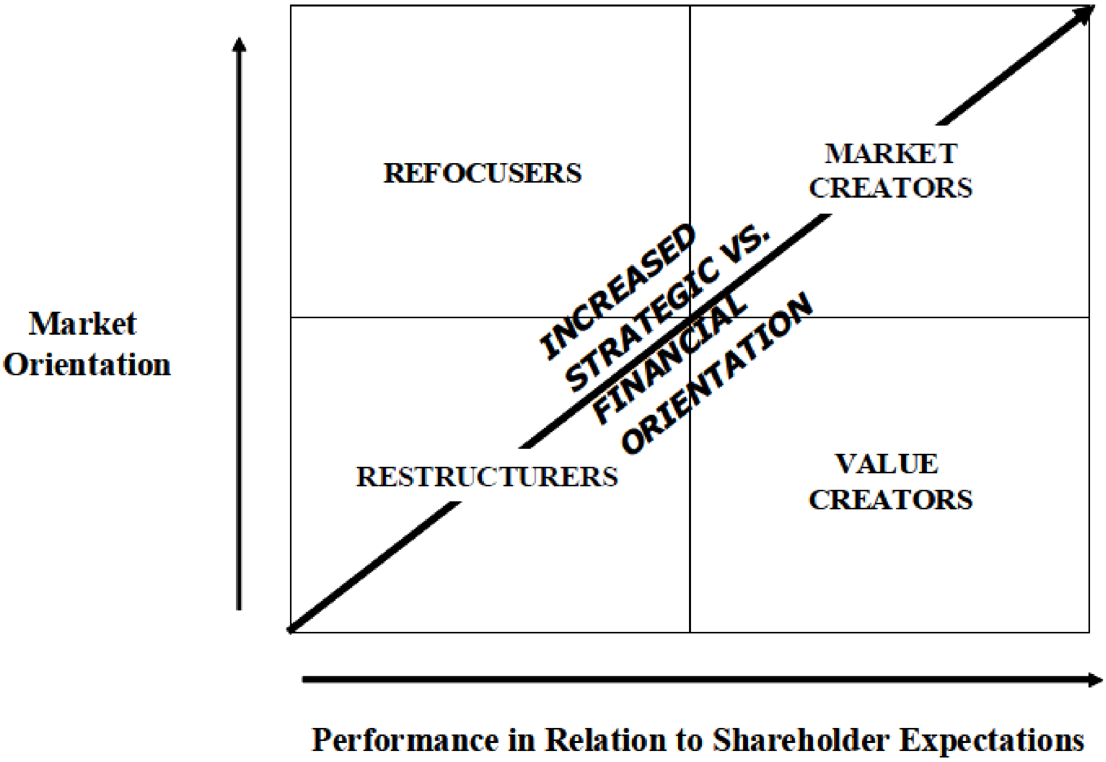

Figure 2.6: Strategic investment decision making contextual framework
Source: Carr et al. (2010)

"*Restructurers*" are characterised with significant financial constraints and as such place emphasis on financial considerations when investing and tend to be conservative when it comes to strategic considerations of investments (Carr et al. 2010:171). It follows that companies from the latter group will most likely not engage in strategic investment.

Thirdly, as Alkaraan (2016) notes, managers of strategic investment firms typically use their intuition and tacit knowledge when forming perceptions of any given problem, including choosing between strategic investment opportunities. It can be reiterated here that these intuitions and mental models are influenced by cognitive factors such as bounded rationality and path dependency (Wüstenhagen & Menichetti 2012). It follows that the same subjective factors influencing investment decision making as reported by Wüstenhagen and Menichetti (2012) can be applied to strategic investment decision making. Furthermore, Alkaraan and Northcott (2013) note that decision makers tend to make more use of their intuition when appraising strategic investment opportunities characterised with uncertainty pertaining to the operating context of the company at which the investment is targeted (Alkaraan 2016). This seems plausible, given that insufficient financial data might be available to appraise an investment opportunity on the basis of pure financial analysis and consequently strategic investors must depend more on their intuition.

Fourthly, Alkaraan and Northcott (2013) argue that strategic fit between the strategic investor and the company also influences strategic investment decision-making. In this way, a company's strategic objectives can be an important factor in strategic investment decision-making (Alkaraan & Northcott 2013).

In summary, this section sought to develop a theoretical understanding of renewable energy investment and strategic investment. The study considered the conceptualisation of renewable energy investment and strategic investment as it was described in this section, when considering the mini-grid context.

2.4.3 Investment in rural mini-grids

Investment is the primary method of deploying financial capital to new technologies, and is thus critically important for the diffusion of such technologies. Mini-grid ESCOs, however, lack investment due to unattractive risk-return profiles and in turn, long payback time periods. This is a challenge that stands in the way of realising the leapfrogging potential of renewable energy mini-grids. As this study and many other scholars and practitioners argue, the lack of investments entering mini-grid ESCOs in sub-Saharan Africa is one of the primary reasons for the slow diffusion of mini-grids in the region (George 2014; Energy Access Practitioner Network 2015; Williams et al. 2015; Raisch 2016).

2.4.3.1 Sources of investment

Mini-grids can theoretically be financed through a combination of grants, subsidies, equity finance, and debt finance (African Development Bank 2016). Grants and subsidies are provided respectively by donors and governments, but these are limited, and as such, commercial private sector investment is also required (Williams et al. 2015). Williams et al. (2015) add that the rationale behind pursing private sector investment is the fact that vast amounts of capital are available in the private sector relative to the public sector and the donor community. This is especially the case in sub-Saharan Africa (Sokona et al. 2012; Williams et al. 2015).

Private sector finance can come in the form of equity or debt, but private sector providers of equity and debt differ significantly. Theoretically, a wide range of equity investors can invest in private companies. These include institutional investors such as pension funds, hedge funds, insurance companies and commercial banks, companies engaged in corporate venturing and venture capitalists (Jackson 2011; Wüstenhagen & Menichetti 2012; IEA & World Bank 2015). However, the only private sector investors who are known to invest in mini-grids in the current climate are those who can tolerate the relatively high risk and low expected returns of mini-grid projects. These include companies from private sector industries such as electric utilities (George 2014; African Development Bank 2016). Risk-tolerant investors also include impact investment companies, especially those that are focused on delivering modern energy access (George 2014).

The reasons for investing vary between these groups. Companies from private sector industries typically invest with strategic considerations in mind. Many practitioners from these industries believe that mini-grids will become widespread over the next few decades (Enel Green Power 2015; Clover 2016; Rolland 2016). Hence, getting a foothold in the market before it expands rapidly is an important step for them (Bardouille & Muench 2014). With regards to impact investing, the financial return criterion is seen relative to social or environmental benefit. The intention is to generate social or environmental impact along with financial return (Ngoepe et al. 2016). Thus, in terms of financial return, impact investors have a higher tolerance for risk compared to investors who are investing solely for financial return.

Debt finance, although currently limited, is typically provided by commercial banks and development finance institutions. The only reports of debt finance being provided to mini-grid ESCOs are emerging from development finance institutions, by virtue of their higher tolerance of risk compared to commercial banks.

2.4.3.2 Structure of investment

Two structures of investment are of concern to mini-grid ESCOs, namely: corporate finance and project finance. Corporate finance entails investments that are made at the company level, i.e. the investor invests in the mini-grid ESCO itself. Project finance, also referred to as non-recourse finance, entails investment made at the project level. With project finance, the investor receives returns through the cash flow of the project. Project finance is typically used only for relatively large projects, in which case cash flows are sufficient to provide a return for the investor. Consequently, project finance is not commonly used in mini-grid investment due to the relatively small size of such projects and the uncertainty of cash flows in mini-grid projects (George 2014; African Development Bank 2016; Oji, Soumonni & Ojah 2016). The only cases where mini-grids qualify for project finance can be when a project has a large generation capacity, when a reliable off-taker is present, such as government purchases through feed-in tariffs in the case of grid-connected mini-grids or large commercial clients (African Development Bank 2016) or when a few mini-grid projects can be consolidated in order to qualify for the minimum sum of project finance. Until revenue streams are well defined, the probability of corporate finance being invested in mini-grid ESCOs is thus higher compared to project finance.

2.4.3.3 Constituents of the unattractive risk-return profile

The unattractive risk-return profile of mini-grid projects is a result of a variety of factors. Essentially, these factors act as barriers to private sector investment and can either relate to financial barriers or policy barriers (Williams et al. 2015).

Rural populations typically have a low ability to pay for electricity coupled with little application thereof pre-electrification (Tenenbaum et al. 2014; Williams et al. 2015). Little economic activity takes place in rural communities and people typically depend on subsistence farming (Williams et al. 2015; Azimoh et al. 2016). It is thus not often the case that rural households have cash on hand to spend on additional expenses. Low ability to pay and low demand in turn lead to revenue insecurity which jeopardises the financial sustainability of the mini-grid project. However, it is worthwhile to reiterate here that rural communities often spend amounts on traditional forms of energy that are higher than the tariffs at which mini-grid generated electricity are sold (Franz et al.

2014; Africa Progress Panel 2015). Hence, replacing the use of these traditional forms of energy with mini-grid electricity indicates a potential solution to the problem of low ability to pay. It must be reiterated, however, that households typically buy small amounts of traditional forms of energy and, at least before having built up disposable income and owning appliances, this might also be the case with regards to purchases of mini-grid electricity.

Furthermore, for the most part, mini-grid business models are still being tested in the field. Unproven revenue schemes and tariff structures are especially important components of mini-grid business models that must still be clarified (Hazelton, Bruce & Macgill 2014; Williams et al. 2015). That is not to say, however, that no options exist in this regard. The literature is inundated with mini-grid business model options (Bardouille 2012; Gaudchau et al. 2013; Franz et al. 2014; Knuckles 2016). Many of these projects, however, are often based on donor or subsidy support in specific geographical settings. Testing fully commercial business models in the field across geographical contexts is required to truthfully provide clarity on viable commercial business models. Consequently, practitioners have embarked on this mandate with great conviction with the result that the first reports of viable commercial business models in development are emerging (Blodgett et al. 2016; Knuckles 2016; Duby & Engelmeier 2017).

With regards to policy, there is now growing consensus on the policy framework conditions required to attract private sector investment to mini-grid ESCOs. It is widely regarded by scholars and practitioners that licensing and permit requirements and procedures should be simplified (Williams et al. 2015; IRENA 2016b; African Development Bank, African Union & Sustainable Energy for All Forum 2017). Secondly, governments should do more to communicate the procedures that will be followed if and when the national grid arrives at a mini-grid site (Schroth 2015; IRENA 2016b; African Development Bank et al. 2017). Thirdly, consensus seems to be growing that mini-grid ESCOs should be allowed to charge cost reflective tariffs as long as rural communities have the ability to pay such tariffs (Economic Consulting Associates & Practical Action Southern Africa 2013; Tenenbaum et al. 2014; Schroth 2015). With the use of subsidies, national electricity tariffs are often set below production costs (Williams et al. 2015). If mini-grid ESCOs are forced to sell electricity at these tariffs, projects will not be financially sustainable in the near term, which in turn will jeopardise the probability of private sector investment (Tenenbaum et al. 2014). Scholars suggest that if a government holds to the belief that rural communities and their urban counterparts should pay the same electricity tariffs, subsidies should be allocated to rural mini-grid projects so that ESCOs can still generate a return and in turn attract private sector investment (Tenenbaum et al. 2014; Schroth 2015).

Unfortunately, most sub-Saharan African countries' energy policy frameworks do not fulfil these three criteria. As a consequence, this has a negative effect on the operations of mini-grids. In turn, it becomes difficult to attract private sector investment to the mini-grid sector due to the increased investment risk (Franz et al. 2014; Williams et al. 2015; Azimoh et al. 2017). For example, Schroth (2015) reports that while some countries such as Tanzania, Nigeria, Cameroon, Madagascar and Rwanda allow varying degrees of cost reflective tariffs, others do not. Additionally, most governments do not communicate plans of national grid extension, let alone procedures to be followed if and when the grid arrives (African Development Bank 2016). Finally, many mini-grid ESCOs are confronted with the issue of unclear, complex, and bureaucratic processes in applying for licences and permits (Gaudchau et al. 2013; Kirchoff et al. 2016). However, due to the already existing knowledge base of required policy frameworks for mini-grid deployment, it is argued that additional sources of investments in the current context of the mini-grid ESCOs made a stronger case for academic research.

2.5 Conclusion

The goal of this literature review was to provide a theoretical framework for this study, which was used to inform the research objectives. The specific focus of the study was on the potential attraction of strategic investment to mini-grid ESCOs in sub-Saharan Africa as a way to increase access to finance. It followed that the position of renewable energy mini-grids in rural electrification, energy leapfrogging and the role of financial capital in technological change were deemed to be appropriate themes to cover in the literature review. These themes intersect in the sense that sub-Saharan African countries could leapfrog the centralised approach to electrification by allowing for the deployment of renewable energy mini-grids in rural areas, the prospect of which could be increased through the deployment of financial capital in the mini-grid sector.

The literature review enabled the researcher to identify a required area of primary research and the objectives associated with the research. Considering the prerequisites of realising the potential of a leapfrogging technology as discussed in the review, the researcher decided to focus on investment requirements, as this was identified as one of the major challenges keeping mini-grid ESCOs from scaling up. In addition, less is known about the manifestation of these requirements in the mini-grid sector compared to others such as technical infrastructure and policy frameworks. Finally, the selected focus addresses the requirement for academic work that explores private sector investment in rural electrification as raised by other scholars (Schmidt et al. 2013; Williams et al. 2015).

Considering the requirement for investment to contribute to the realisation of the leapfrogging potential inherent in renewable energy mini-grids, as well as the current unattractive risk-return climate in the mini-grid sector, the researcher realised that an investor with less of a short term financial return mandate and more of a strategic intent could potentially be attracted. The researcher then posed the question as to whether strategic investments could be appropriate for mini-grid ESCOs, who the potential strategic investors might be and how these investors can be attracted to the sector. It followed that the researcher firstly had to determine whether there is in fact a need for such strategic investments in mini-grid ESCOs. Secondly, the researcher sought to identify the types of private sector companies that could invest strategically in mini-grid ESCOs and finally, to determine the potential of such investments.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter sets out the steps taken in order to address the three respective research objectives. The chapter opens with an outline of the overall research design and research methodology that guided the study. This is followed with a discussion of the research methods and data analysis techniques that were used for each respective research objective.

3.2 Research design

The purpose of a research design is to provide "*a framework for the collection and analysis of data"* (Bryman & Bell 2014:100). Yin (2011:75) distinguishes the research design from other methodological components, such as the research methodology and methods, by noting that it serves "*logical"* plans as opposed to "*logistical"* plans that are concerned with the schedules and coordination of a study. Logical plans in this sense refer to links between research objectives or questions, what kind of data will be collected and the kind of data analysis techniques that will be used (Yin 2011; Bryman & Bell 2014). These plans ensure that the findings of a study adequately address the intended research objectives or questions (Yin 2011). Consequently, they assist in strengthening the validity and accuracy of a research study (Yin 2011). It follows that the type of research design used in a study will be determined by the research questions or objectives and should thus be appropriate for the type of questions or objectives of a particular study (Morra-Imas & Rist 2009; Bryman & Bell 2014). For example, as is the case with this study, when descriptive questions or objectives are set by the researcher, a design that can address such objectives or questions should be adopted (Morra-Imas & Rist 2009).

This study was guided by the principles of qualitative survey research design. The preference for this research design was informed by the research design classifications of Blaxter, Hugues and Tight (2006). In their classification, Blaxter et al. (2006) state that four types of research design that are commonly used in the social sciences include: action research, case studies, experiments, and surveys. Action research constitutes a participatory approach to research, in which research is conducted together with participants instead of on them (Herr & Anderson 2005). Case study research involves the investigation of a specific case, be that an individual, community or event with the goal of establishing generalisations about the wider applicable population (Blaxter et al. 2006). Experimental research is concerned with the enforcement of control on factors that have a causal influence on the outcomes by means of the manipulation of an independent variable (Blaxter et al. 2006). Experimental research designs are more commonly found in the natural sciences than in the social sciences. Finally, survey-based research is traditionally associated with quantitative research, in which case it is seen as a "*research design in which a sample of subjects is drawn from a population and studied to make inferences about the population*" (Brent 2017:12). However, converse to quantitative survey research, survey research can also be qualitative, in which it takes a different form. This study specifically employed a qualitative survey design.

A qualitative survey research design provides depth and meaning to the research questions of concern (Fink 2003a). It follows that these are aimed at *"the discovery, formulation and typification of characteristics with a view to theory building,"* (Van Den Bulck 2002a:68) by exploring a topic of interest in a particular population (Jansen 2010). Thus, the goal of qualitative survey research is not to achieve statistically representative or generalisable results (Fink 2003a), which entails a fundamental distinction from quantitative survey research. Qualitative research designs cannot, and are not designed to make statistical generalisations because the frequency of a pre-defined characteristic in a population is not determined (Jansen 2010; Yin 2011). The goal of the qualitative researcher is thus not to make inferences about a population, but to make analytic generalisations. Analytic generalisation is defined as steps taken to indicate how a study's findings creates an improved understanding of a particular theoretical concept, after which the same theory can be applied to inform similar situations (Yin 2011). Still, even though inferences are not made about the population, a target population is still of importance. Any given theory pertains to one or more populations and thus a sample should still reflect the characteristics of the target population. By essence, analytic generalisation emanates from interpretivism, as it typically occurs during analysis and interpretation of qualitative data (Polit & Beck 2010).

For example, in the case of the first objective of this study, a relevant characteristic of a mini-grid ESCO would be the ability of the ESCO to attract strategic investment. A quantitative survey would count the number of mini-grid ESCOs that can attract strategic investment, which effectively would be a study of distribution, where distribution refers to the frequency of times that the pre-defined characteristic occurs in the population (Jansen 2010). A qualitative survey study, however, would explore the diversity of possibilities of why and how a mini-grid ESCO can attract strategic investment.

Qualitative survey research designs are also useful when a study seeks to "*explore the knowledge and opinions of individuals and groups such as experts in a particular field of knowledge"* (Fink 2003a:7). Fink (2003a) adds that qualitative survey research designs are also appropriate when the literature is unable to guide a researcher in designing close-ended questions. In such cases, such as in the case of this study, the approach is exploratory and requires the design of predominantly open-ended questions.

3.3 Research methodology

The research design of this study, qualitative survey research, associated with non-experimental research, determined the choice of research methodology. Considering the descriptive nature of the research objectives and the requirement of the collected data to be rich and in-depth, a qualitative methodology was used. Furthermore, the exploratory nature of this study required an inductive approach, for which a qualitative methodology is suitable (Bryman & Bell 2014). Bryman and Bell (2014:11) further note that induction involves "*drawing generalisable inferences out of observations,"* which lends itself to being a theory-generating activity. It is exactly this inductive approach that was appropriate for this study given that theory emerged out of the collection and analysis of the data.

Qualitative research involves the collection of non-numerical data and focuses on exploring a smaller number of instances in order to achieve depth as opposed to breadth (Blaxter et al. 2006; Bryman & Bell 2014). It aims to "*achieve an in-depth understanding of a situation"* and is ideal for the extraction of motivations and perceptions (Cooper & Schindler 2014:144). These characteristics made qualitative research methodology applicable to this study. The study has a specific focus on access to finance among mini-grid ESCOs, hence the requirement for depth. Furthermore, to propose solutions, the researcher had to extract the experiences, perceptions and motivations of mini-grid ESCOs and strategic investors.

3.4 Sampling, research methods and data analysis

After incorporating elements of qualitative survey-based research design and qualitative research as the methodology, the research proceeded with the sampling, data collection, and data analysis processes. The sampling process sets out all the steps involved with choosing a sample. In qualitative research, this involves choosing the sampling technique by which a sample can be selected from the target population and determining the sample size (Yin 2011; Cooper & Schindler 2014). The data collection process involves the selection of an appropriate research method, setting up the data collection instrument and conducting fieldwork. Finally, the data analysis process involves the selection of the appropriate data analysis technique and then using this technique to analyse collected data. In the following sections, these processes are outlined for each respective research objective.

The three respective objectives were purposefully developed, such that one informs the next. In order to identify private sector companies that could be interested to invest strategically in mini-grid ESCOs (research objective two), the researcher first needed to determine the nature of and need for strategic investment in the mini-grid sector (research objective one). Lastly, to achieve research objective three, which was to determine the potential of strategic investment from private sector companies identified under research objective two, the researcher first had to identify private sector companies that could be interested to invest strategically in mini-grid ESCOs.

3.4.1 Target population

The target population is the larger group from which the sample emanates (Bryman & Bell 2014). For the purpose of research objectives 1 and 2, the target population was executive managers of mini-grid ESCOs in sub-Saharan Africa that operate to generate a profit. Roughly there are about twenty-five mini-grid ESCOs in sub-Saharan Africa (Troost 2016).

Mini-grid ESCOs are typically small, young companies, with permanent staff of about twenty people, including executive management. The longest-operating mini-grid ESCOs in sub-Saharan Africa were founded around 2010. Furthermore, given that renewable energy mini-grids constitute new technology in the commercial sense, business models take time to become robust and in the only way to achieve this is by testing these business models through pilot projects. In addition, a pilot project has to run for approximately five years to demonstrate that the technology and business model has become robust. During this period, mini-grid ESCOs cannot expand further than its pilot projects. The majority of the longer-running mini-grid ESCOs have recently reached the end of this demonstration phase. It is for these reasons that the most established mini-grid ESCOs are still small with limited scale in absolute terms.

With regards to research objective 3, three different target populations were of concern. The first was mini-grid ESCO executive managers, in the same way as they were applicable to the first and second research objectives. The other two target populations were identified in the second research objective. These constituted private sector companies in sub-Saharan Africa that could invest strategically in mini-grid ESCOs. Executive managers of mini-grid ESCOs mentioned various types of private sector companies in this regard. However, it was not possible to view these private sector companies as a single target population because of their divergent knowledge and experience with mini-grids. Thus, the two target populations of research objective 3 were distinguished from each other in the form of the first being potential strategic investors in the energy sector and the second being potential strategic investors outside of the energy sector. Whether a private sector company is operational in the energy sector depends on whether it is involved with the development, management or financing of energy projects.

Potential strategic investors in the energy sector constituted electric utility companies, IPPs and crowdfunding companies dedicated to off-grid energy. Strategic investors outside of the energy sector were identified as providers of consumer products, electric appliances and connectivity services, which were comprised of mobile network operators (MNOs), online social media mobile application companies, software technology companies and internet service providers (ISPs).

Typically, researchers seek to draw samples that are characteristic of the target population to the extent that inferences can be made about the population based on the findings pertaining to the sample. However, given that the goal of the research design employed in this study is not statistical generalisability, the researcher emphasises that the samples selected in this study are done for the purpose of analytical generalisation as opposed to statistical generalisation.

3.4.2 Sampling technique

For research objective 1 and 2, purposive sampling was used as the sampling technique. Purposive sampling is a non-probability sampling technique with the goal of selecting interviewees that will provide the most relevant data for the given topic (Yin 2011; Bryman & Bell 2014). The goal of purposive sampling is not to create a sample that is statistically representative of the population for the purpose of inference generation, but to create a sample that reflects certain characteristics of the target population so as to achieve analytical generalisability (Mason 2002; Battaglia 2011; Ritchie, Lewis & Elam 2014). For research objectives 1 and 2, executive managers of the established first-mover mini-grid ESCOs of sub-Saharan Africa were selected as they are the group that is to the greatest extent immersed in the phenomenon that the first and second research objectives pertain to and jointly with potential strategic investors with regards to the third research objective. It was thus the view of the researcher that the most relevant data would be yielded from these participants. The executive managers that were interviewed also demonstrated the characteristics of the population of mini-grid ESCO managers, seeing that their jobs entail executive management of a mini-grid ESCO. The majority of executive managers were the founders or chief executive officers of the respective companies, however two of the executive managers that took part in the research were chief financial officers. Positions of interviewees are elaborated upon in Table 3.2.

A combination of purposive and snowball sampling was used in addressing research objective 3. This sampling process started off with purposive sampling, but because the researcher did not initially have enough contacts in the identified industries, snowball sampling was used by obtaining contact details of additional interviewees from the initial interviewees that were identified with purposive sampling. Snowball sampling is a nonprobability sampling technique in which subsequent research participants are referred by an initial nonprobability or probability sample of participants (Battaglia 2011; Cooper & Schindler 2014). It is a commonly used technique in qualitative research that is especially suited for when research participants are hard to find or when the target population is small (Fink 2003b; Cooper & Schindler 2014; Ritchie et al. 2014). Mini-grid ESCO executive managers were asked after the interviews if they would agree to provide the researcher with contact details of private sector companies whom they think have the potential to become strategic investors.

There was more variability in the job descriptions of representatives of potential strategic investment companies compared to mini-grid ESCOs. This was solely because of the fact that mini-grid ESCOs are smaller companies and thus it was easier to talk directly with executive management. Most private sector companies that were identified to be potential strategic investors in mini-grid ESCOs were relatively large international companies. In these cases, Africa regional managers were approached. In cases where smaller companies were approached, the researcher was able to make contact directly with executive management.

There are, however, potential downsides of snowball sampling that should be mitigated. Yin (2011) notes that snowball sampling should only be conducted if the snowballing is purposeful and researchers should guard against it when the only motivation for using it is convenience. The snowballing done in this study was indeed purposeful, in the sense that the surveyed executive managers of mini-grid ESCOs are in the best position with regards to knowledge and experience to say which type of companies have the most potential to become strategic investors, given that they are the longest-standing players in the sector. Further, given their experience in the energy sector and rural electrification in general, their networks were of utmost importance in order to reach interviewees in the strategic investor target population that would yield rich and appropriate data.

Ritchie et al. (2014) note that when using snowball sampling, there is a danger in the diversity of a sample being compromised, which would imply that sample members do not have the required characteristics. This can occur because new sample members are "*generated through existing ones*" (Ritchie et al. 2014:94). This was however mitigated by providing the existing sample members (mini-grid ESCO executive managers) with specific requirements that the referrals should meet. These requirements were extensions of the questions that were posed in order to identify the types of private sector companies that could invest strategically in mini-grid ESCOs. For example, if an existing sample member was of the opinion that electric utility companies could invest strategically in mini-grid ESCOs, the researcher would ask the sample member if he or she can provide the researcher with any electric utility companies. Thus, any new sample member referred by an existing sample member that did not correspond with the existing sample member's recommendation of potential strategic investors was excluded in the selection process. As mentioned, other potential strategic investors were identified to be mobile network operators, providers of consumables and connectivity services providers.

3.4.3 Sample size

The sample size is typically determined by the number of participants required to reach saturation (Cooper & Schindler 2014). That is, as long as the scope and depth of knowledge of the research topic increases in the process of data collection, more research participants should be included in the sample. When no new insights are gained from interviews, saturation has been reached and data collection can be concluded (Cooper & Schindler 2014). Furthermore, the sample size also depends on the depth of data collected from each participant (Yin 2011). As Table 3.1 shows, 10 executive managers of mini-grid ESCOs were interviewed. As mentioned earlier, these ESCOs are operational in East- and Southern Africa and were selected as they are the most established ESCOs and subsequently provided rich responses drawn from vast experience. Three ESCOs are operational in Kenya, four in Tanzania, one in Zambia, one in Kenya, Mozambique and Tanzania and one in South Africa. In total, eleven representatives of potential and current strategic investment companies were interviewed. Seven of these companies were operational in the energy sector, while the other four were operational outside of the energy sector. Those that were operational in the energy sector were mainly IPPs, while others identified as electric utilities[1]. In addition, one energy crowdfunding company was interviewed. Table 3.1 also indicates these participants.

[1] The literature does not seem to make a clear distinction between an electric utility company and an IPP. However, as the definition of concepts section has shown, electric utility companies can be active in the generation, transmission and distribution of electricity, while IPPs are typically specialised in generating electricity and selling to electric utility companies.

Table 3.1: List of contacted and interviewed research participants

Sample	Contacted	No response	Interviewed	Participation rate
Mini-grid ESCOs	15	5	10	66%
Potential strategic investors in energy sector	16	8	7	44%
Potential strategic investors outside energy sector	13	9	4	31%

Potential and current strategic investors outside of the energy sector included one MNO, one ISP, one social networking and cloud services company and one beverage company. From the latter group, it can be deduced that providers of electric appliances were not included in the sample. The reason for this omission is that time limitations constrained the researcher from collecting data from a very large sample and there was thus a requirement to choose types of private sector companies that were regarded by mini-grid ESCOs as having the most potential to become strategic investors. Thus, based on the frequency of mentions, connectivity companies and consumer goods companies were selected. Hence, mini-grid ESCOs were not as convinced with the potential of providers of electric appliances becoming strategic investors compared to connectivity companies and consumer goods companies based on the frequency of mentions. The details of all respondents in this study is provided in Table 3.2.

It is also highlighted here that in terms of consumer goods companies, beverage companies were included in the sample because mini-grid ESCOs pointed to beverages when asked to be more specific as to which consumer goods providers they felt would be most interested in getting involved with electrification activities.

Table 3.2: Details of respondents and interviews

Respondent code	Locations of ESCO's operations	Location of interview	Respondent's position in the company
Respondent A1	Kenya	Skype	Chief financial officer
Respondent A2	Kenya	Skype	President/co-founder
Respondent A3	Tanzania	Skype	Co-founder
Respondent A4	Kenya, Tanzania & Mozambique	Skype	Founder & managing director
Respondent A5	Tanzania	Skype	Co-founder
Respondent A6	South Africa	Cape Town	Founder & managing director
Respondent A7	Zambia & South Africa	Skype	Chief financial officer
Respondent A8	Tanzania	Skype	Chief executive officer
Respondent A9	Kenya	Skype	Chief executive officer
Respondent A10	Tanzania	Skype	Head strategic analyst
Respondent B1	Africa & Europe	Skype	Energy access analyst
Respondent B2	Global	Skype	Head of energy access
Respondent B3	South Africa	Cape Town	Chief executive officer
Respondent B4	Global	Cape Town	Africa development manager
Respondent B5	East Africa	Skype	East Africa regional manager
Respondent B6	South Africa	Cape Town	Managing director
Respondent B7	Global	Skype	Director of investment advisory
Respondent C1	India, Indonesia and East Africa	Skype	Chief operating officer
Respondent C2	Africa & Europe	Skype	Co-founder and chief executive officer
Respondent C3	South Africa	Skype	Head of special projects
Respondent C4	Africa	Skype	Senior specialist

3.4.4 Research method

For the purposes of data collection, a range of qualitative methods was available, namely: focus groups, in-depth interviews, and participant observation (Bryman & Bell 2014). For the purpose of this study, in-depth interviews were conducted. The interviews were all semi-structured. Semi-structured interviews are particularly suited for exploratory research because the questions are not fixed with set parameters (Bryman & Bell 2014). It is a data collection method that allows the interviewee's perception of issues and events to emerge (Bryman & Bell 2014), which was appropriate for this study. In-depth interviews were selected for the following reasons:

- At the very least, interviews, in addition to questionnaires, are commonly associated with survey-based research (Blaxter et al. 2006).
- Generated data, as opposed to naturally occurring data, was required to achieve the research objectives and in-depth interviews are effective in yielding generated data. The required data was not naturally occurring because the data was entrenched in the experiences and knowledge of executive managers of mini-grid ESCOs and current and potential strategic investors and thus had to be physically generated with the use of an applicable method, in this case the in-depth interview. Participant observation, conversation analysis and discourse analysis are effective in collecting naturally occurring data and hence interviewing is preferred above these methods in this case (Lewis 2014).
- Several other qualitative and quantitative methods can also be used to collect generated data. In the qualitative sense, this includes focus groups and quantitatively it includes questionnaires. In-depth interviews were preferred above questionnaires, because little academic research has been conducted in the area of the attraction of investment in a sector as nascent as the mini-grid sector by leveraging non-financial, strategic value. There is thus little to which the phenomenon could be compared and furthermore it required a method that is conducive towards exploration of themes as opposed to investigating relationships between variables.
- This was a niche study. There was thus a focus on depth of analysis as opposed to breadth. Further, as Lewis (2014:58) notes, complex systems or processes are typically best addressed in in-depth interviews because of "*the depth of focus and the opportunity for clarification and detailed understanding.*"
- The aims of the respective research objectives were to understand the experience of mini-grid ESCOs in attracting investment, their opinions of whether they require strategic investment in scaling up their operations and their opinions regarding potential strategic investors. Additionally, the study sought to determine the opinions of current and potential strategic investors regarding

the value that they see in mini-grid ESCOs. Quantitative methods would not be suitable for these objectives as they are not suited to collect in-depth data about people's experiences, opinions and knowledge.

The researcher further allowed for comparability between responses from the respective interviewees by maintaining the same basic structure across all interviews. That is, the list of questions as they appear in the interview schedule (see Appendices A, B and C) were raised in a consistent manner in all interviews, with the only deviation being the researcher's request to an interviewee to elaborate on responses that required further clarification. The majority of questions were open-ended, but comparability was not jeopardised as the same structure was maintained across all interviews.

3.4.5 Design of interview questions

The interview questions were designed for the purpose of attaining the respective research objectives. The various interview schedules are presented in appendices A, B and C. The interviews were semi-structured and the majority of the questions were open-ended. The questions that were asked were informed by the literature and conversations with practitioners in the field of mini-grids and electric utilities at the 2017 Africa Utility Week and South African National Energy Association guest lecture series on off-grid and mini-grid technologies.

3.4.6 The interview process

Interviews with research participants that were located in the Cape Town area were conducted on a face-to-face basis, while participants in Johannesburg and further afield were interviewed with the use of Skype. Skype is increasingly being used for interviewing purposes as it opens up possibilities of the reaching participants that could otherwise not have been reached (Iacono, Symonds & Brown 2016; Seitz 2016). As Seitz (2016) notes, while Skype offers significant benefits for qualitative researchers, care should be taken to avoid some challenges, such as a broken connection, background noise and the respondent not hearing answers clearly. In this regard, the researcher ensured that the internet connection was stable, that the researcher's physical space was quiet at all times and that questions were well articulated. Furthermore, Skype was also appropriate with consideration of the research participants, given that executive managers use Skype regularly for meetings and all participants were thus knowledgeable with the use of the technology. Face-to-face interviews were conducted in the offices of research participants. All interviews commenced with an introduction, in which the researcher gave a brief overview of the study and what the objectives of the study are. Interviews lasted for thirty to forty-five minutes each. All interviewees gave informed consent to participate in the research by signing the Stellenbosch University form of informed consent.

3.4.7 Validity and reliability

In traditional quantitative research, validity is often discussed as having two dimensions, namely internal validity, which refers to whether the researcher is investigating that which he or she claims to be investigating, and external validity, which refers to the extent to which a study's results are generalisable (Mason 2002; Creswell 2013; Ritchie & Lewis 2014). Reliability in quantitative research is generally defined as a measure of whether research findings can be replicated in a different study with the same methods (Ritchie & Lewis 2014).

However, qualitative studies do not lend themselves easily to such testing due to the interpretive nature of qualitative data analysis, the influence of context on qualitative data collection and the non-standardised nature of qualitative data collection methods (Long & Johnson 2000). That is not to say, however, that the validity and reliability of a qualitative study should not be considered. It is the belief of the researcher that rigour is of utmost importance and thus this study was scrutinised according to the validity and reliability principles in a qualitative context. In qualitative research, validity is more appropriately described as the appropriateness of the methods and techniques used in a study (Leung 2015). Reliability in qualitative research is concerned with the requirement of the researcher to demonstrate that data has not been misrepresented and that data collection and -analysis have been conducted in a careful manner (Carcary 2009), which in effect emphasises the value of consistency (Lueng 2015). Morse, Barrett, Mayan, Olson and Spiers (2002:11) provide the following verification strategies to ensure validity and reliability in qualitative research: *"methodological coherence, sampling sufficiency, developing a dynamic relationship between sampling, data collection and analysis and theory development."*

Methodological congruence refers to the extent to which the research method and data analysis technique is compatible with the research objective (Morse et al. 2002). Thus, the validity of this study was strengthened by delineating the most appropriate data collection methods and analysis techniques for the exploratory objectives of the study, which was deemed to be in-depth interviews and content analysis. Regarding sampling sufficiency, Morse et al. (2002) emphasise the importance of ensuring that samples consist of participants who are knowledgeable about the research topic and of reaching saturation. Indeed, the researcher was of the opinion that groups that were best applicable to the area of research were executive managers of more established mini-grid ESCOs as well as potential strategic investors. Furthermore, the researcher concluded the sampling process when it was found that sufficient data was gained to conduct a rich process of data analysis. It was also at this point that no new insightful responses were gained and thus saturation has been reached.

Thirdly, a dynamic relationship between data collection and analysis was created by beginning with analysis while the data collection process was still ongoing. While the majority of data analysis was conducted after data collection came to an end, the initial analysis that was conducted concurrently with data collection ensured an iterative process, which consequently informed the researcher about the nature and amount of data that still had to be collected. The data collection process was further streamlined with the use of a pilot test, which was conducted with three respondents. The pilot test was conducted on 18 and 19 May and on 12 June 2017 and from this test, questions were adapted and ordered chronologically to better suit the research objectives and respondents' knowledge of the research topic. This was also done for the purpose of chronological flow in the interviews. Reliability of the data was further ensured by checking that transcripts were fully representative of the interviews.

Finally, in line with the analytical generalisation approach employed in this study and in concurrence with Creswell (2014), Morse et al. (2002:13) note the importance of theory development, which they appropriately define as a "*move with deliberation between a micro perspective of the data and a macro conceptual or theoretical understanding.*" Thus, the validity of this study was strengthened further by providing a rich description of findings, as presented in Chapter 4 and by augmenting the discussion from Chapter 4's micro perspective of the data to a macro perspective in

Chapter 5, where the findings were compared to existing theory and where the implications of the findings were discussed for further development of relevant theory. However, this was done in a way that was in accord with the suggestion of Morse et al. (2002), which is to avoid making far-fetched theoretical deductions by first analysing the data in much depth with a theoretical perspective so as to ensure that a sound theoretical foundation was achieved before making conclusions and recommendations.

3.4.8 Data analysis

The in-depth interviews that were conducted with respondents yielded rich and in-depth data. Before data analysis commenced, all interviews were transcribed. At the most basic level, Boeije (2010:94) notes that qualitative analysis "*consists of segmenting the data and reassembling them with the aim of transforming the data into findings.*" In conducting data analysis for the purpose of this study, two techniques that are vastly similar were utilised, namely: content analysis, and thematic analysis. Many authors disagree on the extent to which these techniques differ (Braun & Clarke 2006; Marks & Yardley 2011; Ayres 2012), while others use the terms interchangeably (Smith 1992; Wilkinson 2000). What also emerges from the literature is that content analysis is a more frequently cited data analysis technique, as opposed to thematic analysis, which, in the words of Vaismoradi, Turunen and Bondas (2013:400) is a *"poorly branded method, in that it does not appear to exist as a branded method in the same way that content analysis does."* Even where differences are noted, they are so small that authors struggle to successfully articulate a practical distinction (Vaismoradi et al. 2013).

Content analysis is traditionally conceptualised as a quantitative analysis method in the sense that the number of responses pertaining to a category is counted in order to determine the frequency of responses for each category (Wilkinson 2000; Julien 2012). Early writings, especially seminal work on content analysis thus deemed it to be *"a research technique for the objective, systematic and quantitative description of the manifest content of communication"* (Berelson 1952:15). The quantitative use of content analysis is still commonly being practised (Wilkinson 2000; Blaxter et al. 2006; Marks & Yardley 2011; Sovacool 2014). Thematic analysis is defined as a process of "*identifying, analysing and reporting patterns (themes) within data"* (Braun & Clarke 2006:6). Thematic analysis is similar to content analysis, except that it places greater emphasis on the qualitative aspects of the text that is being analysed (Marks & Yardley

2011). In this way, thematic analysis addresses a significant criticism of traditional content analysis, which is that a narrow focus on frequency leads to the removal of *"meaning from its context"* (Marks & Yardley 2011:58). It allows the researcher to combine an analysis of the frequency of responses with an analysis of their meaning in context and in this way, contributes to a data analysis effort that draws from the advantage of systematic analysis with clear procedures on the one hand and subtlety and contextuality on the other (Marks & Yardley 2011).

Thus, while a distinction can be made between traditional content analysis and thematic analysis, it is the view of the researcher that thematic analysis and qualitative content analysis cannot be distinguished. Qualitative content analysis is a term used occasionally in the literature to delineate a departure from the pure systematic quantitative approach to content analysis. The qualitative approach to content analysis is defined as an analysis technique focused on the interpretation and context of content in order to delve into the latent meaning of data (Van den Bulck 2002b; Sovacool 2014) and is thus occasionally referred to as *"latent content analysis"* (Julien 2012:121), which Boyatzis (1998:16) define as *"looking at the underlying aspects of the phenomenon under observation."* Similarly, Berg (2001:242) describes latent content analysis as *"an interpretive reading of the symbolism underlying the physical data."*

With these considerations in mind, the researcher incorporated both quantitative and qualitative approaches to content analysis, the latter which can also be seen as thematic analysis. The former has been applied by counting the number of responses pertaining to a specific concept so as to identify the most common answer. Sovacool (2014) notes that the majority of content analyses in the energy field have been quantitative. Thus, in incorporating both approaches, the researcher followed the approach that the majority of energy researchers used while also incorporating contextuality and acknowledging the subjectivity that arises in qualitative research.

All data analysis processes, as Boeije (2014) notes, start with coding as it constitutes the first step in "*moving beyond concrete statements in the data to making analytic interpretations"* (Charmaz 2006:43). Lewins and Silver (2007:81) define coding as a process *"by which segments of data are identified as relating to, or being an example of, a more general idea, instance, theme or category."* In this sense, coding was conducted by separating and segmenting data into meaningful parts and then naming these parts accordingly (Charmaz 2006). All segments of data with the same code were then placed together under the theme that characterises them. When reporting results in chapter 4, respondents were also given codes, where the mini-grid ESCO category was expressed with A, private sector companies in the energy sector with B and private sector companies with C. Ten mini-grid ESCOs were interviewed, so respondents' titles range from A1 to A10, while private sector companies in the energy sector range from B1 to B7 as seven respondents were interviewed. Finally, given that four private sector companies outside the energy sector were interviewed, these were termed in the range from C1 to C4.

3.4.9 Conclusion

The researcher aimed to design an appropriate study in light of the research objectives. This was done by using qualitative survey research design elements and a qualitative methodology coupled with in-depth interviewing as the research method, purposive sampling and snowball sampling as the sampling techniques and content analysis and thematic analysis as the data analysis techniques.

The importance of fully understanding the theoretical foundation of the selected research designs, methodology, method, sampling techniques and data analysis techniques was reiterated in this chapter. Indeed, the chapter set out to discuss the justification for each of these selections based on the definitions and applications of the respective methodologies, methods and techniques to this study.

CHAPTER 4: RESULTS

4.1 Introduction

Chapter 4 sets out the results that emerged from the analysis of interviews conducted with the respective samples. The results are organised according to each research objective.

4.2 Determining the need for strategic investment in the mini-grid sector

Mini-grid ESCO executive managers were firstly asked about their experience in the pursuit to provide an attractive risk return profile to investors so as to attract private sector investment. All respondents indicated that they find it difficult to provide an attractive risk return profile and in turn to attract private sector investment. There was a variety of responses as to why this is the case, which corresponds with the literature. The majority of respondents mentioned that business models are not fully developed yet. According to respondent A1:

> "Trying to get the economics to work is a challenge and it's definitely hard to get there. And that's what people are working towards, how do you get enough revenue, how do you drop your costs enough, how do you make it operations-efficient enough that it can all work. I mean, we're working really hard to get there. We're hoping some of the projects we bring online later this year or next year will be a testament that it is workable or doable, but right now, the numbers we're seeing and the numbers we hear from other people is not quite there yet."

It would, however, seem that the extent to which an ESCO's business model is viable depends on the length of experience that the ESCO has undergone with a particular business model. For example, respondent A4 noted:

> "If you're just looking at plain electricity on a renewable basis, I think it's extremely difficult to achieve those kinds of returns. But that's my perspective. If you look at our models and assuming that our capital equipment costs are competitive which I am pretty sure they are, and you just look at the electricity

> revenues you'll see that it's in the red for a long, long time. So, what you find what a lot of the mini-grid players are doing now is trying to focus on productive energy use, demand stimulation and financing of appliances, with the objective to drive demand and ultimately increase their income. But it's a long game. We've been running pilots for a number of years and only now we are starting to see kind of an increase of small businesses and productive energy use."

Respondents also mentioned that high capital costs make it difficult to show an attractive risk return profile. In turn, trying to reduce costs is also one of the factors that makes the business model development process harder. Respondent A2 indicated that:

> "Mini-grid developers don't necessarily get access to the best cost, because we're small or in far-away places and the vendors who are selling that hardware actually put a risk-premium on selling into these markets, so even though globally costs of solar, for example, have dropped to $1 a watt or $0.5 a watt or whatever, most of the developers in rural Africa are not seeing those types of prices, which means that the actual costs of the project are a lot more."

Added to the high cost of capital expenditure is what many respondents referred to as the difficulty of absorbing overheads, which is tied to the operating expenditures of a mini-grid ESCO. Respondent A3 stated that:

> "On just a stand-alone basis these mini-grids actually can deliver fairly decent return but by the time you roll in corporate overhead and those kinds of things the returns start to go negative, especially if you're only doing one or two of these things."

A theme that also emerged strongly from responses was that of unfavourable policy and regulation. Policies are often unclear, which creates uncertainty. The result is that policies are often not conducive to mini-grid deployment.

Respondents noted that an overarching reason for why costs and overheads are high and business models are not fully developed is purely because the industry is still too nascent and that over time the risk return profile will improve and so too the investment case. Respondent A4 felt that in five years' time, mini-grid ESCOs will be able to make a stronger case for investment from investors purely looking for a financial return:

> "This is not considered a mature market. It's still very early stage. As a result, it depends very much on who the investors are that you are talking to. Certainly, mainstream investors that are looking for mature markets shouldn't be looking at this market because it is too early. From that perspective, even trying to offer attractive returns to those investors just does not make any sense because we are 5 years away from that. If you look at investors that are more open to getting into the sector in the early stage (and there are quite a number of them), then I wouldn't say it is impossible but still quite difficult, because different companies will have different models and thus different approaches to the market."

Interviewees were then asked what their financing requirements are looking forward. Respondents A1, A2, A4, A5, A6, A7 and A9 mentioned that they require equity investment as well as debt finance, but contended that their track records are not strong enough for most debt providers. Respondents A2, A4 and A5 also noted that grants would assist, but are not the central focus going forward. As a result, the most desired form of financing seems to be equity. For example, respondent A5 underlines the importance of equity investment given the current state of the industry:

> "Going forward, the ideal configuration would be to have more equity and use the equity to fund the OPEX of the company while using debt to fund the CAPEX. This is something that you want to get to. Until you can get there or better, you can only get there if you can demonstrate a reliable revenue stream and a sizeable number of customers and so forth. So, the reality is that until then you basically use your equity for pretty much everything. You do also have typically some grants that can get on board and those are as much as we can use for the assets and so they sort of replace the lack of access to loans."

Respondent A1 concurred:

> "Probably our next capital raise will be a few million dollars which will get us to build, if everything goes well, around 150 to 200 mini-grids. And on the basis of that we'll probably try to get project financing and stretch it out even further."

Respondent A7 elaborated on the movement away from grants and towards equity and debt:

> "We have grants, equity and debt involved… and I would see that moving towards more just equity and debt."

What is evident from the responses is that mini-grid ESCOs move through a gradual progression from grants, to equity and finally to debt. Respondent A6's company is still in the beginning phase of this process and foresees that the company will move through the phases as time passes:

> "Hopefully a grant is still to come to take it to 130 families and after that I would consider commercial equity finance to take it to 1000 families or even 2000 or 3000 families. And then after that I would hope that I have a relationship with a bank to get a loan. So, that's your succession right; from pilot, to grant, to equity and to loan."

Respondent A3 also felt that going forward, refinancing of mini-grid projects will become more common when mini-grid ESCOs have successfully entered the replication phase:

> "If you manage to build up a portfolio of 20/30/40 mini-grids, you would then cash that out in essence and refinance that portfolio so you get money for the next portfolio. I think that's a potential model that could work and I know folks that are trying to put that type of structure in place and it'll be interesting to see how that goes."

The third question that the researcher posed respondents was whether they think that early stage equity investments at the corporate level of their companies can assist in the scaling process. All respondents agreed that such investments would do much to help the scaling process. However, as respondent A6 mentioned, these investments could also have a potential downside, especially when mini-grid ESCOs start attracting numerous equity investors:

> "But what you have to be careful of is that when you come out of the equity financing rounds, because there is going to be one round, and a second and maybe a third before you get a loan, is that the initial founders' equity share has decreased so far that it's not interesting any longer. And that's happening a lot so that's also something to consider. That's why the grant is quite important, because you don't completely want to de-incentivise your owners; the people that drive the project. I mean, if they end up with less than 20% in the end, and it can easily happen, then the whole model also fails because now the people that are doing the hard work gets left out and they also want to get exposed to the upside."

Respondent A3 felt that equity investments can especially be useful for working capital:

> "That's the biggest problem we have with grants: very few of them want to fund working capital, they'll fund a study where you hire an outside consultant or they'll fund some hardware but they expect everyone to work for free and vehicles to run on fumes instead of real fuel. I understand to a degree the reluctance of grant providers to give that working capital, because there has been so much abuse, but there needs to be a middle ground. To put your head in the sand and say they don't need working capital, they just need money to put in poles and solar panels is kind of stupid, but you know it's just the model that people are comfortable with and that they are using."

Furthermore, respondents A5, A7, A8 and A9 noted that there aren't many equity investors that are active in the mini-grid sector as it stands. Respondent A7 felt that this is because the only investors that would invest are those with strategic considerations in mind:

> "I think the problem is it's very hard for a pure financial investor to come in, there's some more strategic investors that see mini-grids as the next big thing

> and they’re trying to figure out who’s going to come out top of the pile when it does break, so they might want to come in there.”

Respondent A8 said that impact investors can also be included in this group:

> “The question is which type of investor is entering these markets. You may have impact investors, they are very keen to enter in these companies at early stage. But if you think more as in private equity investors, it’s not clear as of yet that those investors will enter this market at this moment in time.”

It was thus deduced that investors that are investing in mini-grid ESCOs and those that will invest in mini-grid ESCOs for the foreseeable future are not investors that are purely looking for a financial return, but rather strategic benefits such as market expansion or social and environmental impact. This realisation corresponds with the rationale behind this study, in the sense that investors looking for short to medium term financial return will not invest due to the unattractive risk-return profile and that strategic investments could be more probable given the current state of mini-grid ESCOs.

Fourthly, respondents were asked whether investors that are investing in mini-grid ESCOs only have financial considerations in mind or whether they also have strategic considerations in mind when investing. Nine of the ten respondents felt that investors have both financial and strategic considerations in mind. They mentioned that these strategic considerations are in the form of the premise that an investment in a mini-grid ESCO can be a facilitator for future market expansion for the company making the investment. Respondent A9 noted:

> “They might think that it is a sector where there might be some growth and they want to be one of the first players on the ground.”

The final question that the researcher asked respondents for the purpose of addressing the first research objective was whether there are other ways in which new players can enter the mini-grid sector aside from pure equity investments. The response that dominated this question was that of aggregation of services between the mini-grid

ESCO and the strategic partner, mentioned by respondents A1, A3, A4 and A7. There was variability in responses as to what type of partners these might be. Respondents A3 and A7 noted that the electricity services of a mini-grid ESCO can be tied up with utility services provided by other private sector companies or non-governmental organisations (NGOs). Respondent A3 mentioned that the purification of water can especially be useful:

> "Here's what I've seen in Tanzania, and it breaks my heart, but so many people die of cholera because they've got bad water and there are some of these types of water bottling equipment that needs power so if you bottle or purify the water at village level then you reduce the cost and make it more available to these people. So, you can buy a litre of bottled water in almost any village, but it's a little expensive for most people, so if you can drive down those costs by placing a distiller or something there at the power generation facility then I think that's a logical next step. It increases the load and it leverages your fixed base costs of bricks and mortar. If you can cross-sell then that's just retail 101."

Another form of aggregation of services can come in the form of partnering with a MNO via an off-grid telecom tower, as respondent A4 noted:

> "Then there is also this whole notion of a mini-grid tied to a mobile phone base transceiver station as an anchor. It has been tried out in Lesotho, Kenya, Tanzania, Ghana, Nigeria and Malawi. The approach to that is not so much investment as in securitising investment through a PPA, which I still think is a really interesting model right. Because if you can get a tower company to make a commitment on buying x number of MWh per year in a number of sites, it makes financing, particularly on a debt basis, of those projects so much easier."

Respondent A3 mentioned that another form of aggregation of services can be collaboration with solar home system providers:

> "Villages are sort of like any town – in the centre it's congested and the further out you move the farther apart the houses become. And when you're doing a mini-grid in a village one of your limitations is that you can't extend the grid

> too far because the line losses kill you so you've got a radius of 2km or so and once you get outside of that it doesn't pay to string those customers into the grid, but they still need power. So, we're working with a supplier of little units for one or two or three houses."

Respondents A1, A5, A8 and A10 mentioned that a different form in which new players can enter the mini-grid sector can be electric utility companies establishing spin-off companies through their internal efforts. Respondent A1 said:

> "I think it's called [company A] and [company B], they're all building out their internal efforts so it's kind of partnering with their own and there's also [company C] who are doing it in-house."

4.2.1 Summary of results for research objective 1

In summary, respondents expressed the difficulty that they experience in providing an attractive risk-return profile so as to attract commercial investment. Seven respondents indicated that their financing requirements included equity investments. Respondents noted that early stage equity investments at the corporate level of ESCOs can assist in the scaling process. The researcher realised that there are, however, not many providers of equity as it stands because of the unattractive risk-return profile and that those that would invest would have to have strategic considerations in mind as opposed to purely a financial mandate. Extending that thought, 90% of respondents felt that those equity investors that have already invested do also have strategic considerations in mind and it would thus be important to continue attracting those types of investors. Lastly, respondents noted that there are other ways for strategic investors to get involved in the sector if they prefer not to invest directly in a mini-grid ESCO, such as aggregation of services with MNOs, NGOs and solar home system providers as well as multinational electric utilities establishing their own mini-grid ventures through internal operations.

4.3 Potential types of private sector companies interested in strategic mini-grid ESCOs investment

In addressing research objective 2, the researcher firstly asked respondents which type of private sector companies in the energy sector could be interested to invest strategically in mini-grid ESCOs. All respondents agreed that the most likely group would be electric utility companies and IPPs. Respondent A4 mentioned:

> "I think fundamentally it is the energy utilities and the IPPs. Energy utilities like [company D], [company C], and these guys who have taken an early stab at the market and shown interest, I think that [company B] of course is one that is in Tanzania as well and then I think that the second biggest is IPPs that are operational in other countries, like [company E]. Basically, people who are in the energy space at scale and are starting to see the thinking around electrification is moving away from national grids and moving towards decentralised approaches."

Respondent A1 had a similar response:

> "There are utilities who are viewing this as a way to deploy capital, create more assets and expand. That is [company F], [company C], your companies like that; and then there's more the energy companies who I'll say have more of a dual mandate on this, so when you're talking about [company G] or [company H], I think that they're interested both because they're interested in this from the perspective of it being a new market and potential business line of selling electricity, so they're considering creating these long-term assets and being able to sell electricity is interesting for them and then from the other side it's also a customer channel, so they're having a way to sell more LPG and kerosene or whatever else gives them a channel for sales."

Respondents A3 and A6 added that crowdfunding dedicated to off-grid energy is a likely source of investments given the current risk-return profile, as crowdfunding companies typically take on significant risk.

Respondents were then asked which type of private sector companies outside the energy sector could be interested to invest strategically in mini-grid ESCOs. The majority of responses (respondents A1, A2, A6, A7, A9 and A10) related to connectivity services, under which respondents mentioned MNOs, social networking and cloud services and ISPs. Respondent A9 mentioned:

> "Yea, I think that there are other groups that would be more suited. Telecoms being one. You know, companies that are good at going to remote areas and working in places where there is not a lot of money and where there's not a lot of infrastructure. Mobile telecom operators that are putting up cell phone towers in remote areas, they rely on the economic development of those areas to build up the use of the cell phones. So it goes hand in hand with the development of these remote areas to develop the availability of electricity. Because availability of electricity is a very critical part of economic development of a remote area. So, to say the least that cell phones require electricity, that's like the very baseline."

Respondent A2 concurred:

> "There's also the telecom guys who need to expand their footprint, because telecoms have gotten so competitive. Seeing as they're already operating towers in these places, why not build the grids? I haven't seen much from them, because they've been in a tough spot in terms of consolidation and downsizing lately, but in theory they would be well positioned to move into this."

Respondent A7 was more specific in mentioning that it would rather be the operators of the telecom towers:

> "Well, all the telecom providers. Well, it's actually one layer down to the service providers to the telecoms, so the tower operators. So [company I] goes into a country, they've already got a power problem, so they need to deliver distributed energy service to those power stations and they'll be near people who aren't electrified so there's an opportunity there and they're trying to figure that out how to do that as well."

Regarding social networking and cloud services, respondent A10 noted:

> "Then as a third group I also see digital service providers as a group that can be interested. [Company J], [company K], [company L], they are all having or had some activity in this area.

Respondent A7 concurred:

> "The other interesting guys that are getting into the space are the Silicon Valley companies, the data and software companies like [company K], [company L], [company J] – they've gone back up the value chain to see how they're going to get growth of consumption of their products in Africa in the next 20/30/40 years and they get back to power. So now they have just launched a mini-grid fund called [name], they put $xx into it."

Respondent A10 also mentioned ISPs:

> "I know that internet providers are interested in this, because internet is sort of the second step to me. Energy access is the first step but the later step would be internet access, which I regard as also very important, maybe not as important as electricity, however internet certainly also a lot of opportunities to customers. So they are typically also interested in providing energy access, since that's a requirement for internet access."

Secondly, respondents A1, A4, A5 and A8 alluded to consumer goods. For example, respondent A8 mentioned:

> "I think any kind of company that could be interested in some way to promote products and services. I mean there are 620 million off-grid people in sub-Saharan Africa. Such potential investors could be energy system suppliers for example, it could be consumer products."

When asked to be more specific as to the type of consumer goods, respondents A4 and A5 mentioned beverages, while respondents A1 and A8 said that it could be any consumer product that is applicable to a rural community. With reference to beverages, respondent A4 noted:

> "If you think about it; [company M] right, people drink that stuff cold. So, if you could get a company like that to look at Africa and say: "We've reached 90% of the electrified market, but guess what, 85% of Africa is unelectrified. And what if we can make investments that can accelerate electrification so that we can reach that 85%." That certainly could be an interesting strategy. So yes, beverages for sure because I think its low hanging fruit."

Finally, a smaller number of respondents (respondents A3, A4 and A6) mentioned that providers of electric appliances could be a potential group of companies. In this regard, respondent A3 stated the following:

> "There's starting to be, I think, also more of the commercial players that are selling appliances that are beginning to realise that off-grid companies are starting to scale and becoming potential distributors for them."

Table 4.1 shows the types of private sector companies in the energy sector that could be interested to invest in mini-grid ESCOs, according to executive managers of mini-grid ESCOs. The column indicating number of mentions refers to the frequency of respondents that mentioned a particular type of private sector company.

Table 4.1: Private sector companies in the energy sector likely to be interested to invest in the mini-grid sector

Private sector companies in the energy sector	Number of mentions
Electric utilities & IPPs	10/10
Crowdfunding dedicated to off-grid energy	2/10

Table 4.2 synthesises interviewees' responses with regards to potential strategic investors outside the energy sector. While all respondents agree that providers of

connectivity services would be most likely to invest, responses regarding the type of connectivity services were diverse. In addition, of the four respondents that mentioned consumer goods companies, two added more detail by mentioning beverage companies specifically.

Table 4.2: Private sector companies outside the energy sector likely to be interested to invest in the mini-grid sector

Private sector companies outside the energy sector	Number of mentions
Connectivity services	10/10
• MNOs	5/10
• ISPs	2/10
• Social networking & cloud services	4/10
Consumer goods	4/10
• Beverages	2/10
Electric appliances	3/10

4.4 Potential of strategic investment in mini-grid ESCOs from private sector companies

From the questions raised under research objective 2, it was identified that electric utility companies, IPPs, providers of crowdfunding, providers of connectivity services, consumer products and electric appliances could be interested to invest in mini-grid ESCOs. Thus, in order to explore the potential of investments from these private sector companies in more detail, interviews were conducted with these identified companies as well as the same sample of mini-grid ESCOs that were interviewed in research objectives 1 and 2. However, as was mentioned in chapter 3, electric appliance companies were omitted from this list due to the fact that time limitations impeded the researcher from approaching all of these groups. The researcher thus decided to omit the group that was mentioned the least by mini-grid ESCOs, which turned out to be electric appliance companies.

4.4.1 Mini-grid ESCOs

Building on the questions that mini-grid ESCOs were asked under research objective 1 and 2, respondents from the mini-grid ESCO sample were asked two additional questions. The first question was what kind of strategic value they would be able to provide to strategic investors. The majority of responses (respondents A2, A3, A5, A6) were focused on the relationships that mini-grid ESCOs have with customers as well as information about these customers. For example, respondent A5 was of the opinion that financial information about customers would be key for potential strategic investors that want to scope the potential of selling products or services in these markets:

> “We can leverage the information we have regarding payment history, regarding the creditworthiness of the customer by using direct and indirect financial information. We can use direct information like how much they pay us, but we can also use indirect information by looking at how they use energy. The real issue with this sort of customers is that we are looking at more than one billion people that effectively nobody knows anything about. And so, information that you can gather from those guys, that is something that I feel would be very valuable at some point. That may help those distributors, like [company N] and so on to make more private investments, to try to open up markets that are effectively closed.”

Respondent A6 talked along the same lines:

> “The first thing is, I will have records of people regularly R200/R300 every month and that is already valuable.”

Respondent A2 focused on the value of customer relationships and added the importance of the general knowledge and experience that mini-grid ESCOs have with working in far out rural areas:

> “Specialists with stand-alone mini-grids in far-away places understand the customer-relationships and how to fix things and the kind of technologies to pick for these applications. Having a partner that does that makes a lot of sense,

> having a partner that can be there locally and train people and be the customer-interface with the users of the power is very useful. So utilities, you know, why are they interested in companies like [company O] or [company P] or those others? It's because they know it's a very hands-on, sometimes it's a very difficult, arduous task to provide these systems so that's the interest in the mini-grids."

Lastly, distribution emerged from responses of respondent A3 and A5. Respondent A5's response was as follows:

> "When you are establishing a mini-grid in a place, you have typically a strong distribution channel, you know the customers well, you have strong technical expertise and teams in the area and so there is a lot of potential there to use these existing aspects created by the mini-grid company for one side, distributing goods and the other side, providing technical support."

The final question that the researcher asked mini-grid ESCOs was whether they think there is a specific size that they would need to be in order to have the ability to work with strategic investors. Most respondents didn't provide a fixed answer for this question, but the response that seemed to dominate was that they would at least need to have a proven track record of operations to attract strategic investors, as mentioned by respondents A5, A6, A7, A8 and A10. For example, respondent A8 noted the following:

> "It depends. I think so far, the key drivers for mini-grid operators is first to prove that there is a profitable business model on the activity that they are performing and secondly the ability to scale up. Those are the two main challenges for mini-grid operators."

Respondent A2 mentioned that mini-grid ESCOs would probably be able to show a proven track record when they have a few projects on the ground:

> "What they (strategic investors) are going to want to do is see a track record… it's certainly more than zero, probably more than one, probably doesn't need

> to be more than ten, unless they're really risk-averse and again it depends on the bite they're taking."

Respondent A2 then elaborated on the comment pertaining to investment size:

> "So, for example, [company H] takes a really small piece of some of these companies and they've done solar home systems, they've done mini-grids. They take a 1-3% stake in the company. So it's a teeny weeny little investment to sort of getting to know the company, but once it goes over to the other side of the business, the energy access side of the business, they're looking to take a much bigger stake in these enterprises, like a 15-30% ownership, but they wouldn't do that until that mini-grid company had a track record. So, I guess you can say the smaller the amount of money, the more willing these larger organisations are to take a risk. There's not a one-size fits all quantitative answer to that one."

In continuing the process of addressing research objective 3, the researcher approached private sector companies from the groups identified under research objective 2 (see Tables 4.1 and 4.2). The interview schedule that was used to conduct interviews with private sector companies in the energy sector (electric utilities and IPPs) differed from the one used to conduct interviews with private sector companies outside the energy sector. The reason for this is that electric utilities and IPPs typically have a working knowledge about rural electrification and mini-grids, which typically is not the case with private sector companies outside the energy sector. The responses of the private sector companies in the energy sector, of which six were electric utility / IPP companies and one was a crowdfunding company, will be presented in the following section. The amount of crowdfunding companies that were approached is much lower compared to electric utilities and IPPs because of the latter being mentioned much more frequently by mini-grid ESCOs.

4.4.2 Private sector companies in the energy sector

Respondents were firstly asked if they only take short to medium term financial return into consideration when making a decision to invest or enter a market, or if they also consider strategic value. All respondents answered that they consider both aspects. Respondent B1 noted:

> "Every investment definitely has to align with the general corporate strategy and then there are also the investments that are not 100% caused by the immediate financial returns, but also by the strategic value."

Respondent B2 elaborated and mentioned that this is especially applicable to mini-grid ESCOs given the perception that an investment in mini-grids currently provides more strategic value than financial value:

> "The financial return has not been the reason for investing up until now. In our work here in Africa, we see a lot of potential in energy access through different solutions and that could be through individual systems like solar home systems or mini-grids. But in the case of mini-grids, it's more like market testing and to develop the capacity to scale and be profitable over time."

The second question that respondents answered was which type of company they would rather invest in, between start-ups and more established companies. From the responses, it would seem that there is a preference for more established companies, as four respondents (respondents B1, B5, B6 and B7) mentioned that would invest in both types, while three respondents (respondents B2, B3 and B4) mentioned that they would only invest in established companies. Respondent B1 mentioned that their various investment divisions have different types of companies on the growth continuum under focus:

> "There are different approaches within the whole corporate. There is for example one programme which is called [name of programme], I don't know if you came across that, which is a corporate accelerator and is also where [company Q] was founded. Then for larger investments there's a division called division A and they would be specialised in direct investments, mostly focused on mid-ventures and late-ventures."

Regarding responses related to only established companies, respondent B2 noted that the requirement for a strong track record is why the respondent's company will only consider more established companies:

> "If we were to invest in a company, it would most likely be a more established company than start-ups. They have to have some track record."

Thirdly, respondents were asked whether they would prefer to invest on the corporate level of an ESCO or if they would rather invest on project level. Four respondents leaned towards corporate investments in their responses. Respondent B7 mentioned that the major reason for this is risk mitigation:

> "I generally think it's more interesting to invest on the developer level. You're spreading your risk across more projects and you're getting more scale, so then the question is, I would ask myself "What do I think of the developer? What do I think of the track record of the developer? Do I like the management team? What have they done outside mini-grids that can give me comfort that they will do a good job?" I would definitely invest in a developer."

Respondent B6 concurred that investing on the corporate level spreads risk across more than one project and outlined what the ideal investment strategy in the mini-grid sector would be:

> "The ideal scenario would be to get some shares in a mini-grid company, help them to scale up significantly until they have a large operating portfolio and then at some point maybe renegotiate this whole portfolio as a large utility. In this way, you can mitigate your risks across the different projects. And then you can sell it at a premium of course. Then you hand over and you're gone. It could be that or you could continue operating."

In addition to the four respondents who prefer to invest on the corporate level of ESCOs, respondents B3 and B4 suggested that they would be more inclined to invest on the project level. For example, respondent B4 argued that it is better to fit in with the status quo of what commercial banks expect in the process of moving mini-grid ESCOs closer to where debt finance can be attracted:

> "Look, at this moment if you're going to finance something in a traditional project finance structure that every bank is used to then you're going to find it much easier to bank a project… if I'm a IPP type of developer who looks at developing a mini-grid, which is essentially a power system that has a generation, a storage and a distribution aspect and I'm going to finance it with a typical project finance debt equity structure then it's just all about risks and the risk perception for the bank and you just need to deal with those risks to ensure it's bankable, as per the traditional process of doing any project finance."

Lastly, respondent B2 mentioned that both types of investments would be achievable:

> "It could be both depending on the activity. A typical IPP will obviously be more project finance-based, while in some way, if you think about mini-grids, it is more corporate finance. There wouldn't be much project finance for mini-grids in the short term."

Respondent B2 in effect raised an important point. What emerges from this response is that IPPs are used to project finance through their work in utility scale projects. However, mini-grids are too small to justify project finance and while the consolidation of individual mini-grid projects could justify the minimum required ticket size for project finance, the industry has not developed to a point where mini-grid ESCOs can consolidate mini-grid projects purely because each respective ESCO does not have enough projects. Thus, until the industry reaches this point and if IPPs would want to enter the market in this early stage, corporate investments would be required and as such IPPs would probably need to familiarise themselves with this and put off project finance until a later stage when it can be done viably.

Respondent B7 provided an additional comment on the topic of potential downsides of corporate finance:

> "Someone like [Company U], they are an interesting case because they got such a multiple range of projects and in some ways, it makes it more difficult for someone to invest in them, because an investor will be saying: "Am I interested

> in the utility scale projects? Am I interested in the mini-grids?" The problem if you want to invest in the developer level, is you got to like the whole story."

However, even though it could become more common in the future for ESCOs to develop both utility scale and mini-grid projects, this is not the typical case as it stands.

The fourth question that the researcher asked respondents was whether they think mini-grid ESCOs can provide sufficient value (whether it be financial or strategic) to warrant an investment and if not, if this could change in the future. The overwhelming majority of respondents (respondents B1, B2, B3, B4 and B6) mentioned that mini-grid ESCOs do offer significant value, but noted that this value is only strategic and not financial. Only respondent B5 felt that mini-grid ESCOs offer sufficient strategic and financial value. Respondent B1 commented that investments in mini-grids are inherently risk investments, with the aim of tapping into the strategic value that mini-grid ESCOs offer:

> "I think that mini-girds is definitely in the position to raise capital and to receive funding by larger corporations, which is mostly due to the potential of the area and the market size. It's certainly a risk investment, but that's to some extent part of the game I would say."

Respondent B2 had a similar response:

> "The financial return has not been the reason for investing up until now. We need a proven business model but it is not yet there. However, we are ready to take a risk to enter this market to see where we can play a role in mini-grids at larger scale and prove the business model along the way. It is more an early stage risk investment for early mover positioning in this market. In the specific case of mini-grids, it is related to strategic considerations."

Respondent B3 felt that there is strategic value in mini-grids and the reason for why mini-grids do not offer financial value yet is because business models haven't been fully developed yet:

> "My personal sense is that the answer to that is yes, and that conclusion is drawn from a somewhat naive comparison with cell phone companies and mobile money companies that have shown that in fact one can make money in the poorest communities in Africa, so there should be a way to go there. It is less clear to me what that route is and as far as I know most of the micro- and mini-grid opportunities or projects that are out there have not started as a purely commercial project. The business models that will make these types of projects work are yet to be fully developed."

Respondent B5 said that mini-grids do also offer financial value, but this is due to the company's favourable requirements pertaining to return on investment compared to other equity investors:

> "I mean I think there are a number of companies, I work mainly in East Africa and then we have projects in West Africa and Zambia. There aren't very many mini-grid companies who have made a commercially valuable business model. There are some coming through, but the payback time for these businesses are well known and the typical payback time is quite long, at least 7-10 years to get pay back, but what I would say is that the IRRs are 14/15% which I like. You know we've got companies like [company P], [company R] and [company S] who look like they could be major players, but they're still young. I think we'll look back in 5-10 years and see it is a commercially valuable sector, but investors prefer to see a sector mature first. What comes first, the maturity of the sector or the investment? That's where we come in, we're a company with a high-risk appetite and we are interested also in social impact and environmental, so we're a lot faster getting into the sector, because it's not just about financial return. So yes, to answer your question: I do think it is a financially valuable sector which can provide returns to investors, however it is still immature, we'll have to watch and see over the next 5/10 years when investors start getting their returns and the sector becomes financially viable."

The fifth question that the researcher asked respondents was what kind of strategic value they think can be gained from an investment in a mini-grid ESCO. Responses varied to a great extent. Respondents B1, B3 and B7 mentioned the value of energy storage. For example, respondent B3 conceptualised mini-grids as a testing ground for batteries to be deployed at utility scale:

> "Another component to this which is really important and that is that we absolutely believe that storage going to play a huge role moving forward, a disruptive role, a game changing role at utility scale. So microgrids are very nice because they test how that is going to work. The sun is fantastic in many respects, but the availability, the capacity factor is around 20%. And then you want to run fridges, for which you need to put storage in. And once you put storage in, then you understand and learn intelligently how to store and deploy energy smartly and then you have the ingredients, the formula, the roadmap to do it at utility scale. It just scales up."

The strategic value for respondents B1, B4 and B6 lies in the opportunity to tap into the decentralisation trend of electrification. For example, respondent B4 noted that decentralisation is why strategic players should enter the market through investments at this early stage:

> "…so, if you then look at most African countries, they have very small power systems, but they're small centralised power systems. So, what's really going to happen is that they're going to turn into large decentralised power systems. So the mini-grid and the off-grid and any decentralisation solution is going to happen in Africa. Essentially, you're going to skip the big centralised and go straight from small centralised to big decentralised, which is just what the US is turning into now. The reason is that solar and storage is cheaper, or will be cheaper, than the traditional competitive forms of centralised electricity generation. So, in years to come that's what will transform the electricity grids in Africa, along with inter-connection as well which allows for more renewables to get on the market. So as a strategic investor you know it's going to happen and you know the earlier you get into the market, the more reward you're going to get out in the long term, but ultimately if you're clever you need to think a lot about how you're going to approach the market."

Respondent B6 added that along with decentralisation as strategic value, mini-grids also offer an opportunity for diversification:

> "Then in terms of strategic considerations, well, we wouldn't be interested in mini-grids if it wasn't for that, because in this early stage we believe it's going to happen. As we saw over the last 2 years in those conferences the subject has changed from utility-centric to distributed energy. In the last one, the Africa Utility Week, they were really putting some effort into distributed mini-grids. It was kind of a big subject. So, it's definitely going to happen. There's no question. The train is starting to leave. And that's why it's one of the reasons for us to be interested. From a strategic point of view, we look at what's happening in South Africa with the Renewable Energy IPP Procurement Programme (REIPPPP) and there's a lot of uncertainty currently because we don't know if it's going to carry on actually. And even more, decentralised generation is getting stronger and stronger so I am even questioning if centralised large renewable projects will make sense. So, for us, we want to grow."

Respondent B2 concurred with respect to diversification:

> "The aim for us is to be a player in all the segments of electricity. We want to be a player in generation, the IPP side, we will be interested not only in covering the people on the grid but also people that are off-grid. I think that mini-grids could be a good entry point. They can be integrated into the wider approach of our company as a whole."

Finally, respondents B1 and B3 noted that the large potential market that can be served through mini-grids is an important aspect of strategic value. Respondent B3 said:

> "We are a private for-profit company. That's what we do, and we see a huge business opportunity in managing the supply of and demand for and use of energy moving forward. So we see ourselves as a utility, really. And making our money by creating energy renewably at lower cost and moving it to where there is a demand for it and that can particularly be the large number of unserved

> potential users of electricity, which means that you have a very large potential market that you would have had if you built the infrastructure, if you built the grids, which we could potentially go after."

The sixth question that respondents answered was whether they attach value to the aspects that mini-grid ESCOs felt would be of strategic value to potential strategic investors. These aspects included the following: Strong and stable customer relationships with end-users, extensive knowledge of customer creditworthiness and electricity consumption patterns, extensive knowledge of distribution channels in terms of physical distribution and communication and finally, consumer preferences in rural markets. Only respondents B2 and B5 mentioned that these aspects would not contribute to justifying an investment, even though they consider them to be valuable add-ons. The rest of the respondents mentioned that these aspects are valuable for brand loyalty and cross sales of products and services, while it also helps the investment case. Regarding the latter, respondent B4 mentioned the following:

> "Yes, essentially is the short answer. If you start operating in an area and the customer pays you, all of a sudden, you're creating a credit history, and a positive one (most of what I've seen is in the high 90th percentile) and that is the first step in ensuring a project is bankable. Your customer pays for the service, so as long as they're getting good service of course, they're paying for it and you're making your expected return as per your financial model. That is a very important aspect of proving an investment case. Now, if you go further on, knowing the customer and knowing their usage is pretty important for the design of the project."

It is thus possible to view these aspects of strategic value mentioned by mini-grid ESCOs as add-ons that are not tied to the core business of energy sales per se, or, as respondent B4 noted, these aspects can also strengthen the core business of the mini-grid and in turn strengthen the investment case of an ESCO or mini-grid project, by virtue of the proof of customer creditworthiness and payments. In that light, the concern that respondent B2 brought up can thus be mitigated through strengthening the investment case via these aspects of strategic value:

> "Yes, those things certainly add value, but from my side I would say that the business model itself should be based on the selling of electricity. Those things are a kind of upscale, that we will later on see if it can be monetised in some way, but it's an upscale. I think the business models of mini-grids should be working on the basis of selling electricity to end customers and be profitable. So all these things about customer knowledge, about getting valuable data that can be valuable for other private sector companies, that's an upscale. You shouldn't build the business on that. It's not the end strategy to get that information from end-users. I think energy is the entry point and in some way if we can set up a database of clients, that can lead to the offering of other services. That's a secondary step and not the primary focus."

Respondents B3 and B7 said that they agree that these aspects are valuable in theory, but they doubt to what extent mini-grid ESCOs actually have this data and knowledge. Respondent B7 had some pertinent questions in this regard:

> "Well, that's becoming very strategic and I think there's a logic to what they're saying. The question is whether it's true. And how many customers are you actually getting access to? And then there's the question of are those customers actually attractive customers? So, you're absolutely right, but I'm not sure mini-grids give it to you. I do think it's a very good goal and lots of mini-grid developers talk about it but it needs to happen."

Respondent B3 followed up with a request for more information about this topic:

> "I'm quite intrigued to know to what extent any of these (mini-grid) companies are getting this right because it's not straightforward."

Considering that the solar home system market has been able to attract more investment than the mini-grid market, respondents were then asked if there is any reason for them why an investment in mini-grids would be more valuable than one in solar home systems. This is especially in light of the fact that the solar home system market is more developed than the mini-grid market, with better financial returns. There was a wide variety of responses. Respondent B5 was aware of the fact that investments in solar home system ESCOs are easier to do, but still prefer investments in mini-grid ESCOs because of the revenue generation potential of mini-grids:

> "I actually prefer mini-grids as an investment, mostly because of the revenue generation potential. The saying goes "give a man a job, not a loan". With solar home systems on a PAYG basis, you give someone a product that adds value, for example, the kids can study etc and it has a social impact sure, but mini-grids can have a much higher impact, because they offer higher productivity and lots of the companies I talk to show that you can use mini-grids to power a factory or a small business or some way of generating revenue and that de-risks the investment, because you know you're guaranteed returns. One of the key issues in investing in companies in Africa is that the customers typically don't have a lot of disposable income so if you provide a product in which you can guarantee that you're going to increase the net income of the customer you then de-risk the investment. And to me, that is the key difference between mini-grids and home solar systems; you reduce risk by giving people the opportunity to generate revenues and that then off-sets the risks of long-term exposure."

Respondents B1 and B6's answers were closely tied to respondent B5, as they mentioned that they would rather invest in a mini-grid ESCO because of the productive power that mini-grids provide (which is in turn a facilitator of revenue generation). Respondent B1 noted:

> "I think that the main justification for mini-grids is the potential to also run larger appliances. So the idea is to have electricity usage sort of at industrial scale, not meaning that you have to run an entire factory on it, but that it allows you to run for example a grinder or a mill, any kind of equipment which requires larger currents, which usually requires three-phase electricity."

From a technical standpoint, respondents B3 and B6 mentioned the value of load balancing which can be achieved in a mini-grid:

> "For me it's quite obvious that you need a smoothing of demand in order to get around at least part of the challenge of solar. Of course, there's batteries which

> can mitigate this to some extent, but the devil is in the detail of batteries and that is that batteries cannot be charged infinitely and fast. They have finite discharge times and they need to be managed. In practice, there's always advantage in aggregating. I mean, if a client doesn't use the power or can't pay for it then I have a problem. Whereas in a mini-grid environment, I can hedge that challenge and so from a commercial point of view, the ability to fund a mini-grid as opposed to a solar home system is much better. And banks hate single buyer problems."

Respondents B4 and B6 further mentioned that they would prefer an investment in mini-grids because of a mini-grid's compatibility with the national grid. Respondent B4 said the following in this regard:

> "And until wireless electricity transmission happens, the grid is still going to be needed. It will grow organically to a certain size but sooner or later the main grid will come and then you can sell in bulk or negotiate to have some form of an agreement."

Respondent B4 continued by also stating that cross-subsidisation is important:

> "Mini-grids have the ability to allow for some form of cross-subsidies between consumers so yea, that's why I chose that direction."

Finally, respondents B2 and B4 see investments in the mini-grid and solar home system markets as complimentary, in the sense that all tiers of energy services are covered, as respondent B2 noted:

> "I think that both solutions are complimentary, in that our feeling is that solar home systems cover, let's say, basic household needs such as lighting, charging the phone, small TVs and radio. The mini-grids cover areas that the solar home systems can't, by being focused on productive uses, whether it be commercial or agricultural and also at the same time covering the household."

Respondent B4 extended this thought by conceptualising waves of electrification:

> "So the solar home system guys – I would deem them to be a temporary solution to a long term problem, because of their technology, the battery only lasts for about 4 years before it has to be replaced and that adds costs. However, what they are doing is basically displacing the current energy usage with electricity using a small solar home system kit, but what they're really doing is creating an electrification need. So, in the event that a mini-grid developer just pops into one of these areas, people need electricity, there's appliances and these guys sell appliances on credit like TV's, radio's and lights. So, all of a sudden you have an electricity need in an area so if the grid or a mini-grid comes, then you know there's a need for electricity. So, it reduces one risk in that respect."

As an eighth question, respondents were asked if there are other ways in which they would prefer to be involved with a mini-grid ESCO if they prefer not to invest directly. Respondents B1, B4 and B6 recognised that some sort of partnership with a mini-grid ESCO could be fruitful. Respondent B4 felt that a partnership could be useful because of the lack of knowledge that the respondent's company has on the ground:

> "Our current model in sub-Saharan Africa is that we partner with local developers because we don't have presence on the ground and we're not set up to operate in the markets. So, it's always going to be a partnership. It all comes back to your approach to the market. We look at approaches to markets and we determine which one is the best and we might be using different approaches in different markets, but for me partnerships is always necessary from our perspective, because we're not on the ground and we don't have the local experience, but we do have the ability to bring projects to close and to provide funding for those projects and when you have a track record like we do, it's easier to get banks to lend you money and then you also share the risk as well, so it makes investment from an internal perspective easier to prove."

Respondents B1 and B2 mentioned that spin-offs by means of internal operations are also useful if a strategic investor prefers not to invest in an already existing mini-grid ESCO.

As the last question to respondents in the sample of private sector companies in the energy sector that could potentially invest in mini-grid ESCOs, the researcher asked whether respondents think there is a specific size that mini-grid ESCOs should be to be able to work with strategic partners or investors. Respondents B1 and B2 mentioned that the mini-grid ESCO should at least have a profitable business model, while respondents B3 and B6 said that they would like a mini-grid ESCO to show potential of scaling up. Respondent B4 felt that it depends on the size and the goal of the investment:

> "So if we invested now in a mini-grid company it would be about market presence and learning about the technology and not making too much of a return on your investment, but you're thinking longer term. However, if we were to make a significant investment, there would have to be decent return on the investment, there would have to be reward for your development effort and there would have to be scalability and potential expansions."

Respondent B5 mentioned that a mini-grid ESCO should at least have one mini-grid project that is set up with 50 connections:

> "So my main criteria is that you have to have at least one mini-grid set-up with at least 50 connections. That's a very small grid so we feel that it's a small ask. We have a lot of companies that come to us who haven't done anything yet, but they want start-up capital and I don't think that makes a lot of sense, from a financial perspective. It's basically a question of how to run a business - If you start looking for debt or expensive equity in order to start up a business it is a non-sensical decision. Start with the cash that you have, raise money from friends and family, get convertible notes, look for some equity or grants etc. I think strategic investment should come in once you have an established track record, once you can prove the certainty of revenues. I know we have the highest risk appetite on the continent, there is no one else that will go for someone with just one mini-grid with 50 connections unless it's a donor."

4.4.4 Private sector companies outside the energy sector

The final sample that was approached in this study constituted those private sector companies outside the energy sector that mini-grid ESCOs identified in their responses to questions posed for addressing research objective two. As shown initially in Table 4.2, these companies constituted connectivity providers (comprised of MNOs, ISPs and providers of social networking and cloud services), providers of consumer goods (specifically beverages) and providers of electric appliances. As electric appliances were mentioned to a lesser extent, only connectivity companies and beverage companies were approached.

The first question that the researcher asked respondents was whether the non-electrified population can be seen as an untapped market for their electricity dependent products and services. All respondents felt that the non-electrified market is indeed a latent market for their products or services. However, respondent C3 raised some concerns regarding the non-electrified population as the target market:

> "The concern that we have with a lot of stuff, if we take a step back and we consider the low LSM (Living Standards Measure) which overlaps with your sample, our biggest concern is payment. We don't focus on those LSMs at the moment, so for us personally, it will be difficult because we will struggle to get our payments."

Respondent C3 rightly highlights a common challenge that is also present in the development of mini-grid business models. However, the very basic idea of strategic investment in mini-grid ESCOs or some sort of partnership is that a strategic investor such as respondent C3's company would be able to leverage the knowledge and experience of mini-grid ESCOs who have already worked with this issue for a few years.

Respondents were secondly asked if they feel that the arrival of electricity in non-electrified areas can open up these untapped markets for their products and services, given the requirement of electricity infrastructure for the functioning of these products and services. All respondents agreed that electricity will definitely open up these untapped markets. Respondent C1 mentioned that it is important to acknowledge that a lot of additional work needs to be done as opposed to solely depend on the presence of electricity:

> "Yes, I think so, with the caveat that it is not solely the arrival of electricity. I think we're seeing and thinking of this problem as, you need more groundwork than just bringing electricity to actually drive demand and usage."

Respondent C4 elaborated on how electricity can expand the market for mobile network services in off-grid areas:

> "As soon as you put in electricity, there will obviously be a communication network too. People want electricity because they want to charge their phones. So we can even have a small shop in a previously off-grid village where there can be a charging station and where people can buy sim cards and phones."

Thirdly, respondents were asked whether they consider an investment in electrification as a step towards opening up these untapped markets. All respondents were of the opinion that an investment in electrification will contribute to opening up the non-electrified latent market, but respondents C2 and C3 noted that they probably won't invest in electrification. Respondent C2 stated the following in this regard:

> "We are unlikely to be investing/partnering in projects such as energy generation. It's big capital, long pay-offs, and lots of benefits not directly tied to our business. It may make more sense for a very large or close to monopoly operator to invest in these (e.g. [company M] or [company T] since they could recoup a big percentage of the upside."

Respondent C1 added that while the investments that the company in question make in mini-grid ESCOs feed into the strategic intent of the company itself, the manifestation thereof is currently more along the lines of philanthropy or corporate social responsibility (CSR) due to the timescale of the process being so long-term:

> "Yea I think based on our work we see a lack of financing as a critical gap in expansion of electricity services across the world. So, we're trying to fill that gap. I think the larger picture of the investments that we make is that you know, we would love for everyone in the world to have access to electricity so that they can use the service but I think that at this point it's more removed than that; it's more CSR than it is strategic investment. And for our partners it goes a little beyond just using devices, they have a large data storage arm to their business and would like to see that the data that is generated across the board to be on their servers but I think right now the investments are perhaps more philanthropic. There's no question that it makes sense in the long term, I just don't know whether the results will be on the timescale that everyone is hoping."

The fourth question that respondents answered was how they would prefer to get involved in with mini-grid ESCOs. Only respondent C1 mentioned that corporate investments directly into mini-grid ESCOs is the preferred choice, but added that refinancing of mini-grid projects could be a future option as well as to build a knowledge base in the pursuit to making the mini-grid sector more attractive:

> "We also have a role to play in building attractive policies for mini-grids and building the ecosystem of information available to other investors, so that the perceived risk of investments in mini-grids is lower. So we're doing a lot on sharing information and data to hopefully make this a more attractive market."

Respondent C3 preferred the delivery of their internet services in mini-grid locations as a form of a partnership with a mini-grid ESCO:

> "Off the top of my head I would say to come in as a partner and through that partnership, whether it be capital investment, whether it be subsidising of products, for us we would probably then focus on Wi-Fi hotspots, where people can just buy scratch cards that are a rate lower than (mobile) data. Where Rxx gives you 30 minutes or something like that. But yea, I think the capital outlay is so high, so those global companies with billions to invest would be more suitable. If it fails, they can just write it off, it wouldn't be a big deal for them."

Respondent C4 stated that it would be preferable to be an anchor client for a mini-grid ESCO by means of an off-grid mobile telecom tower:

> "Our load is about 2-3kW. So, for example, in addition to giving power to the tower, you can power the village. In addition to having power, people will now also have a mobile signal thanks to the tower. We call this community power projects. However, if we do this, the mini-grid operator would have to give me surety that the tower will have power 99.8% of the time, because as soon as there is no power, there will be no signal, which will reflect bad on us. That's where it will become difficult for a mini-grid operator. But if the mini-grid operator can deliver on these requirements and deliver power at a tariff that is cheaper than what we currently pay in using a diesel generator, well that would be a win-win scenario. Because we don't really want to use diesel generators; they are expensive to operate and they get vandalised and stolen."

As a fifth question, respondents were asked if they would consider investing in a mini-grid ESCO if the ESCO offers sufficient strategic value but the short to medium term financial return is not what is desired. Only respondent C1 noted that there would still be interest:

> "Yea, I think we are a little bit special in that we're built as concessionary finance, so we're blending both grant capital with equity investments from strategic players. We think that there are sources of financing out there for mini-grids; commercial financing available, but the lack of track record and the lack of understanding around mini-grids sort of makes that a really hard choice for commercial financing, so hopefully by helping build the track record of mini-grids, we can help unlock that additional financing that's beyond grant money, that large donor funds and start to move towards unlocking commercial capital."

Respondents C2 and C3 said that they wouldn't be interested because of limited investable capital that can be allocated towards energy generation, while respondent C4 emphasised the requirement for profit:

> "Look, at least we must be able to make a profit out of it. So the most important thing is the business case and what the advantage is for us. The question is basically how many people we will get using our service if we put up a new tower and if they get electricity."

Respondents then answered the question as to whether they think there is a specific size that mini-grid ESCOs should be to be able to work with them. Respondents C3 and C4 mentioned that the ESCO should at least have a proven business model. In the words of respondent C3:

> "I don't think there would be a specific required size. I think it comes down to whether they can prove it will work and that it can be rolled out. If you can make the proof of concept so compelling in terms of future potential, I think it would be very easy to pick up additional partners."

Respondent C1 emphasised the minimum requirements that would be considered:

> "This is something that we struggle with because we have to support new developers in this space, but as this is a fairly risky space, we know we need to have at least some track record, so right now we are requiring developers in order to be considered for financing to have at least one completed operational mini-grid but we're exploring how we can move past that in the future. The only real challenge is that we are a larger fund so the ticket sizes of individual mini-grids is smaller than we would like to invest. You know, we're doing due diligence before investing in any mini-grid, so we would like to be looking at a set of mini-grids to invest in and help drive down the transaction cost in the long term."

The seventh question that respondents answered was whether they prefer working with or investing in start-up companies or more established companies in a general sense. All respondents except respondent C2 mentioned that they can work with companies of both sizes, while respondent C2 said that the company does not tend to invest in other companies currently.

Lastly, respondents were asked whether they attach value to the aspects that mini-grid ESCOs felt would be of strategic value to potential strategic investors. As mentioned in the previous section, these aspects included the following: Strong and stable customer relationships with end-users, extensive knowledge of customer creditworthiness and electricity consumption patterns, extensive knowledge of distribution channels in terms of physical distribution and communication and finally, consumer preferences in rural markets. Respondents C3 and C4 agreed that they attach value to these considerations. For example, respondent C3 emphasised the value of distribution and already existing customer relationships that can be leveraged:

> "Yea, definitely. Definitely! We can get our products there quicker and easier and that close relationship with the end user in an untapped market, it's kind of going into a new geographic region where it was not an option and now it's really a reality."

Respondent C1 felt that these aspects would be of value in theory, but doubted the accuracy of the claim:

> "That one is a little bit tough. I mean, if the developers really do have those relationships and understanding of the customer, then yes, however I have also been talking to a lot of developers and I think we hear mixed things about whether or not developers are truly getting that close to customers with understanding their credit risk, etc. But, we are starting to think that maybe that is an important role for mini-grid developers to play because it builds demand for the mini-grid and the profitability of the mini-grid, we're just not sure who the right set of players are. Depending on who you talk to, the relationship between mini-grid developers and their clients might vary quite a bit."

Respondent C1 added why collecting such information could be challenge for mini-grid ESCOs:

> "I think some are having to play in that field but don't necessarily want to; some of the developers that we're talking to, they want to be energy service providers, they don't want to be evaluating credit risk for appliances and they don't

necessarily have the expertise to do so. They are also receiving a lot of pressure from their investors to focus on executing a successful mini-grid and not necessarily stretching themselves thinner."

4.4.5 Summary of potential strategic investment

In summarising the results regarding the potential of strategic investment in mini-grid ESCOs from private sector companies, mini-grid ESCOs indicated the following elements of strategic value that they can offer to strategic investors: strong and stable customer relationships; financial information about customers regarding how much they pay and how often they pay; energy consumption patterns, knowledge and experience of working in far out rural areas and the complexity of mini-grid deployment, as well as distribution channels. Mini-grid ESCOs felt that in order to be able to work with strategic investors, they would need to have a proven track record, which, according to them, they will have when they have more projects on the ground.

Furthermore, potential strategic investors in the energy sector reported that they do not only attach value to financial return, but also the strategic value that an investment can offer. Four respondents said that they would invest in start-up companies and more established companies, while three mentioned that they will only invest in more established companies. There was a preference for corporate level equity investments, with four respondents mentioning that they prefer these investments and only two preferring project-level investments. One respondent indicated an interest in both levels. There was an acknowledgement among respondents that mini-grid ESCOs offer significant value, albeit only strategic. They mentioned that they attach value to mini-grids being a testing ground for energy storage, decentralised electrification, diversification away from utility scale projects and the large potential market that mini-grids can serve. When asked if they also attach value to those aspects that mini-grid ESCOs mentioned could be of value to them, the majority agreed that those aspects would indeed be valuable for them, with only two stating that they do not consider it to be particularly important and two others stating that they attach value to these aspects, but that they doubt whether mini-grid ESCOs actually have that data and knowledge. Comparing against the successful traction that the solar home system market has achieved, five respondents said that they would still rather consider an investment in mini-grids. Reasons for this included revenue generation potential, productive power, load balancing, compatibility with the main grid and opportunity for cross-subsidisation. Two respondents said that they see the two technologies as complimentary and would thus consider both. Regarding alternative ways to enter the sector as opposed to solely equity investments, respondents mentioned that they would consider partnerships with mini-grid ESCOs or consider spin-offs from internal operations. Finally, two private sector companies in the energy sector said that in order to work with or invest in mini-grid ESCOs, ESCOs would at least have to have a profitable business model, while two others said that ESCOs should be able to show the ability of scaling up. One also mentioned the minimum requirement of one operational mini-grid with at least fifty connections.

Regarding the final sample of research objective 3, the types of private sector companies outside the energy sector that were identified as potential strategic investors all agreed in their first responses that they see the non-electrified population as an untapped market for their products or services. They also agree that the arrival of electricity in these locations can open up these untapped markets, but one respondent added that it is important to remember the caveat that it is not solely electricity that will open up these markets, although it is the strongest leverage point. What is implied is that significant groundwork needs to be done to ensure that the electricity infrastructure is operational over the long term. Thirdly, all respondents stated that an investment in mini-grid electrification would do much to open up the untapped markets, although two respondents contended that their companies do not prioritise a risk investment in energy generation and would thus not allocate their investable capital in this direction. Only one respondent said that equity investments in mini-grid ESCOs would be the preferable way of entering the mini-grid sector while other respondents mentioned the delivery of their own services at mini-grid sites or acting as an anchor client for a mini-grid ESCO.

Private sector companies outside the energy sector further indicated a lack of interest to invest in a mini-grid ESCO that offers strategic value but little financial value. This is due to low priority placed on risk investments in energy generation on the part of two of the respondents and the requirement for a short term financial incentive for one other respondent. Only one respondent indicated interest in a mini-grid ESCO that offers strategic value without good financial return prospects. Two respondents also said that a mini-grid ESCO would have to at least have a proven business model to work with them, while one mentioned that an ESCO should at least have one operational mini-grid to work with them. Respondents further indicated that in a general sense, they do work with both start-up companies and more established companies. Lastly, when asked if they also attach value to those aspects that mini-grid ESCOs mentioned could be of value to them, the majority of respondents agreed that those aspects would indeed be valuable for them, while one other respondent expressed doubt regarding to the claims that mini-grid ESCOs make because of the difficulty of getting such detailed data.

4.5 Conclusion

In conclusion, the results show that mini-grid ESCOs find it difficult to provide an attractive risk return profile. They hope to attract equity investments in the future, as they believe that such investments can assist them to scale up. They believe that investors that could be interested would need to have a strategic mandate as opposed to purely a financial mandate and other ways for these potential investors to enter could be a join-up of services or the creation of spin-offs through internal efforts. Thus, there is indeed a need for strategic investment in mini-grid ESCOs.

Companies in the energy sector that could be interested to invest strategically in mini-grid ESCOs include: electric utilities, IPPs, and crowdfunding companies dedicated to off-grid energy. Further, companies outside the energy sector that could be interested to invest strategically in mini-grid ESCOs include providers of consumer goods and connectivity services, which is comprised of MNOs, ISPs and providers of online social networking and cloud services.

Mini-grid ESCOs feel that they can offer strong and stable customer relationships, financial information about customers, knowledge of end-users' energy consumption patterns and knowledge and experience with rural electrification and distribution channels as elements of strategic value to strategic investors. They feel that in order to be able to work with strategic investors, they would need to have a track record. Potential strategic investors in the energy sector reported that they indeed do attach value to strategic considerations and that they can work with start-ups and established companies. In line with mini-grid ESCOs' financing requirements, potential strategic investors in the energy sector have a preference for equity investments at the corporate level of ESCOs. The potential investors attach strategic value to mini-grid ESCOs in their own ways, but they also feel that those strategic aspects mentioned by ESCOs are also valuable. Before working with these potential investors, ESCOs would need to have a profitable business model and show potential of scaling up.

Potential strategic investors outside the energy sector see the non-electrified population as a latent market for their products and services and feel that an investment in mini-grid electrification will assist in unlocking these markets. They do however attach more value to short and medium term financial return considerations compared to strategic considerations. Still, they feel that the aspects of strategic value that mini-grid ESCOs mentioned would be valuable for them. Thus, there is significant potential for strategic investments in mini-grid ESCOs from private sector companies identified under research objective 2. However, private sector companies in the energy sector will more likely invest compared to private sector companies outside the energy sector.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The objectives of this study were to determine the need for strategic investment among mini-grid ESCOs, to identify types of private sector companies that could invest strategically in mini-grid ESCOs and to explore the potential of strategic investments in mini-grid ESCOs from private sector companies identified under research objective 2. Overall, this chapter provides a discussion of the implications and relevance of the results of the study. The chapter connects the findings with the literature review and provides insights into the contributions of the findings to practice and academia along with accompanying recommendations. These recommendations are aimed at practice and academia, the latter via a basis for future academic research.

5.2 The need for strategic investment in mini-grid ESCOs

The literature review indicated a need for investment among mini-grid ESCOs in sub-Saharan Africa (Williams et al. 2015). It was the idea of the researcher that a suitable compromise between the desire for financial return on the part of private sector investors and the inability of mini-grid ESCOs to offer an attractive risk return profile would be in the form of strategic investment. The point of leverage that the researcher hoped to hone in on was that of participating private sector companies' interest in electrification by seeing mini-grids as a diversification opportunity or by seeing the non-electrified population as an untapped market in their line of business. Thus, to gain insights into mini-grid ESCOs' experiences in trying to attract private sector investment and consequently whether strategic investments can fit into their financing requirements, the researcher set out to determine the need for strategic investment in mini-grid ESCOs as the first research objective.

In summary, the difficulty of offering an attractive risk-return profile is tied to economic and policy considerations. Regarding economic considerations, executive managers of mini-grid ESCOs have mentioned that for the most part, their business models are not fully developed yet and capital costs are still high even though cost trends are pointing downwards. There is an inconsistency between this finding and a claim made in recent literature that viable business models do exist (Duby & Engelmeier 2017). This inconsistency is perhaps unsurprising, because it would seem that it is challenging to draw conclusions about mini-grid business model viability, seeing that experimentation is still very much in the order of the day, as recently noted by the Microgrid Investment Accelerator (MIA) (2017). Indeed, as the results have shown, it would seem that the more mini-grid ESCOs experiment with different options, the better the prospect of a viable business model becomes.

Among the policy reasons is the fact that appropriate policy regarding the deployment of mini-grids is in most cases not in place even though working knowledge exists regarding the changes that should be made. Indeed, a wide range of literature pertaining to the required policy frameworks for mini-grid deployment has emerged over the past five years (Franz et al. 2014; Tenenbaum et al. 2014; GIZ 2015; African Development Bank 2016; Bhattacharyya & Palit 2016; IRENA 2016b). Furthermore, the lack of clarity regarding which areas national utilities will electrify and which they won't, adds to the disfavour of the prevailing policy landscape. Mini-grid ESCOs have made it clear that if investors do not have certainty that mini-grid projects will be continuous over the project lifetime due to the arrival of the national grid, the investment case is nullified. These findings are consistent with the challenges reported by Williams et al. (2015) and Knuckles (2016). However, it would seem that as the discussion builds in the industry and as ties are strengthened between mini-grid ESCOs and potential investors as well as policymakers, the investment case is strengthening.

It was found that mini-grid ESCOs would welcome strategic investments in the form of equity at the corporate level as a way to complement grants. This realisation led to the conclusion that there is indeed a need for strategic investment in mini-grid ESCOs, which is consistent with the technology diffusion path discussion (see Figure 2.3), as reported by Wüstenhagen and Menichetti (2012). Based on respondents' financing requirements and the fact that their pilot projects have been operating for one to five years respectively, it is argued that the mini-grid sector in East- and Southern Africa and by extension sub-Saharan Africa is still in the pre-commercial phase, indicated by the "*demonstration*" phase in Figure 2.3 (Wüstenhagen & Menichetti 2012:5). Furthermore, the costs of mini-grids are still declining to the required level for commercial viability, which is characteristic of the pre-commercial phase.

The findings pertaining to this research objective are further consistent with the literature on investment in rural electrification, which recognises the lack of and subsequent need for private sector investments in mini-grids (Schmidt et al. 2013; Williams et al. 2015). However, the findings add to the existing literature by reporting the need and suitability of strategic investment in mini-grid ESCOs in light of the prevailing unattractive risk-return profile.

However, in line with the researcher's initial preconceptions, it would seem from responses that there are not many providers of equity investments due to the small investment case that mini-grid ESCOs represent from a financial return standpoint. As a result, potential investors would most likely need to have strategic motivations, in order for an investment to be realised. This led to the need to identify types of private sector companies that could have such strategic motivations with regards to the mini-grid sector, as the following section discusses.

5.3 Potential strategic investors

The rationale behind attracting strategic investors is that when the commercial viability of mini-grids becomes apparent and risk-averse investors scramble to buy into the growth, strategic investors would already be one step ahead and reap the benefits of their early entry. Indeed, as has been shown in the literature, strategic investors across the board typically benefit from an early mover advantage when the technology or company becomes commercially viable and grows at a fast pace (Chevalier-Roignant et al. 2011). When executive managers of mini-grid ESCOs were asked to identify types of private sector companies that they think could become strategic investors, the researcher opened up the space for respondents to not only think about options within the energy sector, but to also cast their thoughts to possibilities that could seem remote but still carry significance and applicability. Mini-grid ESCO's felt that electric utility companies and IPPs are the most likely candidates for becoming strategic investors.

Indeed, a growing consensus is emerging that centralised electricity generation coupled with high voltage transmission is making way for decentralised generation coupled with low voltage distribution and it is the feeling of mini-grid ESCOs that electric utilities and IPPs might want to tap into this trend in order to be at the forefront of changes in the way electrification is approached. Mini-grids are also rather close to the core business of utilities and IPPs (which is typically utility scale renewable energy) and so the act of diversification in this case does not constitute the move to a market segment that they know nothing about.

Regarding private sector companies outside the energy sector but who still have an interest in electrification, results indicate that players that would most likely be interested to invest are companies providing either consumer goods or connectivity services, such as MNOs, ISPs and social networking and cloud services. The rationale behind these companies potentially investing in mini-grid ESCOs is that it would unlock a latent market, that is, the non-electrified population. The premise is that as people gain access to electricity, an uptake of electricity dependent products and services emerges and according to the responses of mini-grid ESCOs, in particular mobile network coverage, internet services, social networking and consumer goods. Regarding MNOs, ISPs and social media, the premise is that the first step following electricity access is internet access.

The private sector companies that mini-grid ESCOs mentioned here could thus gain early first-hand knowledge of how to approach rural markets through tapping into the knowledge and experience of mini-grid ESCOs. By identifying these private sector companies, these findings add to the limited literature pertaining to potential strategic investment in decentralised ESCOs. Bardouille and Muench (2014) have stated that providers of electric appliances are well suited to become strategic investors and these findings add private sector companies mentioned above to that list.

5.4 Potential of strategic investments in mini-grid ESCOs

The rationale behind the third research objective was to explore the potential of strategic investments from identified private sector companies. Based on the results, it would seem that there is indeed significant potential for mini-grid ESCOs to attract investments from potential strategic investors. However, much still needs to be done to realise such investments, and consequently, the researcher offers recommendations in this regard.

Executive managers of mini-grid ESCOs noted that they can offer stable customer relationships, data regarding the creditworthiness of customers, energy consumption patterns and knowledge of distribution channels as aspects of strategic value to prospective strategic investors. This is of course over and above the value of decentralised electricity generation in rural areas with experience in business model development and, in some cases, an already viable business model. The majority of potential and current strategic investors were of the opinion that these aspects of strategic value are indeed of value to them and that it would contribute to justifying an investment in a mini-grid ESCO that can demonstrate such value. Still, however, the core value remains the ESCO's ability to deliver decentralised electricity in rural areas. Indeed, IPPs and electric utilities reiterated that this represents a testing opportunity for energy storage with a prospect of tapping into decentralised electrification and serving a large potential market, which in effect manifests as an act of diversifying their utility scale project portfolios. The majority of IPPs that were interviewed are operational in South Africa and are particularly interested in the opportunity that mini-grids provide in the sub-Saharan African region because of the trouble that they are experiencing during the stall of the REIPPPP in South Africa. As presented in chapter 2, Masini and Menichetti (2013) emphasise the value of portfolio diversification between renewable energy projects and thus following on from Masini and Menichetti (2013) the implication of this finding is that IPPs could consider an investment in a mini-grid ESCO as a way to diversify their utility scale portfolio.

The fact that these companies also attach value to the strategic value that a given investment can offer in addition to short to medium term financial return is also a fundamental characteristic of the *"refocusers"* component of the strategic investment decision making contextual framework developed by Carr et al. (2010) discussed in chapter 2. That is, these companies exhibit a strong strategic orientation even though they do have some financial constraints and thus have a balanced view between strategic and financial value. It would further seem that some of the respondents can be plotted along the *"market creators"* component of the framework, in particular those that have already invested in mini-grid ESCOs in East- and Southern Africa. These companies are in strong financial positions and can afford to wait for more than five years for financial payback.

In addition to continuously improving the efficiency with which mini-grids are operated, the recommendation for ESCOs is to also focus on building knowledge and experience of customer relationships, data regarding the creditworthiness of customers, energy consumption patterns and rural distribution channels. These findings complement recent literature that has started to build a discussion around the fact that mini-grid ESCOs should not only focus on selling mere electricity, but to also explore the opportunity for the delivery of related products and services that will stimulate demand for electricity (Agenbroad, Carlin, Doig, Henly & Wanless 2017; Duby & Engelmeier 2017). In effect, the findings contribute to the evolving best practices of viable mini-grid business models, by suggesting that mini-grid ESCOs should build competencies in customer relationship management, rural distribution practices and the extrapolation of rural households' uptake of electricity dependent products and services from electricity consumption data. It is the belief of the researcher that when mini-grid ESCOs can demonstrate these competencies successfully, the probability of successfully attracting strategic investment would be higher.

Added to the recommendation, however, is that dialogue between mini-grid ESCOs and potential strategic investors should be improved, given that some of the potential investors doubted whether mini-grid ESCOs really have such data and knowledge. It would be useful to inform strategic investors exactly the extent to which mini-grid ESCOs have this data and knowledge and it is the belief that such specific information can effectively be shared between mini-grid ESCOs and prospective strategic investors. A useful way forward in this regard could be to create a forum in which mini-grid ESCOs and strategic investors can converse with respect to the leverage points of strategic value.

Other than the ability of demonstrating strategic value as mentioned above, it would further seem that mini-grid ESCOs should at least have a proven track record in order to be able to work with strategic investors. The majority of executive managers of mini-grid ESCOs that were interviewed said that their companies have a number of projects on the ground. The track record of selected mini-grid ESCOs that took part in the study are presented in Table 5.1.

However, as was discussed earlier, the extent to which mini-grid business models encapsulate commercial viability is debatable. The implication is that a consensus ought to develop as to when a mini-grid business model is indeed viable. When this consensus is shared between mini-grid ESCOs and potential strategic investors, the prospect of attracting strategic investment could improve even more.

Table 5.1: Track record of selected participating mini-grid ESCOs

Respondent	Start of pilot project operations	Number of projects as at August 2017	Expansion plans	Average mini-grid size
Respondent A1	2012	In the process of rolling out 20 projects	100-200 projects	10-50kWp
Respondent A4	2011	In the process of rolling out 25 projects	25 sites by 2018 65 sites by 2019	7.5 kWp
Respondent A5	2012	12 projects	330 sites by 2020	1-10kWp
Respondent A6	2016	1 project	13 sites when funding comes in	1kWp
Respondent A7	2014	3 projects	150 projects, 10 projects by mid-2018	10-24kWp

Regarding the most likely form of investment, the potential for equity investment on the corporate level of ESCOs seems to be strong as the majority of potential strategic investors in the energy sector indicated a preference for this form of strategic investment, with the acknowledgement that two respondents indicated a preference for project finance. As was mentioned, project finance is not suitable for mini-grids due to the small size of each individual project and the fact that ESCOs haven't been able to consolidate projects yet. There seems to be logic behind the preference for investing on the corporate level of mini-grid ESCOs as this enables the investor to benefit from spreading risk across a variety of mini-grid projects. Indeed, Gershenson et al. (2015) have also found that a portfolio approach as opposed to an investment in a single mini-grid project enables the diversification and the mitigation of risk. The theoretical implication that can be drawn from this is that a portfolio approach that comprises more than one project is especially applicable in the case of early stage risk investments, given that the main deterrent seems to be high risk.

With the exception of one respondent, the majority of potential strategic investors outside the energy sector do not seem to have a preference for equity investments at the corporate level of mini-grid ESCOs. It would seem that they would rather invest financial capital closer to their core business, where they have more knowledge that can be leveraged in the appraisal of the particular investment. It follows that the majority's lack of interest is not a result of a perception that the non-electrified population does not represent an untapped market, because according to the results, they do feel that this population is an untapped market and that the arrival of electricity would do much to unlock these markets. Indeed, the majority indicated a preference for the delivery of their own services at a mini-grid site or to act as an anchor client. This is still a positive prospect though, seeing that this would increase the load of a mini-grid and in turn increase revenue flows.

Following on from Perez (2007), the formation of relationships between entrepreneurs in an emerging industry and investors constitute the first indication of the advancement of a particular industry. As was indicated in chapter 1, such relationships have started to form between mini-grid ESCOs in East- and Southern Africa and global investors. Thus, by discussing the mini-grid sector with private sector companies identified by mini-grid ESCOs to be potential strategic investors, the findings of research objective 3 assist in increasing the probability of such relationships forming. Indeed, it is the hope that such relationships would form in the near future, which, as mentioned, could be accelerated with a forum of engagement between mini-grid ESCOs and potential strategic investors. Following on from renewable energy investment decision making framework developed by Masini and Menichetti (2013) (see Figure 2.5), respondents of the potential investors samples carry knowledge of the mini-grid sector but haven't dealt extensively with mini-grid ESCOs and consequently, the institutional isomorphism surrounding these players does not seem to influence them to invest as soon as they will get the chance. Thus, the researcher anticipates that as soon as the viability of mini-grid business models have been communicated and policy frameworks have been streamlined to allow for the replication of projects employing these business models, will the potential that private sector companies in the energy sector see in established mini-grid ESCOs be converted into actual investment.

On a final note, the literature has previously pointed to a required shift from a centralised paradigm to a decentralised paradigm regarding the approach to the provision of electricity (Levin & Thomas 2012; Williams et al. 2015). This research has followed on from the literature by being centred within the decentralised paradigm, but proposes an additional change in how we think about electrification. This research addressed the need for academic work in private sector investment in rural electrification and has subsequently been carried out with the belief that rural electrification projects must be financially sustainable if private sector investment is to be attracted and in turn, if the energy access narrative in sub-Saharan Africa is to be changed. In working towards this goal, this study sought to find a middle ground between concessional capital deployed for impact and commercial capital deployed for short term financial return. However, this middle ground requires a paradigm shift from one in which rural electrification is not merely perceived as impact-based, but also an endeavour that provides significant strategic value from an infrastructural development perspective. Indeed, this study has placed a great deal of importance on strategic value and has tried to use it to find a middle ground between mini-grid ESCOs and investors. As scholarship develops in the domain of private sector investment in rural electrification, it is the belief of the researcher that it is indispensable to approach the conceptualisation of rural electrification in this way, due to the importance of enabling investors to see the value that they can also gain from an investment in rural electrification. The successful demonstration of renewable energy mini-grids in rural areas, which is consistent with the decentralised model, has to a great extent enabled this line of thinking, given potential strategic investors' strong interest in getting involved with mini-grid ESCOs. Indeed, as the results have shown, the opportunity for diversification, revenue generating potential and knowledge of customers that mini-grid projects present seem to drive this strategic value.

5.5 Recommendations for future research

This study was exploratory of nature and consequently opened up a range of different research avenues that can be pursued in the future. Firstly, as some research participants suggested, it would be a fruitful exercise to put ESCOs and potential investors in direct contact with each other so as to facilitate a detailed discussion between the groups. As a research project, it would be useful to document this process so as to conceptualise pathways for private sector investment attraction to mini-grid ESCOs in addition to the contribution that this study makes. Secondly, a social network analysis can also be conducted to determine the extent to which investor-entrepreneur ties have formed in the mini-grid sector. Thirdly, there are opportunities for future research within each respective strategic investment approach that was identified in addition to equity investment in this study. This study focused on equity investment as it is the quickest way to deploy financial capital and fits into the theoretical framework of the role of financial capital in technological change, but no assessments of the potential of other forms of partnerships between prospective strategic investors and ESCOs have been conducted to date.

Fourthly, the snowball samples pertaining to potential strategic investors were created based on the responses of the mini-grid ESCO sample and included IPPs, electric utilities, connectivity companies and consumer goods companies. However, in line with the researcher's initial preconceptions, it is reiterated here that providers of electric appliances could nevertheless exhibit potential to invest strategically in mini-grid ESCOs, even though the frequency with which these companies were mentioned by mini-grid ESCOs were lower than those listed above. Exploring the potential of investment or any form of collaboration between electric appliance companies and mini-grid ESCOs could thus be an avenue for future research, given the desire of newly electrified households to purchase appliances. Evidence of this trend can be seen in various studies (Blodgett et al. 2016; Lee et al. 2016). It is also well known that the cost of appliances impedes household purchases (Louw, Conradie, Howells & Dekenah 2008; Bhattacharyya 2013), which leads to a reduction of electricity consumption and consequently the financial sustainability of a mini-grid project also comes into jeopardy (Tenenbaum et al. 2014). In this way, it becomes more evident that mini-grid ESCOs and electric appliance companies could work together towards a common goal of enabling the uptake of appliances and consequently increasing electricity consumption. There is a need for academic work to explore this opportunity.

Finally, part of the shift towards a strategic conceptualisation of rural electrification is the formulation of strategies that incorporate the complementary deployment of solar home systems and mini-grids. Several accounts of the importance of solar home system experience among rural households for the uptake of mini-grid electricity emerged in interviews with respondents. This is also consistent with reports that made similar claims (Blodgett et al. 2016; Duby & Engelmeier 2017). It is thus the belief of the researcher that there could be an opportunity for collaboration between solar home system ESCOs and mini-grid ESCOs, the appraisal of which would require further research.

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Appendix A: Interview schedule for research objective 1

Interview schedule for semi-structured interviews to be conducted with mini-grid ESCOs for the purpose of research objective 1: Determine the need for strategic investment in mini-grid ESCOs

1. In your experience, how difficult is it to provide an attractive risk-return profile and thus to attract private sector investment?

2. What are your financing requirements going forward in terms of scaling up your company?

3. Do you think that early stage (equity) investments at the corporate level can assist in scaling up mini-grid ESCOs?

4. Regarding equity investments made in mini-grid ESCOs on the corporate level, would you say that those investors are only looking at financial considerations such as return on investment or are there also strategic considerations involved in their decision to invest, such as access to new markets or knowledge of how rural markets operate, for example?

5. Aside from pure equity investments, are there any other ways in which new players can invest strategically in the mini-grid sector?

Appendix B: Interview schedule for research objective 2

Interview schedule for semi-structured interviews to be conducted with mini-grid ESCOs for the purpose of research objective 2: Identify types of private sector companies that could be interested in investing strategically in mini-grid ESCOs

1. Which type of private sector companies in the energy sector do you think could be interested to invest strategically in mini-grid ESCOs, whether it be through equity investment or any other forms of strategic investment?

2. Which type of private sector companies outside the energy sector (whose products or services are dependent on the availability of electricity) do you think could be interested to invest strategically in mini-grid ESCOs, whether it be through equity investment or any other forms of strategic investment?

Appendix C: Interview schedules for research objective 3

Interview schedule for semi-structured interviews to be conducted with mini-grid ESCOs for the purpose of research objective three: Determine the potential of strategic investments in mini-grid ESCOs from private sector companies identified under research objective two.

1. What kind of strategic value would your company be able to provide to strategic investors?

2. Do you think that there is a specific size that mini-grid ESCOs should be to be able to work with strategic investors in terms of scale of operations and what might this be?

Interview schedule for semi-structured interviews to be conducted with private sector companies in the energy sector for the purpose of research objective three: Determine the potential of strategic investments in mini-grid ESCOs from private sector industries identified under research objective two.

1. Generally, when making a decision to invest or enter a new market segment, do you only take short to medium term financial return into consideration, or do you also consider the strategic value that a given investment or market entry can provide?

2. If we distinguish between start-ups and more established companies, which type of companies would you rather invest in or work with?

3. Generally, if you provide capital of some sort, is it more corporate finance of nature or rather project finance?

4. Shifting the focus to mini-grids, mini-grid ESCOs are known to struggle to provide an attractive risk-return profile if only viewed from the short to medium term financial return perspective given the relatively high risk of investment due to the early stages of the industry and uncertainty regarding revenue flows. Thus, in order for mini-grid ESCOs to successfully attract investment at this

early stage, the investor would probably have to attach value to non-financial considerations, i.e. strategic considerations such as access to new markets for example. Simultaneously, the mini-grid ESCO would have to show that it can provide such value. Based on your experience, do you think that mini-grid ESCOs in the region of sub-Saharan Africa can provide sufficient value (financial or strategic) to warrant an investment and if not now, do you foresee that this can change in the future?

5. If you do also attach value to strategic considerations, what kind of strategic value do you think can be gained from an investment in a mini-grid ESCO? (If you don't, why not?)

6. When asked what kind of strategic value they can provide to strategic investors, mini-grid ESCOs mention:
   - Strong and stable customer relationships with end-users
   - Extensive knowledge of customer creditworthiness and electricity consumption patterns
   - Extensive knowledge of distribution channels and consumer preferences in rural markets.

   They mention that this information can be key for a market player who wants to gain more insights into the types of products that these consumers might be interested in as well as how to distribute those products to these markets. Would you consider these aspects to be valuable, and in turn, would they contribute to justifying an investment?

7. Is there any reason for why an investment in mini-grids would be more valuable than one in solar home systems, such as better growth and diversification opportunities, for example?

8. If you prefer not to invest directly in a mini-grid ESCO, are there any other ways in which you would consider be involved with an ESCO?

9. Do you think that there is a specific size in terms of scale of operations that mini-grid ESCOs should be to be able to work with strategic partners or investors and what might this be?

Interview schedule for semi-structured interviews to be conducted with private sector companies outside the energy sector for the purpose of research objective three: Determine the potential of strategic investments in mini-grid ESCOs from private sector industries identified under research objective two.

1. Across sub-Saharan Africa 590 million people still lack access to electricity. Would you say that this population is an untapped market for electricity dependent products and services, such as the ones that your company provides?

2. Given the requirement of electricity infrastructure for the functioning of your company's products or services, do you feel that the arrival of electricity in non-electrified areas can open up these untapped markets for your product or service?

3. Do you consider an investment in electrification as a step towards opening up these untapped markets?

4. If you were to get involved in the mini-grid sector, how would you like to get involved?

5. If a mini-grid ESCO provides sufficient strategic value, would you consider investing even if the short to medium term financial return is not what is desired?

6. Do you think that there is a specific size in terms of scale of operations that mini-grid ESCOs should be to be able to work with strategic partners or investors and what might this be?

7. In a general sense, if we distinguish between start-ups and more established companies, which type of companies would you rather invest in or work with?

8. When asked what kind of strategic value they can provide to strategic investors, they mention:
   - Strong and stable customer relationships with end-users
   - Extensive knowledge of customer creditworthiness and electricity consumption patterns
   - Extensive knowledge of distribution channels and consumer preferences in rural markets.

They mention that this information can be key for a market player who wants to gain more insights into the types of products that these consumers might be interested in as well as how to distribute those products to these markets. From the standpoint of your operations and product or service offerings, would you consider these aspects as valuable and in turn, would these aspects contribute to justifying an investment in a mini-grid ESCO?