Towards Integrated Business and Partnership Models for Universal Energy Access in Kenya and Rwanda

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Declaration

I *Whitney Lisa Pailman* herewith confirm that the work presented in this thesis is my original work (except where acknowledgements indicate otherwise) and that neither the whole work or any part has been or is being submitted for another degree in this or any other university. This thesis uses the UCT Harvard Author-Date referencing convention, with literature sources cited appropriately.

Signature: Date: 26 October 2023

This thesis is dedicated to my dad, Kenny. Your love and support has sustained me through this journey and has left an indelible impact. Grateful that I had the opportunity to share my topic with you.

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"The Steadfast love of the Lord never ceases; His mercies never come to an end."

Abstract

Integrated electrification models have garnered significant attention in the energy access discourse as an essential element of achieving universal access to electricity. The absence of integration often results in competing rather than complementary electrification solutions, fragmentation in the market and a duplication of financial resources, with off-grid providers primarily serving certain geographic regions while others remain unelectrified. This thesis proposes integrated business and partnership models to improve the viability, inclusivity and scalability of off-grid electrification models in Kenya and Rwanda. In recent years the concept of the Integrated Distribution Framework (IDF) has been conceptualised to support the achievement of universal access to electricity and improve the viability of electrification models. This framework is premised on four core principles (pillars), namely *(i) inclusiveness, (ii) permanence, (iii) a combination of electrification modes and (iv) external resources for viable electrification models.* These pillars form the foundational elements of the IDF framing, upon which this thesis expounds.

Notwithstanding the developing literature on the IDF, this thesis addresses several knowledge gaps in the implementation of the IDF in different contexts. An important contribution to knowledge this thesis makes is operationalising IDF principles for financing and partnership models commonly used for mini-grids and stand-alone solar systems in Kenya and Rwanda. Specifically, this study applies the tenets of the IDF to results-based finance (RBF) models and flagship off-grid electrification programmes using public private partnerships (PPP)s. Integral to the IDF, is addressing the *viability gap*. This is a central aspect of this thesis and is intricately linked with a complex array of factors, including the regulatory environment, affordability, financing and geographic considerations.

This study used qualitative research methods to carry out the empirical investigation, and a case study design through in-depth case studies of Kenya and Rwanda. Forty-nine semi-structured interviews were conducted with key stakeholders in the off-grid energy sectors in Kenya and Rwanda, including mini-grid developers, stand-alone solar companies, international development partners, industry associations, the national utilities and Ministries of Energy. Specifically, this study found that for mini-grids, determinants of the viability gap included: revenue which is influenced by tariffs and demand; affordability; funding to address the viability gap; policy support; the regulatory environment; institutional priorities and long-term planning. For stand-alone solar systems the viability gap was mostly influenced by affordability, quality standards and financing. This study further identified key determinants of the IDF pillars for mini-grids and stand-alone systems in Kenya and Rwanda. *Inclusivity* was impacted by affordability; incentives and subsidies; and national electrification planning.

Permanence was influenced by tariffs and regulation; planning certainty; incentives and subsidies, quality standards and demand stimulation and productive uses. *The efficient combinations and co-existence of electrification technologies* was affected by the prioritisation of off-grid technologies in electrification plans, geography, institutional priorities and the availability and affordability of finance. These all impacted the *external finance* leveraged and the continuity and sustainability of business models within the case studies of Kenya and Rwanda.

This thesis demonstrates the complexities of RBF and PPPs as approaches to address the viability gap. It shows how the framing of the IDF can improve the permanence and inclusivity of RBF programmes and PPPs. It further highlights that there are many trade-offs that need to be considered when the private sector form part of larger scale national electrification projects. As this thesis demonstrates, even when there are targeted incentives in place through RBF programmes and PPPs, there are a variety of challenges which need to be overcome and it therefore identifies ways in which partnerships can be strengthened to improve the financing ecosystem.

Contents

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List of Acronyms

AfDB - African Development Bank

AMDA - African Mini-grid Developers Association

BRD- Development Bank of Rwanda

CAPEX- Capital Expenditure

EARP - Energy Access Rollout Programme

EDCL - Energy Development Corporation Ltd.

EDPRS - Economic Development and Poverty Reduction Strategy

EnDev - Energising Development

ERC - Energy Regulatory Commission

EPRA – Energy and Petroleum Regulatory Commission

ESMAP - Energy Sector Management Assistance Programme

ESSP - Energy Sector Strategic Plan

EUCL - Energy Utility Corporation Ltd

DFID- UK Department for International Development

FCDO – United Kingdom Foreign, Commonwealth and Development Office

GIZ – German Development Organisation

GOGLA – Global Off-grid Lighting Association

IDA - International Development Agency

IDF - Integrated Distribution Framework

IEA - International Energy Agency

IPPs - Independent Power Producers

IFC - International Finance Corporation

KEREA – Kenya Renewable Energy Association

KNES - Kenya National Electrification Strategy

KOSAP - Kenya Off-grid Solar Access Project

KPLC - Kenya Power and Lighting Company

MECS – Modern Energy Cooking Services

MFI – Microfinance Institution

MININFRA - Ministry of Infrastructure

NEP - National Electrification Plan

OPEX – Operational Expenditure

O&M – Operation and Maintenance

PAYG -Pay As You Go

RBF – Results-Based Finance

REA - Rural Electrification Authority

REG - Rwanda Energy Group

REF – Renewable Energy Fund

RURA - Rwanda Utilities Regulatory Authority

REREC - Rural Electrification and Renewable Energy Corporation

SEAP - Scaling Up Energy Access Programme

SEforAll – Sustainable Energy for All

SME - Small Medium Enterprise

SPP – Small Power Producer

SNV - Netherlands Development Organization

SWAp - Sector Wide Approach

TEA - Transforming Energy Access

PPA – Power Purchase Agreement

PPP - Public Private Partnership

UEF - Universal Energy Facility

USTDA - United States Trade and Development Agency

VAT- Value Added Tax

Chapter 1 Introduction

1.1 The need for integrated approaches for universal energy access

Integrated electrification approaches, coupled with viable and inclusive business models, are needed to achieve universal access to electricity (Urpelainen, 2014; Rahnama, 2018; Pérez-Arriaga et al., 2019; Power For All, 2019; Sustainable Energy for All [SEforall], 2019; Jacquot, 2021). Increasingly, international development partners and scholars have advocated for integrated electrification models, integrating a range of grid and off-grid configurations and delivery modes, including public and private arrangements, to achieve SDG 7: affordable, reliable, sustainable modern energy for all (Pérez-arriaga et al., 2018; Rahnama, 2018; Pérez-Arriaga et al., 2019, 2021; Power For All, 2019; SEforAll, 2019). In Sub-Saharan Africa it is estimated that 568 million people do not have access to electricity, with 12.43 million people in Kenya and 6.91 people in Rwanda lacking electricity access (International Energy Agency [IEA] et al., 2021). The absence of integrated approaches often results in competing rather than complementary electrification solutions, fragmentation in the market and a duplication of financial resources, with off-grid providers primarily serving certain geographic regions while others remain unelectrified (Lepicard et al., 2017; Pérez-Arriaga et al., 2019). This hinders scaling of energy access solutions and progress towards universal access (Urpelainen, 2014; Pérez-Arriaga et al., 2018; SEforAll, 2019; Jacquot et al., 2020). Kenya and Rwanda are among countries in Sub-Saharan Africa that have been exploring and actively pursuing more integrated approaches to achieve their energy access targets. In Kenya integration can be seen through public private partnerships (PPPs) for off-grid electrification and Rwanda through intentional coordination and collaboration between public, private and international donor organisations (Bisaga, 2018; Pérez-Arriaga et al., 2020; Energising Development [EnDev], 2021).

Achieving SDG 7 necessitates viable and scalable business models, coupled with appropriate regulatory frameworks (Bardouille, 2012; Pérez-Arriaga, 2016; World Economic Council, 2016). The *viability gap* is a key concept in this study and has been defined as the shortfall between the cost of service and revenues collected or estimations from willingness to pay (Pérez-Arriaga et al., 2018). The viability gap hinders developing electrification models that are both *inclusive* (from an affordability and geographic perspective) and *financially viable*. To meet the objectives of SDG 7, inclusivity and viability need to be balanced and incorporated into the design of electrification models and programmes (Pérez-Arriaga et al., 2019; SEforAll, 2019). Electricity distribution models are important to consider as distribution is the closest activity in the electricity value chain to the provision of electricity access (Pérez-Arriaga, 2016). According to Pérez-Arriaga (2016) a suite of context-fitting business models coupled with appropriate regulatory frameworks is needed to achieve universal electricity access. As such, many private sector companies seize the opportunity to build businesses to serve remote off-grid and under-the-grid unelectrified communities, filling part of the gap in regions where the national grid has not reached nor will likely reach in the foreseeable future. Private sector involvement in off-grid electrification is also driven by funding from large international efforts to do so, and national governments to fill the gap (e.g., Transforming Energy Access (TEA) and SEforAll) (SEforAll, 2019; TEA, 2022).

As countries move closer to achieving their electrification targets beyond the *low-hanging fruit*[1] of financially viable off-grid electrification, achieving the targets of SDG 7 becomes more challenging and complex due to challenging geographies (Eras-Almeida & Egido-Aguilera, 2020), low affordability and demand (Lepicard et al., 2017; Hoeck et al., 2022), the intricacies of building viable business models in low income and income-constrained communities, competing institutional priorities (Rahnama, 2018), and sustaining electrification numbers in the long-term. Consequently, some off-grid stand-alone solar companies have focused on market segments where ability to pay is higher. This leads to the saturation of markets in certain geographic regions, whilst other market segments remain underserved (Lepicard et al., 2017). Similarly, private mini-grid developers focus on viable sites that make business sense from their own business perspective, for example with the potential of anchor loads and would need to provide a return to their investors. While this makes business sense, it leaves a large lacuna for inclusive electrification models that reach the harder to reach end-users.

Despite a plethora of technological and business model advancements, realising the targets of SDG 7 remains a multi-faceted and complex challenge (Hafner, Tagliapietra & Strasser, 2018; Eras-Almeida & Egido-Aguilera, 2020). Not only does this require various technologies, business models, regulatory environments, and financing models to be aligned (Falchetta et al., 2022) but also the aligning of institutional priorities and addressing affordability from an end-user perspective (Rahnama, 2018; Ogeya et al., 2021). The COVID 19 pandemic has further compounded these challenges and placed a spotlight on many of the underlying inequalities which make achieving universal energy access (and other development imperatives) particularly challenging to achieve (de Groot & Lemanski, 2021; IEA et al., 2022).

[1] This study conceptualises low-hanging fruit as areas that are easier to electrify from a technical and socio-economic perspective, including areas where affordability is higher, where grid extension is technically possible and financially viable, and areas with high potential anchor loads for mini-grids.

Recent developments in off-grid markets across Sub-Saharan Africa, including Kenya and Rwanda, signal a paradigm shift in the business and partnership models used to deploy off-grid technologies, moving from a *silo*[2] *approach* towards more collaborative paradigms (Rehman et al., 2017; SEforAll, 2019; Korkovelos et al., 2020). Whilst at present, the *silo approach* remains a dominant feature of many off-grid markets, concurrently there is an increased impetus from the public sector to scale off-grid electrification by incentivising and leveraging private sector investment into large scale national off-grid electrification programmes (Phillips, Plutshack & Yeazel, 2020). This implies more government involvement and coordination in off-grid sectors for national electrification projects and a greater degree of coordination between the public sector, international development partners funding these projects, and private sector actors who will be key implementors in these projects (SEforAll, 2019; Korkovelos et al., 2020). Although individual private sector efforts contribute towards universal energy access targets, this study argues that greater synergies can be achieved through more effective collaboration and coordination between public, private and donor actors to advance SDG 7, and proposes entry points for achieving this.

The Integrated Distribution Framework (IDF), the main conceptual framework for this study, has been conceptualised by the MIT-Comillas Energy Access Laboratory to support the achievement of universal access to electricity and improve the viability of electrification models (Pérez-Arriaga et al., 2019, 2020, 2021). The framework has been proposed as a set of guiding principles to facilitate universal energy access, through core 'pillars' to guide electrification planning and business models for energy access. These guiding principles serve as a framework and analytical tool to enhance existing business models and regulatory approaches, with the purpose of improving the viability, inclusivity, and sustainability of electrification models. The IDF responds to the fragmentation that often characterises electrification approaches, especially when there are multiple actors (i.e., public, private and international development partners) working to deliver energy access. This framework is premised on four core principles namely (i*) inclusiveness,* (ii) *permanence,* (iii) *a combination of electrification modes and* (iv) *external resources for viable electrification models.*

[2] This study conceptualises a 'silo approach' as a fragmented approach to electrification where different sector actors largely work individually or in 'silos' to achieve individual organisational or institutional objectives. Each sector actor is often not sufficiently aware of areas of complementarity or overlaps, which often leads to duplication of efforts and resources.

These pillars or principles form the foundational elements of the IDF framing, which will be used for this thesis, namely:

- **Pillar 1: A commitment to universal access that leaves no-one behind** through ***inclusiveness*** and ***permanence***; off-grid providers privately or in partnership with national utilities delivering off-grid energy access within assigned specific geographic territories.

- **Pillar 2: Efficient *and coordinated integration of grid and off-grid solutions*** by focussing on the integration of off-grid technologies in tandem with the existing grid infrastructure.

- **Pillar 3: *A financially viable business model supported*** *through* ***external financial resources*** *– integrating financing and partnership models to address the viability gap.*

- **Pillar 4: *A focus on development to ensure that electrification produces broad socio-economic benefits*** *by looking beyond electricity connections but at the wider socio-economic impact and benefits for end-users through e.g., productive uses of energy.*

This framework (expounded in Section 2.2) allows for a detailed analysis of the off-grid energy system (i.e., institutional actors and business models) in Kenya and Rwanda and provides a holistic framing linking universal access and *inclusivity* objectives with financially viable business models. This framework is apt for analysing the drivers of the viability gap and approaches to closing this gap by applying an IDF lens. Notwithstanding the development of the IDF framing (see Section 2.2) this study has identified knowledge gaps for implementing the IDF for mini-grid and stand-alone system models, where concession models are not strictly applied. A key gap this study fills is operationalising the IDF for mini-grid and stand-alone solar models in Kenya and Rwanda and illustrating how an IDF framing can be applied to enhance these models. By addressing these gaps through an analysis of key off-grid sector programmes in Kenya and Rwanda, this thesis builds and expands on the IDF framing as an important analytical and conceptual tool for energy sector policy and planning. Particularly this thesis will demonstrate how the IDF can be applied to current and emerging off-grid finance and partnership models and programmes in Kenya and Rwanda to facilitate the achievement of universal energy access objectives in these countries, while addressing the viability gap.

1.2 Research to date

Currently many international initiatives are working on energy access challenges including scaling mini-grids and off-grid stand-alone solar, for example SEforAll, the Shell Foundation, the Rockefeller Foundation, the Transforming Energy Access (TEA) Programme and the Crossboundary Energy Access Mini-grid Innovation Lab (SEforAll, 2019; Crossboundary, 2022; TEA, 2022).

In addition to the focus on these initiatives in the international development arena, there is a growing body of academic literature on business models for energy access (see e.g Zerriffi, 2011; Chaurey et al., 2012; Pérez-Arriaga et al., 2018; Vanadzina et al., 2019; Mukoro et al.,2022). These authors call for new kinds of business and partnership models that are more inclusive and financially viable to advance SDG 7 and specifically serve low-income customers. This thesis will contribute to this literature, by operationalising the IDF for Kenya and Rwanda's off-grid sector. This will be done by applying the principles of the IDF to existing off-grid partnership and financing models in Kenya and Rwanda and proposing how these existing approaches can be incorporated into and enhanced through the IDF.

The IDF advocates for integrated models for electricity distribution with a long-term vision of the power sector, with built-in financing and regulatory considerations to address the viability gap. The IDF encompasses business models (including partnership models), financing and regulation needed to achieve universal access. A few scholars have investigated certain aspects of the IDF including Rahnama (2018) who studied the attitudes and behaviour of low-income energy users and the application of grid and off-grid integration in India and Jacquot (2021) who analysed concession models for stand-alone solar systems within the IDF. However there remains paucity in the literature looking at specific applications of the IDF for off-grid stand-alone solar and mini-grids in Sub-Saharan Africa and operationalising an IDF perspective on financing models in practice.

Pérez-Arriaga et al. (2020), in a report for the Global Commission to End Energy Poverty, explored the high-level application of the IDF in Colombia, Rwanda, Uganda, Nigeria and India, providing recommendations of what an IDF framing could look like in these countries. Rwanda, according to Pérez-Arriaga et al. (2020) is an ideal country for a more straight forward implementation of the IDF due to clear universal energy access objectives and a utility that can co-exist with mini-grid developers and off-grid providers. However, the IDF framing has not specifically been applied to off-grid contexts and partnership and financing models in Rwanda or Kenya, at a more granular level and through empirical inquiry. Pérez-Arriaga et al. (2020) and Jacquot (2021) have mainly explored stricter territorial concession models for case studies on the IDF. Considering the dynamism of the off-grid sector in Kenya and Rwanda, which comprises a range of public, private and international development actors and a range of off-grid business models, an empirical inquiry that specifically explores the off-grid context is needed. An in-depth study is thus needed to understand the impact of applying an IDF paradigm on existing sector business and financing models in these countries, and how the IDF framing could enhance these existing models.

Notwithstanding a growing interest in new framings for partnerships for SDG 7 and the IDF, there remains a gap in the academic literature operationalising IDF principles in off-grid settings, in particular concerning partnerships and financing models. Nagpal & Pérez-Arriaga (2021) have recognised the rise of Results-based Finance [3] (RBF) programmes like, for example, the Universal Energy Facility (UEF) and other prominent Pan African RBF programmes, especially for mini-grids. In a position paper they argue that combining the strengths of the IDF with RBF approaches could yield positive benefits for *inclusiveness* and *permanence* of the universal energy access objectives in the IDF framing (Nagpal & Pérez-Arriaga, 2021). However, there is significant paucity in the literature linking RBF to the IDF; the above paper is the only[4] paper that specifically links RBF to IDF models. Thus, an empirical enquiry is needed to explore what this would look like in the case studies of Kenya and Rwanda and to better understand the nuances of RBF approaches at a more granular level. This study addresses this gap through empirical case studies of Kenya and Rwanda, by applying the principles of the IDF in case study sites where a strict territorial concession is not the norm, through tangible examples of how the IDF applies to PPPs [5]and RBF models in Kenya and Rwanda. It explores how emerging partnership and financing models in these countries can be incorporated into integrated distribution models and improved, through the lens of the IDF.

While the above framings of integrated electrification approaches encompass the integration of both grid and off-grid electrification modes (Urpelainen, 2014; Pérez-Arriaga et al., 2019; Power For All, 2019), this thesis focusses specifically on the application and operationalisation of the IDF within the *off-grid* context, investigating public and private sector collaborations and how utilities and off-grid providers can work collaboratively and synergistically to advance common objectives of universal access within their respective countries. Notwithstanding the central and complementary role of grid-based electrification, there is a gap in the literature for understanding the opportunities and challenges for greater integration with the off-grid sector, both between different off-grid companies and between off-grid private companies and government utilities. Apart from a few studies (see Jacquot et al., 2019; Jacquot, 2021) that explored concession models for grid, mini-grid and stand-alone solar models, very few studies have specifically applied the principles of the IDF to the off-grid sector. While authors who have developed the IDF endeavour for the framework to be adopted and applied to different country contexts (see e.g. Pérez-Arriaga et al., 2019, 2020, 2021), an empirical

[3] RBF is a key financing approaching for mini-grids and off-grid stand-alone solar systems which this thesis analyses in relation to the IDF. RBF refers to financing, usually in the form of grant payments which are disbursed upon pre-defined results or milestones, and usually covers a percentage of the project capital expenditure.

[4] While Pérez-Arriaga et al. (2020) mention RBF as a financing model, Nagpal & Pérez-arriaga (2021) is the only paper that specifically focuses on RBF through an IDF lens.

[5] Like RBF models, PPPs are a key focus area of this study, which it explores in relation to IDF guiding principles. PPPs are more comprehensively defined in Section 2.3. In the context of this study refers to partnerships (and contractual arrangements) between public and private sector entities for delivery off-grid energy projects or programmes, with respective roles in building, owning and operating off-grid infrastructure for pre-defined periods.

case study is needed to help operationalise the IDF's tenets. This thesis allows for an in-depth empirical enquiry into applying the IDF in the off-grid sector.

1.3 Focus and rationale

This study proposes applying and operationalising the IDF for off-grid business and partnership models for universal energy access in Kenya and Rwanda, with a focus on off-grid mini-grids and stand-alone solar systems. As highlighted above, integrated electrification approaches are increasingly recognised as essential for delivering universal access (Urpelainen, 2014; Pérez-Arriaga et al., 2018; Rahnama, 2018; SEforAll, 2019; Pérez-Arriaga et al., 2020, 2021). Integral to the IDF is addressing the *viability gap* which is a central aspect of this thesis and as this study finds is intricately linked with a complex array of factors including the regulatory environment, affordability, financing and geographic considerations. This study identifies the drivers of the viability gap in Kenya and Rwanda alongside emerging business and financing models for mini-grids[6] and stand-alone[7] solar systems.

Kenya and Rwanda provide excellent contexts through which to explore emerging partnership and financing models, and approaches to addressing the viability gap, as both countries are exploring more integrated electrification futures. These countries provide complementary case studies as they have similar electrification approaches in some respects but also have differences and nuances in others. The first similarity is that both countries are concertedly working towards universal access with national electrification plans and programmes that have a mix of grid and off-grid technologies to achieve universal access targets, which aligns with IDF pillar 1: *a commitment to universal access* and IDF pillar 2: *a mix of electrification technologies*. Both countries have made notable progress in closing their electrification gaps through a combination large scale grid electrification projects and off-grid programmes and have set ambitious targets[8] of reaching universal access. Notwithstanding, both countries still have a significant energy access gap. In Kenya the national electrification rate is 78% (Hako, 2023), but in underserved counties, like those targeted by the Kenya Off-grid Solar Access Project (KOSAP), a flagship off-grid electrification programme in Kenya, access is only 23%[9] (Power

[6] Mini-grids are decentralised grids (usually ranging from a few kWp to 10 MW) that can be isolated from the main grid with localised energy generation and distribution lines to end-users (i.e. households or business).
[7] Stand-alone solar systems are 'solar in a box' applications that usually consist of solar panel, a battery, charge controller and connecting wires that can be connected on a rooftop or placed separately with a few lights and can power small appliances usually in the scale of between 20Wp to 150Wp (Bardouille, 2012).
[8] The government of Kenya initially set a target of universal access by 2022 but is now earmarking 2030 as the year it could achieve universal access. Rwanda has set a Universal access target year of 2024.
[9] This figure provides an estimate from 2019 and 2020 figures in Power Africa study. Arguably with KOSAP underway, this figure would be more, with the off-grid stand-alone RBF windows financing companies.

Africa, 2020). In Rwanda the cumulative connectivity rate is 74.5%[10] (i.e., 50.9% grid connected and 23. 6% off-grid) (Rwanda Energy Group [REG], 2023).

Secondly, both countries have a mix of mini-grids and stand-alone systems in their off-grid sector and have implemented RBF programmes for mini-grids and stand-alone systems. RBF, as will be discussed in Chapters 2 and 6, is increasingly used in many countries in Sub-Saharan Africa (including Kenya and Rwanda) as a dominant approach to finance mini-grids and stand-alone solar systems (Johnstone & Garside, 2019; Phillips, Attia & Plutshack, 2020; Nagpal & Pérez-Arriaga, 2021). RBF programmes form an important part of the empirical analysis of financing models in Kenya and Rwanda to address the viability gap in relation to IDF pillar 3, a *financially viable business model*.

Thirdly, both Kenya and Rwanda have started to exhaust the low-hanging fruit of off-grid electrification; off-grid providers are finding it more challenging to reach households and businesses that are geographically and socio-economically marginalised (Lepicard et al., 2017; Power Africa, 2020). This challenge is not unique to Kenya and Rwanda and is likely to pose a significant barrier to many countries in Sub-Saharan Africa and the global South, as the premise of universal access is to reach everyone with electricity that is affordable, reliable and sustainable. Furthermore, Kenya and Rwanda are implementing national scale electrification programmes to incentivise private sector participation and collaboration in previously marginalised counties and regions in the country.

Differences include the approaches Kenya and Rwanda have taken for off-grid development and coordination of the off-grid sector. While Rwanda's approach to off-grid development has been more coordinated, with the public sector implementing a hands-on approach for energy sector development, the Kenyan off-grid sector has developed with more open market freedom[11] and less guidance than Rwanda. However, in programmes like KOSAP, the Kenyan government and public sector actors are taking a more active role in off-grid project development, e.g., in site selection for mini-grids and directing finance into the sector. A second notable difference is that while Kenya and Rwanda both have mini-grids and stand-alone solar in their electrification mix, in Kenya the off-grid sector is considered to be a more lasting feature of their universal access strategy, whereas in Rwanda, off-grid technologies, especially mini-grids are viewed as more as transitionary and temporary technologies as the Government of Rwanda aims to electrify most of the country with the grid beyond 2024, its universal access target. This leaves less room for mini-grid development in Rwanda than in

[10] This is based on a country level census done in Rwanda in August 2022.

[11] In the context of this study, open market freedom refers to energy sector players having more autonomy and freedom to participate in the off-grid sector, and often have control over several aspects of the value chain, within the bounds of regulatory requirements and compliance.

Kenya, and has notable implications for applying IDF principles like a long-term vision of the power sector, a *combination of electrification modes* and *permanence.*

The abovementioned factors allow these case studies to be compared, which provides a nuanced picture of emerging dynamics in off-grid markets. Furthermore, the case studies of Kenya and Rwanda offer lessons on partnership and financing models, within IDF paradigms that could be transferable to other contexts.

This research study is timely since new models and approaches to partnerships are needed to effectively serve areas that are more challenging to electrify from technical, financial, socio-economic and geographic perspectives (Chaurey et al., 2012; Sovacool, 2013; Rehman et al., 2017; Pérez-Arriaga et al., 2020; IEA et al., 2022).

1.4 Aim and research questions

Considering the problem and focus of the study presented above, the overall aim of this thesis is to explore how the principles of the IDF can operationalised and be applied to partnerships and financing models for mini-grids and stand-alone solar systems in Kenya and Rwanda, to facilitate the achievement of SDG 7. It will achieve this through an analysis of the business model, partnership, financing and regulatory aspects of off-grid grid electrification programmes and financing partnerships in the case study countries.

The overall aim can be broken down into the following research objectives:

1. *To analyse the unique contextual drivers of the viability gap for mini-grids and stand-alone solar systems in Kenya and Rwanda;*
2. *To assess how the IDF principles can be applied to enhance the design and implementation of financing and partnership models for mini-grids and stand-alone solar systems in Kenya and Rwanda;*
3. *To identify the key empirical factors that influence the conceptual IDF pillars in Kenya and Rwanda;*
4. *To operationalise the IDF framework for mini-grid and stand-alone system financing and partnership models in Kenya and Rwanda.*

Correspondingly, the research questions identified below will help to achieve the overarching aim and objectives of the study:

1. *What are the key factors impacting the viability gap for off-grid stand-alone solar and mini-grid businesses in Kenya and Rwanda?*

2. *Which business model and financing approaches are currently being implemented to overcome the challenges of viable and scalable electrification models in Kenya and Rwanda and how can an IDF lens improve the implementation of these approaches*?
3. *What are the key empirical factors that influence the conceptual IDF pillars in the Kenyan and Rwandan contexts?*
4. *How can the IDF be applied to Kenya and Rwanda's mini-grid and stand-alone solar system models to facilitate progress towards SDG 7?*

Table 1 below shows how each research question relates to the contribution to knowledge across the chapters.

Table 1: Research questions and knowledge contributions

Research question	Contribution to knowledge	Chapter(s)
1.	An analysis of the unique contextual drivers of the viability gap in Kenya and Rwanda including the regulatory context, affordability, demand and institutional priorities.	5
2	Exploring how emerging finance models can be incorporated into integrated distribution models, and effectively embedded into national electrification programmes in Kenya and Rwanda.	6,7
2,4	Assessing the impacts and implications of existing partnership models for off-grid electrification on existing private sector and PPP business models in the case study sites. Defining novel ways to overcome the siloed approach in where private off-grid provides (e.g., private companies or through PPPs) can collaborate in a more meaningful and mutually beneficial ways and develop synergies that can advance SDG 7.	6,7,8
3, 4	Operationalising the conceptual IDF in the context of Kenya and Rwanda through developing a deeper and nuanced understanding of the dimensions of integration in the IDF framework for off-grid stand-alone solar and mini-grids. This will be done through the different geographies and institutional contexts of Kenya and Rwanda, thereby furthering the IDF theory. Using the concepts and principles of the IDF to propose recommendations for incentives and favourable conditions for off-grid companies and PPP models to be integrated into an IDF to reach unserved populations.	7,8

1.5 Outline of the thesis

This thesis is outlined as follows. Chapter 2 reviews the existing academic and grey literature on off-grid electrification business and partnership models, finance, regulation, with the IDF serving as a conceptual (analytical) framework for the data analysis presented in Chapters 5, 6, 7 and 8.

Chapter 3 outlines the research methods used to carry out the empirical investigation and sets out the epistemological basis of the study, the case study research strategy, data collection instruments and sampling approach as well as the data analysis approach.

Chapter 4 provides an overview of key policies and regulations and energy access programmes that facilitate the goal of universal access to electricity in Kenya and Rwanda, which will serve as a foundation for the analysis in Chapters 5-8. This enhances the understanding of key institutional priorities, policy directions and regulatory frameworks that guide off-grid development in these countries, which have a direct impact on the IDF pillars. This chapter primarily draws on the insights of key policy documents, legislation and grey literature while also incorporating insights from the semi-structured interviews.

Chapter 5 investigates the factors influencing the viability of mini-grid and stand-alone solar models through findings from the semi-structured interview data, supplemented by grey and academic literature, including key recent reports on the Kenyan and Rwandan off-grid sectors. This chapter explores the viability of mini-grids and stand-alone systems by looking at tariffs, affordability and demand as well as the overarching regulatory impacts on the viability of these models.

Chapter 6 explores emerging partnership and financing models to address the viability gap through the lens of the IDF, drawing primarily on interview data. It analyses emerging financing models like EnDev RBF programmes for mini-grids and solar home systems in Kenya and Rwanda, and the KOSAP RBF for stand-alone solar systems. This helps to operationalise the IDF particularly for financing models like RBF.

Chapter 7 uses the case study of KOSAP in Kenya, to analyse how an IDF lens can be applied to PPPs for mini-grids. This chapter demonstrates the trade-offs between speed and scale and long-term and short-term objectives in the energy sector and balancing institutional priorities of sector actors.

Chapter 8 brings together the findings of Chapters 5, 6 and 7 to answer the research questions and provides new theoretical and practical insights and presents the combined IDF framework informed by the empirical interview data. This furthers the IDF theory and helps operationalise it for partnerships and financing models in Kenya and Rwanda.

Chapter 9 presents the key findings of the study in relation to research questions, highlights the academic contributions, proposes recommendations as well as areas for future research.

Chapter 2 Literature Review

2.1 Introduction

Chapter 1 introduced the rationale for the focus on integrated business and partnership models and highlighted that achieving universal access necessitates viable and scalable business models, coupled with appropriate regulatory frameworks, as set out in the problem statement, focus and rationale, and research questions (Sections 1.1 – 1.4). As highlighted in Section 1.4 the overall aim of this study is to explore how the principles of the IDF can be applied to partnerships and financing models for mini-grids and stand-alone solar systems in Kenya and Rwanda. It also considers how the principles can be operationalised in these countries to facilitate the achievement of SDG 7. However, as this literature review demonstrates, achieving the IDF pillars (see Section 1.1) is complex when affordability is low, and end-users reside in geographically distant or dispersed settings. The literature review will focus on key interrelated concepts in the IDF including business models, viability, finance, and regulation. While the literature often discusses these concepts separately, there is a notable gap in the literature exploring these concepts in relation to integrated electrification models.

This chapter presents a review of existing academic and grey literature on the IDF, business and partnership models for electrification, finance and regulation which will serve as a conceptual (analytical) framework for the data analysis presented in Chapters 5, 6 and 7. While acknowledging the role of both grid and off-grid electrification for achieving SDG 7, the scope of this review is focused on off-grid solar stand-alone systems and mini-grids, and the complementary role of these technologies to national grid-based electrification. The shift towards more collaborative paradigms for energy access warrants an in-depth review of existing and emerging off-grid models and how these models can be incorporated into integrated electrification paradigms *on the ground* at a practical level.

Section 2.2 begins by defining key concepts for integrated distribution models and electrification approaches with specific reference to the IDF. It then delves into business model theory and an emerging body of literature on electrification business models for mini-grids and stand-alone solar systems. Section 2.2.4 defines the concept of viability and the viability gap for mini-grids and stand-alone solar systems. Section 2.4 focuses on electrification finance to close the viability gap. Section 2.5 then discusses regulatory considerations for energy access. Section 2.6 concludes with identifying gaps in the literature in relation to the IDF framing as a conceptual framing for the empirical analysis in this study.

2.2 Conceptualising key concepts for off-grid integrated electrification business models

2.2.1 Integrated electrification models and the Integrated Distribution Framework (IDF)

Before examining and applying principles of integrated electrification models and the IDF, it is necessary to define the meaning of *integrated* as this term may be conceptualised differently across settings. For example, Urpelainen (2014) uses the term *integrated* to refer to a combination of grid and off-grid electrification approaches, while SEforAll (2019) also emphasises integrated policies and plans at a national level, as well as the integration of private and public sector entities. In the Utilities 2.0 initiative in Uganda, coordinated by Power For All, an integrated utility model was piloted where centralised and decentralised utilities (public and private) interconnect and collaborate to enhance energy service provision (Power For All, 2019). Linking integration to partnerships, Power For All (2019) argues that PPPs should be viewed as an important conduit to leverage private investments to achieve maximum electricity connections and use capital more efficiently.

This study uses the definition and theorical framing of integration as articulated in the IDF developed by Professor Ignacio Pérez-Arriaga and colleagues at the MIT-Comillas Energy Access Laboratory (Pérez-Arriaga et al., 2018; Pérez-Arriaga et al., 2019, 2020, 2021). This thesis adopts and expands the IDF as the main theoretical framing for the study through which the empirical data presented in chapters 5, 6 & 7 are analysed. The IDF is a conceptual framework that enables the identification of viable electrification approaches, with the key requirements of underlying viability and long-term planning for expansion and economic growth (Pérez-Arriaga et al., 2020). Using the framing of the IDF to define *integration*, this thesis draws on the insights from the empirical interview data to offer new theoretical and practical perspectives. The four *original* principles upon which the IDF is based include:

i. *Inclusiveness:* an energy service provider (e.g., utility, private sector company or a PPP) responsible to electrify all the people within a certain geographic region
ii. *Permanence:* long term vision with institutional oversight
iii. A combination of grid and off-grid modes
iv. *External resources* including external funding from donors, Development Finance Institutions (DFIs), equity investors to invest in off-grid projects (Pérez-Arriaga et al., 2019)

Inclusiveness is premised on electrification business models that go beyond the *low-hanging fruit* and serve the more challenging areas that are harder to electrify. This requires critical consideration for the types of incentives (including subsidies) that will be needed to support off-grid service providers and households/end users. Further linking the principles of the IDF are the financial resources needed to reach these more challenging areas including last mile customers. This is premised on a utility-like entity, private sector providers or a partnership between public and private sector actors that would be responsible for electrifying households within a particular territory.

Permanence requires a long-term vision of the power sector to enable the co-existence of a range of grid and off-grid technologies and the sustainability required to enable these models to function in a sustainable manner. A key challenge for achieving and facilitating the objective of permanence within private sector off-grid contexts is the nature and uncertainty of many off-grid electrification modes and models. Therefore, externalities impacting these models need to be managed e.g., regulatory environment and external financial resources off-grid providers need and can bring in to sustain their business models and make these models work.

A combination of electrification modes is necessary to achieve the IDF and international development ideal of *leaving no-one behind* through inclusiveness in energy provision. This mix of technologies is needed to get energy access to end-users in unelectrified communities expediently and is mostly aligned with the least cost electrification planning objectives. Although entry level options like solar home systems provide lower tier access, these technologies and business models could enable an entry level of access and allow for transitions to a mini-grid or grid connection where possible. Importantly the integration and coordination in planning between these technologies is imperative to consider.

Financial resources undergird all the IDF pillars; without suitable and sufficient financing the above pillars would not be possible to achieve. Within this pillar it is important to consider the continuity and financing pipeline. While external finance is a key mechanism for deploying off-grid projects and programmes, a total dependence on external[12] finance poses a risk to both *inclusivity* and *permanence* if private sector companies and other off-grid providers become too dependent on certain type of donor funding.

[12] This includes international donor funding (including grants) as well as private capital/equity investments into off-grid projects or debt financing instruments.

However, as shown in Table 2 below, the IDF framework has undergone further development since its original conceptualisation in the late 2010s. The concept of the IDF was initially proposed by Pérez-Arriaga (2016) with papers up to 2019 using the terminology: (1) *inclusiveness,* (2) *permanence*, (3) *a mix of electrification modes* and (4) *harnessing external resources.* This framing was also used in the Inception Report for the Global Commission to end Energy Poverty (see Pérez-Arriaga et al., 2019). In 2020 a follow-up report for the Global Commission was published that contains a slightly modified articulation of the IDF framework. This report articulated the principles of the framework as:

(1) A commitment to universal access that leaves no-one behind,
(2) *Efficient and coordinated integration of on-grid and off-grid solutions*,
(3) *A financially viable model for distribution and,*
(4) *A focus on development to ensure electrification produces broad socioeconomic benefits*.

When comparing the original IDF framing and the latest framing, pillar (1) A *commitment to universal access that leaves no-one behind*, in essence, comprises the original pillars (1) *inclusiveness and* (2) *permanence*. The latest framing of pillar (2) *Efficient coordination of grid and off-grid solutions* is essentially the same as the original pillar (3) *A mix of delivery modes*, but with an emphasis on how the mix of technologies need to be efficiently and effectively integrated. In the new IDF framing pillar (3) *A financially viable business model* encompasses harnessing external financial resources, as one of the elements needed to address the viability gap and make the business models work. In the new framing pillar (4) *A focus on development to ensure electrification produces broad socio-economic benefits* is a new addition[13] to the core pillars of the framework which emphasises the need to ensure that the socio-economic benefits of energy access are maximised and included in the design of electrification models.

While acknowledging the progression of the IDF and its articulation, this thesis largely draws on the overarching and collective principles derived from the original and revised framing of the IDF. The original core principles of the IDF (as articulated in papers from 2019 and earlier) provide key building blocks for analysing the emerging off-grid partnership and financing models, presented in the analysis chapters. The new framing, while based on the core principles, shows the end-goal in the wording as well. For example, the original pillars *inclusivity* and *permanence* are the building blocks for achieving the objective of *universal access and leaving no-one behind*. Similarly, the original IDF pillar 4:

[13] Previously, this pillar was discussed as a sub-topic in the overall IDF framing/ articulation.

harnessing external financial resources is a building block for the end-goal of *financially viable businesses modes* (i.e., pillar 3 in the new framing). Furthermore, there is a need to ensure that the maximisation of socio-economic benefits is well articulated as it is a key part of SDG 7. Therefore, this study will use the original four pillars for the core of the analysis presented in Chapters 5-7 and will integrate the findings from these chapters into the latest, expanded framework in Chapter 8.

Table 2: Development of the IDF - comparison between original and updated framings

IDF (original) 2019 and earlier (Pérez-Arriaga et al., 2019)	**IDF (revised) 2020 and onwards** (Pérez-Arriaga et al., 2020)
1. Inclusiveness. This involves ensuring the electrification of all customers within a specific region is achieved, particularly in areas where connectivity is lacking or absent. This requires an entity that is responsible for the overall implementation of such connectivity in a region, notwithstanding varying levels of demand and basic thresholds for quality conditions.	**1. A commitment to universal access that leaves no-one behind.** This requires a permanent supply facilitated by a utility-like entity that is ultimately responsible for ensuring electricity access within a specific region.
2. **Permanence.** Electricity access must be provided over a prolonged and permanent period. This requires institutional oversight to facilitate long-term electrification.	**2. Efficient and coordinated integration of on- and off-grid solutions (i.e., grid extensions, mini-grids and standalone systems).** This requires distribution-side integrated planning coupled with fit-for-purpose business models which serve various customer types within a specific region.
3. **A mix of delivery modes.** A combination of both centralised grid and decentralised off-grid modes is needed to meet rural demand identified in a least-cost electrification plan. These modes must be deployed by entities responsible for distribution in a manner that takes cost, energy security and customer preferences, among other factors, into consideration.	**3. A financially viable business model for distribution.** A form of legal security, usually in the form of a distribution concession, as well as subsidies for viability gap funding, will be required to promote external and specifically private investment.
4. Harnessing external (financial) resources. Electricity distribution companies require external investment and technical and managerial interventions to improve their financial viability. This ordinarily requires partnerships with external entities to access capital to develop their technologies. This will enable improved customer engagement and loss reduction.	4. **A focus on development to ensure that electrification produces broad socio-economic benefits.** This requires a focus beyond electricity connections to enable economic benefits for off-grid customers and should extend energy services to public institutions including health care facilities and education institutions.

Analysing the development of the framework, *inclusiveness* and *permanence* are key building blocks to *a commitment to universal access that leaves no-one behind* and thus for the purposes of this thesis *inclusiveness* and *permanence* will be considered as the key building blocks of updated IDF pillars.

The baseline IDF framing that will be used in this thesis is:

1. **Pillar 1: A commitment to universal access that leaves no-one behind** through ***inclusiveness*** and ***permanence*** *with off-grid providers privately or in partnership with national utilities delivering off-grid energy access within assigned specific geographic territories.*

2. **Pillar 2: Efficient and coordinated integration of grid and off-grid solutions** by focussing on the integration of off-grid technologies in tandem with the existing grid infrastructure.

3. **Pillar 3: *A financially viable business model supported*** *through* ***external financial resources*** *– emerging financing and partnership models to address the viability gap.*

4. **Pillar 4: *A focus on development to ensure that electrification produces broad socio-economic benefits*** *by looking beyond electricity connections but at the wider socio-economic impact and benefits for end-users through for example., productive uses of energy.*

This thesis uses the framing of the IDF as a departure point to define *integration* and operationalise it in the context of Kenya and Rwanda, by applying it to existing partnership and financing models used in national electrification and donor funded projects in these countries. The IDF enables an analysis of different levels of the energy system from institutions and entities involved in electrification to enable *inclusiveness* and *permanence* and the mix of technologies and finance needed to create viable business models and achieve universal access goals. As described in Sections 1.1. and 1.3, this thesis specifically applies the framing of the IDF to emerging partnership and financing models for off-grid energy access in Kenya and Rwanda. The IDF serves as the overarching theoretical and conceptual framework, upon which the thesis builds; it provides an in-depth analysis of the viability gap, emerging financing, partnership models to address the viability gap, as well as the challenges, and opportunities of being part of more coordinated electrification approaches.

As introduced in Section 1.2, the IDF as a guiding framework for universal energy access and regulatory design for electrification planning, has received increased attention in recent years (see Pérez-Arriaga et al., 2018; Rahnama, 2018; Jacquot et al., 2019; Pérez-Arriaga et al., 2019, 2020; Jacquot, 2021). The seminal studies of the IDF as proposed by the MIT Comillas Energy Access Laboratory (see Perez-Arriaga et al., 2018, Pérez-Arriaga et al., 2019, 2020, 2021) presented introductory literature on the concept of the IDF. It proposed the IDF as a tool and approach that could guide business models and regulatory design to facilitate the achievement of universal energy access, while addressing key aspects of the viability gap. These studies however have primarily focused territorial concessions as the recommended approach for the IDF (as will be shown in Section 2.3). Studies on the IDF that have emphasised aspects of the affordability of end-users, for example Rahnama (2018) have considered this in different geographic regions to this thesis (e.g. exploring attitudes, behaviour, and willingness to pay of end-users in India), while considering both grid and off-grid electrification approaches.

As noted in Section 1.2. the report for the Global Commission to End Energy Poverty considered applications of the IDF in Rwanda, Nigeria, Colombia, Uganda and India (see Pérez-Arriaga et al., 2020). While this report argued that Rwanda would be suitable for a more 'straight forward' implementation of the IDF, it did not specifically analyse current off-grid programmes for mini-grids and stand-alone solar systems in Rwanda or consider alternatives to territorial concessions. This thesis, acknowledging Rwanda as an apt case study, delves deeper into the specifics and dynamics of current off-grid programmes and institutional priorities in Rwanda and Kenya. This further contributes key insights on emerging tensions between grid and off-grid technologies in Rwanda and Kenya, in pursuit of universal access, and the co-existence and combination of electrification modes (which is a key consideration in the IDF pillars). With regard to the topic of finance in the IDF and RBF specifically, Nagpal and Pérez-Arriaga (2021) was the only working paper highlighting the need to consider RBF through the lens of the IDF, and how integrating the principles of the IDF and RBF could enhance sustainability of RBF approaches. This paper however does not provide empirical data on how practically IDF and RBF approaches could be combined, or applied to the growing RBF programmes in Sub-Saharan Africa, or Kenya and Rwanda specifically.

Thus, notwithstanding the developing literature on this topic highlighted above, this study has identified several knowledge gaps in the implementation of the IDF in different contexts. For example, it explores questions such as: how does the IDF accommodate different partnership models and how can different partnership models be enhanced by applying the principles of the IDF? How will existing off-grid private sector business models (namely stand-alone solar mini-grid models) need to be adapted to account for more collaboration between off-grid energy utilities and what would the impacts be on private sector business models and the goal of achieving SDG 7. How will the concepts of business models, viability and regulation need to be conceptualised or change to consider the end-goals of *inclusiveness, permanence, combinations of modes and external resources* on the ground? Within the broader umbrella of *external finance*, another gap identified is what emerging financing models are predominantly used to address the viability gap in Sub-Saharan Africa (and in Kenya and Rwanda specifically) and how applying the IDF principles can enhance the long-term sustainability of these models.

Figure 1 below shows a visual representation of the IDF, which this thesis visualizes, with modified pillars and sub-pillars (outlined in dark blue and white blocks), *inclusiveness, permanence, mix of grid and off-grid technologies* and *external finance* still remaining core to the analysis presented in this thesis. The original core sub-pillars will be used as the basis for analysing the empirical data in Chapters 5,6,7 and 8. The yellow blocks represent gaps this study identified in the IDF framing, and will be addressed in part through the remainder of literature review and primarily through the empirical analysis in chapters 5, 6, 7 and 8. This figure will be iteratively adapted throughout the thesis (with the full expanded framing presented in Chapter 8) to show how the literature review analysis and empirical findings build on the foundational framing of the IDF.

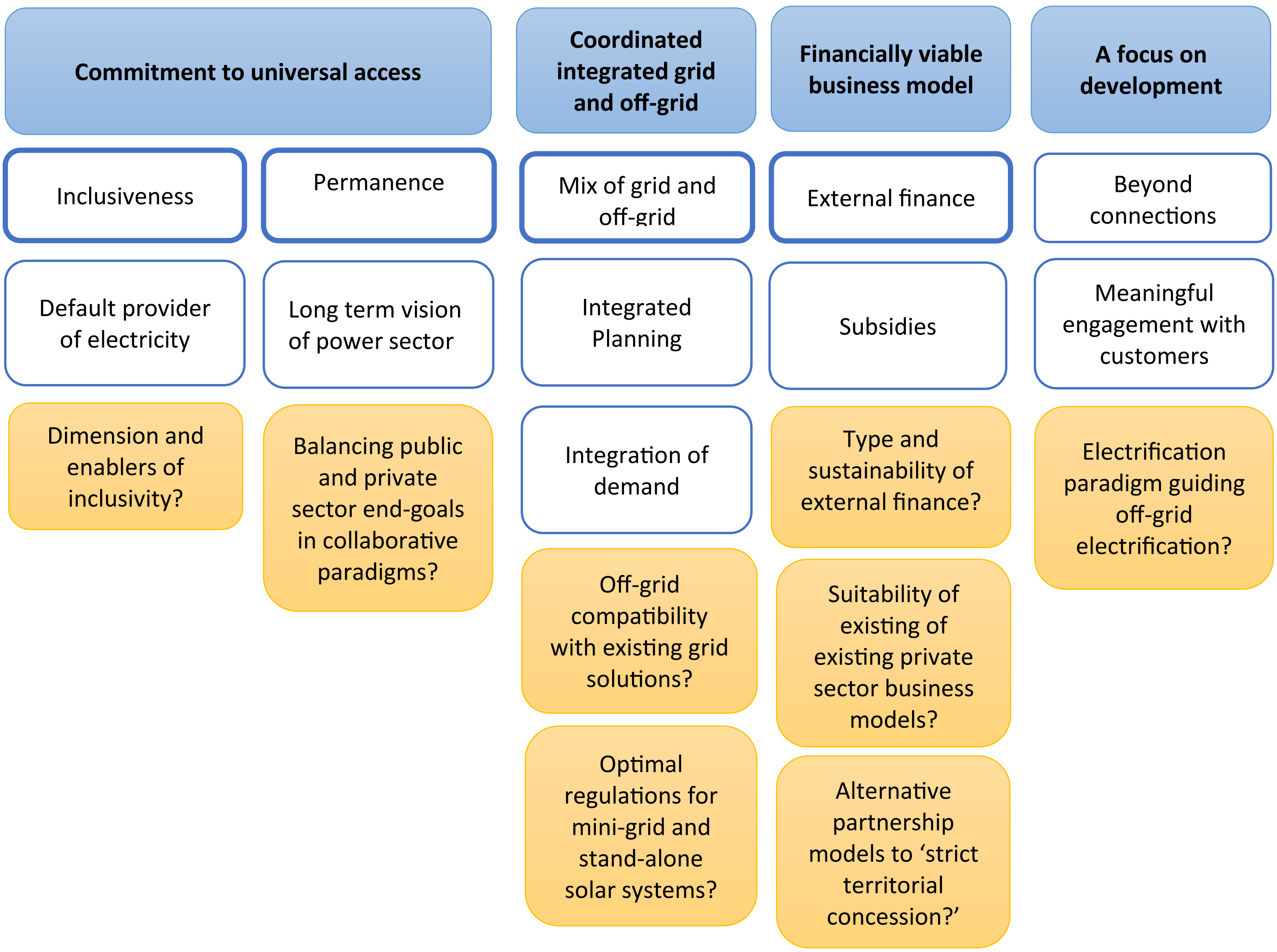


Figure 1: IDF (V1) (Author's figure) (incorporating IDF pillars from (Pérez-Arriaga et al., 2019, 2020, 2021))

Considering the framing of the IDF as the key theoretical framework of this study, the literature review uses IDF Pillar 3: *financially viable business models*, as a starting point to unpack related concepts of the IDF, presented in the sections below.

2.2.2 Conceptualising business models

Business models are an integral part of achieving universal access to electricity and a key element of the IDF, considering the private turn towards electricity provision, with a range of private sector business models and PPPs being used to achieve universal electrification objectives. Definitions of business models draw from various disciplines including business management, information technology, e-commerce and economics (Fielt, 2013). Osterwalder & Pigneur (2010) define a business model as: the creation, delivery and capture or monetisation of value. Value capture relates to the revenue model and business viability. Chesbrough & Rosenbloom (2002) conceptualise a business model as, 'a focusing device that mediates between technology development and economic value creation' (Chesbrough & Rosenbloom, 2002: 532). They assert that, 'the inherent value of a technology remains latent until it is commercialized in some way' (Chesbrough & Rosenbloom, 2002: 530). This conveys the idea that the value of a technology remains dormant in the absence of a suitable business model to convert technological value into economic value.

The terms *energy delivery model*, *energy business model* and *electrification model* are often used interchangeably in the literature. Bellanca & Garside (2013) define an energy delivery model as the financial, technological and management approaches required to facilitate energy supply to end users, and the attendant policy and legal frameworks. This definition encompasses elements of the aforementioned definitions with respect to the core delivery model, i.e. technology, finance (Chesbrough & Rosenbloom, 2002; Osterwalder, Pigneur & Tucci, 2005; Osterwalder & Pigneur, 2010) and broader ecosystem which include policy, legislation and network partners (Chesbrough & Rosenbloom, 2002). Off-grid business models are dependent on and influenced by a broader eco-system including policy, legislation, institutional arrangements, and financial considerations. It is also therefore useful to frame business models within the context of a broader ecosystem of actors.

Compared to the numerous studies above that have looked at business models in the context of private firms, (see for example Chesbrough & Rosenbloom, 2002; Osterwalder, Pigneur & Tucci, 2005; Amit & Zott, 2012), there is a notable gap in the literature that links business model theory to the evolving context of public private partnerships for infrastructure projects and off-grid energy more specifically. The study by Davies, Frederiksen & Dewulf (2010) is one of the few studies that considers business model theory in relation to PPPs. They contend that business model theory and literature mostly exclude the public-private sector interface. However, it is this interface that allows for an analysis of shifting roles, risk and interactions between public and private sector actors and business model innovation in PPPs. In the case studies of Kenya and Rwanda, explored in this study, the emergence of PPPs particularly for mini-grids and off-grid stand-alone solar is an important shift in development which will be discussed in more detail in the analysis in Chapters 6 and 7.

This study defines off-grid energy access business models as the *models off-grid providers like mini-grid developers and stand-alone system companies use (either privately or in partnership with a national utility) to provide energy access to end-users (i.e., households, businesses or community facilities) and the financial model for revenue and a return for their investors.* Viability, as will be elaborated in Section 2.2.4, is an integral part off-grid energy access business models as it relates to the revenue model, but also needs to be balanced with the *inclusivity* objectives in the IDF framing.

Considering the above conceptual framing of business models, the section below will specifically discuss off-grid stand-alone solar and mini-grid business models as the focus on this thesis.

2.2.3 Off-grid stand-alone solar and mini-grid business models and the IDF

Off-grid stand-alone solar and mini-grids have emerged as an integral part of the electrification mix in many countries in sub-Saharan Africa (Hansen, Brix & Nygaard, 2015; Bisaga et al., 2018, Jacquot et al., 2019). Off-grid stand-alone systems like solar home systems and pico-solar systems[14] (which are compact and portable) are considered an important part of achieving universal access (Bisaga, 2018; Harrington, 2020) . They enable households, businesses and communities to access a minimum level of energy services at a faster rate (i.e., Energy Sector Management Assistance Programme (ESMAP) tiers 1 – 3) in unelectrified or weak grid settings and where there is not sufficient density or anchor loads to make mini-grids viable. These systems can meet low demand in smaller urban centres and more remote rural regions, with many countries recognising the limitations of electrification models solely based on grid electrification (Hansen, Brix & Nygaard, 2015; Jacquot et al., 2019).

Pay As You Go (PAYG) is a prominent business model for off-grid stand-alone systems and is an important entry level option for many households without access to electricity, by providing lower

[14] Pico- solar systems use solar modules with a power output ranging from 0.1-watt peak (Wp) up to 10-15 Wp (Keane, 2014). These systems can power smaller lighting devices in including rechargeable solar lanterns and smaller appliances (Keane, 2014).

tier[15] energy access to power basic lighting, mobile phone charging and other smaller appliances like TVs, depending on the type of solar system used (Bisaga, 2018). Innovative mobile payment systems through mobile money, integrated into PAYG models, have made these off-grid solar systems more affordable and accessible to many households in sub-Saharan Africa (Pailman, Kruger & Prasad, 2015; Reichert & Trivella, 2015; Bisaga, 2018). Notwithstanding innovation and increased market penetration in many countries in Sub-Saharan Africa, PAYG companies often cater to unelectrified households with higher ability to pay, leaving many low-income households without access to a minimum level of energy (Lepicard et al., 2017; Zollmann et al., 2017).

Currently, solar home systems are considered the fastest growing segment of the electricity distribution value chain (Bisaga, 2018; Jacquot et al., 2020), however, there are key challenges hindering the diffusion of these technologies (Lepicard et al., 2017). The first notable challenge is saturation in the markets that have had the most success in deploying off-grid solar systems, while entire regions remain unserved. In Kenya, a leader in solar home systems in East Africa and Sub-Saharan Africa, sales are concentrated in the bigger cities, e.g., Nairobi and Western counties. While some companies have started to expand their footprint into other counties, some counties remain unserved, with companies finding it difficult to expand into the Northern and Eastern regions (Lepicard et al., 2017). In Rwanda companies experienced problems in expanding into the more challenging markets with lower affordability (EnDev, 2019). Similarly, in Tanzania, sales have been concentrated in the bigger cities, Dar es Salaam, Arusha and the Great Lakes areas, while penetration in the rest of country is extremely low. In the above contexts, a concentration and unequal distribution of sales is a problem in markets with higher penetration. However, in more complex markets, other challenges persist including small off-grid populations, low population density, unconducive regulatory environments, high import tariffs, and changing regulations on Value Added Tax (VAT) exemption (Lepicard et al., 2017). This makes a case for stronger collaboration between public, private and donor entities to fill the gap, by providing and designing subsidies in a way that reaches and benefits low income unelectrified communities. This is an important consideration in the design of national electrification programmes that include off-grid technologies and links to the principle of *inclusivity* as highlighted in the framing of the IDF. Chapter 6 will consider in depth how these national electrification programmes for off-grid technologies are being designed and the partnership models used.

[15] Here tier refers to ESMAP's Multi-tier framework which is an approach to measuring energy access through 5 tiers framework which includes metrics amongst other, numbers of hours of energy services ranging from e.g., basic lighting through an entry level solar home system to having comprehensive "full energy access".

The second challenge is that the level of service offered through solar home systems (tiers 1-3) is not on a par with grid access, or what some mini-grids could offer for powering appliances for heating and cooking and productive loads, which could be coupled with income generating opportunities (EnDev, 2019; Pérez-Arriaga et al., 2019). For larger and more comprehensive solar home systems, affordability and risk are key barriers to adoption. Solar home systems are, at present, often unaffordable for many low-income end-users requiring in-house finance from the off-grid solar companies or micro-finance institutions (MFIs) (Zollmann et al., 2017; Ketelaars & Wheeldon, 2021). While stand-alone solar home systems are popular and provide more affordable alternatives for better off unelectrified households, they do not provide a level service on a par with grid access and cannot support productive loads at the level required to power economic growth (Pérez-Arriaga et al., 2019), which impacts IDF pillar 4, *a focus on development*. This is also an important challenge which the IDF framing, seeks to address (see Section 2.6). That includes ways to transition from lower levels of access to higher levels, which also implies a trade-off between lots of lower tier (i.e., tiers 1-3) entry level access versus higher tier access (Pérez-Arriaga, 2016). This transition between tiers of service is important to avoid another type of *technological lock-in* where households who have been considered *electrified* though solar home systems would be left behind and not considered to be eligible for higher levels of access as demand and affordability grows. This also presents a challenge as substantial development (and other) finance is being directed into promoting lower tier off-grid systems, which for households might cost the same or even more than grid or mini-grid electrification, but the level of service is not the same. It should also consider the complexities of these energy transitions as this is often not a straightforward pathway to a 'modern infrastructure ideal' (Essex & de Groot, 2019).

Linking the above to the concept of the IDF, Jacquot et al. (2020) describes the paradox off-grid solar companies face, regarding the need for subsidies and regulation and how this may affect their willingness to participate in integrated distribution models. They argue that while PAYG companies are able to demonstrate profitability[16] without a complete reliance on subsidies (including grants and other incentives) being incorporated into IDF paradigms could provide them with access to new markets and incentives to extend their reach to market segments previously considered unprofitable.

Thus off-grid solar companies can do well in the absence of subsidies and stringent regulation yet have difficulty in moving into the more challenging market segments without it. Stand-alone systems are

[16] Compared to mini-grids or the grid, stand-alone solar models could have the ability to be more independent from 'structured' electrification approaches or regulated paradigms, and potentially achieve profitability without a complete reliance on subsidies. Studies like the Persistent Energy report speak to the profitability struggles PAYG off-grid companies are facing, and more data/ studies are needed on the profitability of off-grid models (Aidun, Eva & Bougern, 2023).

also relatively agile, with fewer moving parts and less infrastructure needed to enable them and less long-term infrastructure investment compared to mini-grids. While very few PAYG companies have reached profitability, in comparison to grid extension and mini-grids, the off-grid solar sector has shown the greatest ability to be profitable in the absence of a subsidy within certain market segments. This is due to a lower capital infrastructure investment per stand-alone system unit compared to mini-grids or grid extension and shorter pay-back times for systems (1-3) years compared to mini-grids (7-10 years[17]). Subsidies cannot be relied on primarily to build sustainable off-grid business models, as they are subject to changes (i.e., political, administrative, financial), yet are needed to address the viability gap of systems that are still out of reach for many low-income end users.

Like stand-alone solar systems, in recent decades mini-grids have started to feature more prominently in the electrification strategies of many countries in the global South, with several countries including mini-grids as part of their electrification plans (International Finance Corporation [IFC], 2020; Phillips, Plutshack & Yeazel, 2020). Mini-grid business models can be categorised in several ways, more commonly by ownership and operation, and the amount of private sector involvement in the ownership and management of the mini-grid, see e.g. (Weston et al., 2018; Graber et al., 2019; Korkovelos et al., 2020; Serasu & Sahinyazan; 2021). Mini-grid ownership and operation models can broadly be classified as utility owned, community owned, privately owned and PPP models (Weston et al., 2018; Graber et al., 2019; Serasu & Sahinyazan; 2021; BloombergNEF & SEforAll, 2020). In a utility model, ownership and operation of the mini-grid is undertaken by the utility and funded through public funds from the national tariff charged, which is cross-subsidized by grid connected customers. This model is, however, unsustainable for utilities with capital constraints, and many utility-owned mini-grid models have as such shifted their focus from mini-grids to grid connected customers. With inadequate resources being devoted to operation and maintenance, these public mini-grids are often poorly maintained (African Development Bank [AfDB], 2016).

In a private model, the private developer is responsible for construction, ownership and operation of the mini-grid, and finances the mini-grid through private equity and grants. This can be contrasted with a community model, where the mini-grid is owned and managed by the community or local NGO, with communities as beneficiaries or recipients of the electricity (Graber et al., 2019; Peters et al., 2019). In the context of the private models specifically, some mini-grids are not able to offer affordable tariffs which significantly impacts the level of *inclusiveness* that can be achieved in the models and widens the affordability gap. This necessitates subsidies and grants to bridge this gap.

[17] See CrossBoundary (2020)

Acknowledging that all of the above-described models have shortcomings, it becomes evident that variations to these models or hybrid approaches are needed in the deployment of mini-grids so that they are able to reach the desired scale and significantly make a mark in energy access targets. In this way the strengths of private, public and donor-based approaches can be maximized. The idea of hybrid models or partnership approaches is an area of increasing interest (Sovacool, 2013; Rehman et al., 2017) but requires further insights in specific country contexts, where the empirical case study serves to fill this gap.

The above section introduced key considerations for stand-alone solar and mini-grid business models including exhausting the low-hanging fruit and being more challenged when serving regions where affordability is low, or end-users reside in distant or geographically dispersed settings. In line with the overall focus of this thesis on integrated models for off-grid access, it is necessary to explore what private sector off-grid models would look like under more integrated paradigms including PPPs. As discussed in Section 2.2.1 IDF *pillar 3 Viable business models* comprise different delivery models including public, private and PPPs, including distribution concessions. The next section will first define viability and the viability gap, as a central concept in this thesis, before exploring PPP models and more collaborative partnership approaches.

2.2.4 Defining viability and the viability gap

Viability is a central concept to the IDF for achieving universal energy access and is important to define. As discussed in Section 1.1 the *viability gap* has been defined as the difference between the cost of providing an energy services and revenues collected or projected from willingness to pay (Pérez-Arriaga et al., 2018). From the above, the viability gap is the result of a mismatch between revenues and costs, where costs cannot be recovered through the available revenues. This is a problem which negatively affects the functioning and sustainability of utilities and energy service providers and their ability to provide energy services to new and existing customers.

Studies have also considered how viability can be framed from a social, economic and financial perspective (Rehman et al., 2017; Phillips, Plutshack & Yeazel, 2020; World Bank, 2010). Rehman et al. (2017) identify subsidy-driven and market-led paradigms which are approaches to achieving the socio-economic and financial viability objectives in electrification projects. Each of these approaches will be elaborated on in the paragraphs below.

The subsidy driven paradigm is regarded by Rehman et al. (2017) as the dominant paradigm for the provision of electricity access where governments, through the assistance of energy access programmes, provide energy at subsidised rates. Phillips, Plutshack & Yeazel (2020) illustrate the role subsidies and public finance have played in advancing electrification and addressing the affordability gap in several countries in the Global South including, Chile, Peru, Brazil, South Africa, Thailand and Tunisia, as well as the United States and China. This has been through substantial government and donor funding into national electrification programmes which were primarily grid-based but also included an off-grid component.

For off-grid electrification, Phillips, Plutshack & Yeazel (2020) find that subsidies and public finance need to include off-grid systems and need to be adapted to the needs of the off-grid sector. This, however, in practice remains challenging as it requires suitable mechanisms to direct public funding to private sector initiatives. This is complex as the private sector is driven by a profit motive, but at the same time fills a gap by electrifying areas that the public sector has not yet been able to electrify. Innovative ways of directing subsidies to companies therefore need to be considered. Several authors have argued that subsidies that are not well targeted, will not reduce the viability gap and/or increase access to electricity (Zerriffi, 2011; Kojima & Trimble, 2016; Rehman et al., 2017). Rehman et al. (2017) emphasises that subsidies are often misdirected and poorly targeted, with the intended beneficiaries not always benefitting, and those who can afford higher tariffs being over-subsidized. SEforAll (2022) compared the subsidy programmes for off-grid solar home systems implemented in Uganda and Togo. For Uganda, they found that the subsidy was largely considered successful and due to accurately calculating subsidy thresholds for different regions and directing the subsidies to areas where it was needed most. In Togo, the subsidy programme focused on accuracy for calculating the affordability gap, which is an important part of calculating the subsidy threshold. This shows that careful consideration is needed to direct subsidies to where they are needed most. This is an important theme that will be elaborated on in the country programmes of Kenya and Rwanda in Chapter 6.

The market-led paradigm is a private sector led approach for energy provision, where energy provision is predominantly left to private sector actors and market dynamics of supply and demand apply (Rehman et al., 2017). An important critique of this approach is its focus on profit maximisation through tariff enhancement, by electrifying areas that could provide fast and high returns (Bhattacharyya & Palit, 2016; Rehman et al., 2017). Sound regulation should guard against arbitrary tariff increases or unjustifiably high tariffs, which are problems associated with the market led paradigm (Bhattacharyya & Palit, 2016; Pérez-Arriaga, 2016). In a recent paper Groenewoudt & Romijn

(2022) also highlight the emerging critique against market based *corporate-led* models for off-grid energy access and argue that the prioritisation of short-term private sector priorities of higher sales volumes and higher prices could perpetuate social injustices, despite the intentions for more equitable energy access. In Sub-Saharan Africa the diffusion of off-grid stand-alone solar home systems have largely been driven by a market led paradigm in certain countries like Kenya which is considered a leader for solar stand-alone systems.

The literature above draws attention to the fact that subsidy-driven and market-based paradigms both have shortcomings relating to inherent inefficiencies in the system and limitations on the capacities needed to effectively role out a subsidy, which diverts from the goal of energy access (Rehman et al., 2017). In this regard the strengths of both subsidy-driven and market-based approaches should be maximised by combining social welfare and viability objectives (Rehman et al., 2017). This is an important concept that will be discussed in Chapters 6 and 7 which analyse financing and partnership models to address SDG 7, and apply an IDF lens to examine *viability* but also the *inclusivity* objective. Here combining subsidies and guided sector approaches with market-based private innovation is necessary for reaching geographically marginalised areas and other regions where ability to pay is low in inclusivity objectives.

From the above an important theme in the literature is that the full value of electrification should be viewed through wider lenses than purely financial lenses to account for the broader socio-economic benefits these approaches could provide in the long-term (Hunt, 2017; Sharma, Mishra & Shekhar, 2017; Phillips, Plutshack & Yeazel, 2020). This raises the concern about whether the responsibility for electrification should lie with the private sector. While private sector actors are contributing to broader social-economic objectives, they would need to prioritise their business case and making a financially viable business model. Sharma, Mishra & Shekhar (2017) argue that while it is necessary to evaluate the financial viability through a purely financial lens, only considering financial viability may not be able to account for additional costs for market development, scoping and evaluation studies. As electricity transcends simply being a service, but a key tool for achieving broader electrification objectives, the higher costs of electrification can be justified in terms of the wider developmental benefits like local economic development, education, and health benefits. This also links to the IDF pillar 4, a *focus on development*. Sharma, Mishra & Shekhar (2017) conclude that although the discourse focuses on the viability of private sector energy access models, discussions about viability should be framed within the wider mandate of delivering a public good, and the responsibilities shaped accordingly. This challenges and stretches the idea of what it means to *viably* electrify the unelectrified households and communities, who have responsibility for (part of) the outcome, and that SDG7 will not be achieved by solely considering financially viable systems. A more nuanced understand of viability and the viability gap is needed, not only looking at financially viable models but also considering the longer-term social impacts and the subsidies that will be needed in to bridge the viability gap.

The Viability Gap for mini-grid and stand-alone systems

The viability gap exists for various reasons. In the case of rural electrification, the viability gap is particularly pronounced because electricity distribution costs in rural areas are substantially higher than in urban areas because rural areas are more dispersed and usually have lower demand than dense urban areas (Bandi et al., 2022; Pérez-Arriaga et al., 2018; Pérez-Arriaga, 2016). Concerning mini-grids, Melnyk & Kelly (2019: 14) define the viability gap as the 'difference between the revenue that a mini-grid operator is able to collect from the communities they serve and the costs and profits that are required'. In the IFC's Distributed Energy Company (DESCO) programme for mini-grids and solar home systems in Togo, the viability gap was defined as the difference between the return in investment investors required and what end-users would likely be able to contribute, which was an important part of the business model assessment of the programme (Tanvez, 2018).

Notwithstanding the technological advances in terms of the declining costs of solar photo voltaic (PV) and battery storage[18], making a viable business case for mini-grids is still challenging. This is due to a plethora of factors including low demand, affordability, challenging geographies, competition with grid tariffs, regulatory environments, risk of grid encroachment, investment payback periods etc. (BloombergNEF & SEforAll, 2020; USAID, African Union & Power Africa, 2021). Korkovelos et al. (2020) contend that while mini-grids offer a lot of promise for improving energy access, incorporating mini-grids in national electrification plans results greater uncertainty, as this requires new actors, business models and technical standards to be developed or iterated. This necessitates revisiting and developing mini-grid business models that are tailored to local contexts.

Mini-grids serving rural customers face the challenges associated with rural electrification mentioned above i.e. high costs, low affordability and low demand. For mini-grids to be viable, the revenues

[18] Solar photovoltaic (PV) modules declined by approximately 80% between 2009 and 2018 (IRENA, 2018). Coupled with the rapidly declining costs of solar PV, the cost of lithium-ion energy storage has declined significantly - approximately 70% between 2014 and 2016 (IFC, 2016) with lithium-ion battery packs dropping from about $1200 per kWh in 2010 to $132 per kWh[18]

derived from the tariff should be able to cover the costs of and provide a return for investor, which is commensurate with the risk. However, rural customers are not often able to afford the energy services and have a smaller demand for electricity, resulting in an affordability gap (Melnyk & Kelly, 2019). Mitra & Buluswar (2015) assert that without subsidies low-income end-users would not be able to afford the high costs of connecting to a mini-grid.

Many low-income rural households are unable to afford mini-grid tariffs. In addition, mini-grids are unviable without subsidies or donor finance or alternatively large commercial, industrial customers or utilities as off-takers (Pérez-Arriaga et al., 2019; Bandi et al., 2022). This highlights the link between the *viability gap* and the *affordability gap*, as the viability gap largely exists because there is an affordability gap between what mini-grid customers can afford to pay and the price at which the service is marked. Bandi et al. (2022) argue that there is a perpetual disjuncture between what customers can afford and business viability.

For off-grid stand-alone systems the viability gap is also a key consideration driven by the lack of affordability of off-grid solar systems for many unelectrified households and communities. This is a significant barrier to getting cleaner and safer entry level energy access technologies to unelectrified communities (Africa Clean Energy & Open Capital Advisors, 2020; Ketelaars & Wheeldon, 2021). With relevance to the viability gap, it is important to consider both the *access gap* and the *affordability gap*. The access gap means that households are not able to readily obtain an off-grid solar product even though some might have the ability and willingness to pay. Challenges include low population densities and lacking infrastructure which adversely impact the economics of setting up in hard to reach areas (Africa Clean Energy & Open Capital Advisors, 2020; SEforAll, 2022). The affordability gap[19] includes customers who can access off-grid products but cannot afford them. This links to the principle of *inclusiveness* in the IDF, where incentives are needed to encourage off-grid investments into areas that are more challenging to electrify. Furthermore, there are customers that fall into both categories, i.e., not being able to physically access to nor afford off-grid products (SE4ALL, 2022). Here governments can play an active role in designing subsidies to facilitate SDG 7 targets. This requires understanding the *hard to reach areas* and combining both supply sides incentives (i.e., concessional finance and grants for off-grid solar companies) and targeted demand side subsidies (i.e., subsidies that reduce the cost of acquiring off-grid solar systems for low income and the most vulnerable

[19] It is estimated that $3.4 billion will be needed to close the affordability gap in addition to public finance and support (African Clean Energy & Open Capital Advisors, 2020).

populations who cannot afford these systems (Africa Clean Energy & Open Capital Advisors, 2020; Perera, Johnstone & Garside, 2020).

The amount of subsidy required for mini-grids and off-grid solar home systems is significantly less than that required for grid extension (Melnyk & Kelly, 2019). This supports the case of directing subsidies to mini-grids and stand-alone solar technologies. As grid extension is highly subsidised, to enable off-grid models (which complement grid-based electrification), subsidies are equally needed for off-grid technologies, as the viability gap which affects grid models also impacts off-grid models. This finding is supported by research from the mini-grid Innovation Lab led by CrossBoundary and Energy4Impact which suggests that cross-subsidising off-grid renewable energy technologies and attendant private sector models can reduce the subsidy required for rural end-users (Musonda et al., 2021). Tailored viability gap finance for mini-grids is especially important as mini-grids operate within a limited geographic territory, with a limited consumer base in comparison with utilities who have a large base of grid connected customers who can cross-subsidise others (Pérez-Arriaga et al., 2019).

Subsidies are a key part of financing electrification projects (grid and off-grid), are one of the ways to address the viability and affordability gap, and have been an integral part of electrification in both developed and developing economies (Pérez-arriaga et al., 2018; Phillips, Plutshack & Yeazel, 2020). These subsidies need to be well-targeted and designed in order to facilitate electricity access goals and objectives. Melnyk & Kelly (2019) emphasise that subsidies have played a key role in the history of rural electrification. Grid extension to rural areas is greatly subsidised and funded through national governments, donor organisations or cross-subsidies from other grid customers (Melnyk & Kelly, 2019; Phillips, Plutshack & Yeazel, 2020). To reach electrification policy objectives in Sub-Saharan Africa, significant subsidies have been required. By addressing the affordability gap, subsidies could enable rural households to pay for energy services e.g., by lowering the tariff. Subsidies can also improve the sustainability of decentralized energy access and incentivise the private sector to invest in off-grid electrification (IEA, 2019). Williams et al. (2015) highlight that although subsidising electricity could lead to distortions in the market and may not be economically sustainable, it is necessary for making electricity affordable for the rural poor and achieving the IDF pillars. It is further worth considering that although subsidies are necessary to close the viability gap, subsidies need to be well targeted to reach households and communities that need them the most. This will also help to reduce the volume of subsidy that is necessary.

While the literature defines this mismatch between affordability and ability to recover costs, it does not provide deep contextual insights into the different contextual drivers of the viability gap and how they interrelate: e.g., regulatory contexts, affordability contexts and differences and similarities in shaping the viability gap. This thesis contextualises the drivers of the viability gap in Chapter 5.

2.3 Public private partnerships (PPPs) for off-grid electrification

2.3.1 Defining PPPs in the context of the concession model

As described in Sections 1.2 and 2.1 off-grid partnership models, including PPPs, are a key aspect of this thesis. As noted in Section 2.1, IDF Pillar 3, envisions a territorial concession as a key implementing mechanism for addressing aspects of the viability gap and IDF sub-pillars of *inclusivity, permanence and externa*l resources (Pérez-Arriaga et al., 2019, 2020). Before analysing the merits and challenges of PPPs and concessions specifically for delivering electricity access, it is necessary to define a PPP. Yescombe (2007: 3) defines a PPP as a 'long-term[20] contract between a public-sector party and a private sector party for the design, construction, financing, and operation of public infrastructure by the private-sector party'. According to Hosier et al. (2017), concessions can be better understood, when viewed on a spectrum of PPPs. A concession is a type of PPP where the private sector is granted rights to construct and operate public infrastructure for an agreed period (Kerf et al., 1998; Hosier et al., 2017). Concession models are important to analyse in relation to Research Question 2 introduced in Chapter 1, which explores partnership models to advance energy access and address the viability gap. Furthermore, within the IDF framing, concession models are considered one of the key implementation mechanisms to facilitate inclusiveness and allocate responsibility to a single entity, or a few, to electrify everyone within a given geographic territory (Jacquot et al., 2019; Pérez-Arriaga et al., 2019; Jacquot, 2021). It is however important to consider the suitability of concessions in the off-grid context, to advance electrification objectives and compatibility with private sector business models. The sections below analyses the literature on concession models, looking at key lessons from the experiences in different countries.

In electrification concessions, private companies are granted monopoly rights for the distribution and retailing of electricity, within a certain geographic territory. These rights usually require a certain minimum level of service to be maintained by the concessionaire and the requirement that all or a certain minimum number of people be connected (Williams et al., 2015; Hosier et al., 2017; Diouf & Miezan, 2021). Rural concessions have proved challenging in attracting the required level of private

[20] This usually ranging from 7 – 20 years. Usually 20 years for longer term concessions.

investment, as rural electrification is perceived as high risk and unprofitable. In order to overcome these challenges some companies have used the strategy of bundling concessions; to service more dense urban areas and more dispersed rural areas (Williams et al., 2015). In a leasing variant of the concession (PPP), ownership remains with the public sector entity, and they are also responsible for new infrastructure investments – growing the infrastructure asset base. The private entity is tasked with operation and maintenance, the public service provision and payment collections. The private sector entity, the concessionaire in return, makes payments to the public sector entity for the right to collect payments. A stricter variation of the concession requires the concessionaire to assume some of the public sector's responsibilities of growing the infrastructure asset base, in addition to performing the operation and maintenance function. At the end of the concession period the concessionaire has to return the asset to the public entity (Hosier et al., 2017).

Rural electrification concessions in Sub-Saharan Africa have produced mixed results. There are salient features of concession approaches that can be incorporated into successful frameworks for futuristic concession models, and a growing body of literature is in favour of adapting concession models specifically in the context of low-income regions (Hosier et al., 2017; Jacquot et al., 2019; Pérez-Arriaga et al., 2019). Hosier et al. (2017) studied four countries in sub-Saharan Africa where national utility concessions were implemented: Uganda, Cameroon, Mali and Madagascar. The concessions contributed to less than 1% growth per year in electrification access between 2000 -2012 in South Africa, Senegal, Gabon, Togo, Cape Verde, Uganda, Mali, Cameroon, Madagascar. However, it is important to keep in mind that these concessions were not introduced with the purpose of increasing access as the primary objective, but rather to improve the operational performance of the utilities. Similarly Jacquot et al. (2019) contend that concessions that are well designed and well implemented can help to achieve universal access.

Hosier et al. (2017) found that while mini-grid concessions have been able to attract local investment and supply more rural end-users with electricity, the six mini-grid case studies examined in Burkina Faso, Guinea, Madagascar, Mali and Senegal, were unsuccessful in attracting larger international investors and/or quickening the pace of electrification. In all these cases the rural electrification agency originated the concession and carried the cost in part or full (i.e., through a rural electrification fund). The case of Mali was the most successful, where 70 000 people were electrified. What appears to be instrumental in the success of Mali, was private financing. The case for mini-grid concessions can be strengthened through tariffs that enable investments to be recouped, thereby enhancing financial viability (Hosier et al., 2017). This links with the IDF sub-pillar, *external financial resources*.

Furthermore, there should be a strategy in place for these mini-grids to achieve scale e.g., concessionaires operating a group of mini-grids. Jacquot et al. (2019) argue that although mini-grid concessions have not shown significant results yet, concessions have the potential to deliver energy access targets if they are designed in a way that can leverage economies of scale and attract the necessary finance to improve the viability of off-grid mini-grid projects. To improve the success of mini-grid models there is a need to consider the barriers to scaling mini-grids and achieving greater impact beyond smaller scale impact demonstrated a local level (Jacquot et al. 2019). They contend that some of the challenges of making mini-grids work relate to the bottom-up nature of private mini-grid projects in term of the limited viability of these projects and that min-grid concessionaires can raise equity and debt funding to develop the mini-grid but have limited ability to maintain the mini-grid and grow the asset base.

Researchers at Duke University's Energy Access Project found that increasingly concessions are being used as part of mini-grid incentive programmes in Sub-Saharan Africa (Phillips, Plutshack & Yeazel, 2020). They further highlighted three typologies for mini-grid programmes, including a *top-down, site specific* approach where the government selects the specific sites for mini-grid development and the social institutions that they would want to electrify as part of the programme. This can be seen in Kenya's KOSAP programme where mini-grids sites are divided into lots and pre-determined by the public sector as well as the clinics, schools and other social institutions within the programme (ESMAP, 2017). In Nigeria's Electrification programme this site selection approach was used in one of the programme components, which was combined with an auction. Within a *top down* concession, the government decides the concession area with a range of mini-grids sites developers can choose from, giving private mini-grid developers some flexibility in site selection. Examples include Sierra Leone's Rural Renewable Electrification Project. In contrast, a bottom-up, developer led approach allows mini-grid developers to select their own sites and is subject to regulatory approval for example, the Beyond the Grid Fund in Zambia. Phillips, Attia & Plutshack (2020) furthermore highlight the trade-off between the three approaches discussed above. They argue that more government involvement in site selection i.e., through top-down site specific or top-down concessions, could be better suited to serving last mile, harder to reach customers than bottom-up developer led approaches. However greater centralisation in the selection of sites could result in the need for greater subsidy levels.

Solar home system concessions however have not been successful, as illustrated through the solar home system concession programme in South Africa and Senegal. In South Africa, six companies were granted the exclusive right to provide solar home systems to certain rural areas in Kwa-Zulu Natal and the Eastern Cape provinces of South Africa for a period of five years launched in 1999. Challenges included legal difficulties in implementing the concessions, where responsibilities under the concession were not respected. Furthermore, the concession model proved to be unsuitable for a solar home system market, which is dynamic and dependent on innovation and competition, and does not work well under monopolistic conditions. Challenges with system maintenance of the systems in a financially viable manner, in addition to restriction to areas of operation as per the concession regions originally assigned to concessionaires (Wlokas, 2011; Hosier et al., 2017). Similarly, in Senegal, the introduction of a zonal concession which included solar home systems, made limited progress with the number of connections being less than expected evaluated 10-year period after the concession was instituted (Hosier et al. 2017).

The unsuitability of the concession model for stand-alone solar systems links to the idea of off-grid[21] models, particularly stand-alone solar models, being more compatible with market-based approaches, and less compatible with more stringent approaches that assign specific territories for off-grid solar products. The lack of suitability of the strict concession models for stand-alone solar systems also links to the idea of how PPPs would need to be designed within integrated distribution paradigms, to be further discussed in Sections 2.6 and Chapter 7. From the above experience with electrification concessions, while key principles can be drawn in terms of how off-grid providers can be remunerated for their service and contractually obligated to electrify anyone within the service territory over a long term (usually 10-to-15-year period), more flexible types of PPPs are needed to advance SDG 7 in markets with the presence of many actors in the off-grid sector. Furthermore, these partnerships should be compatible with the specific needs and nature of the off-grid sector. A key gap in the literature on PPPs within an IDF framing is our knowledge of different variations of PPPs, to accommodate the range of models that are currently implemented in off-grid contexts. While authors developing the IDF have proposed a territorial concession in the stricter sense (Jacquot et al., 2019; Pérez-Arriaga et al., 2019; Jacquot, 2021) in many countries (including Kenya, Rwanda, Ethiopia, Togo, Sierra Leone, and Zambia) different variations of PPPs and concessions are emerging (Jacquot et al., 2021). This will be further elaborated on in the section below and in Chapter 6, which analyses emerging partnership and financing models for off-grid electrification in Kenya and Rwanda.

[21] While the IDF applies to all off-grid technologies (is not technology specific) the focus of this study is mini-grids (mostly using solar and solar hybrids) and stand-alone solar systems

2.3.2 Towards a new framing for partnerships for universal access to electricity (SDG7)

As highlighted above, while PPPs offer a workable model to deliver energy access under certain conditions, there is a knowledge gap on how variations of territorial concessions and PPPs can be incorporated into the IDF, to offer more flexibility in the design and delivery of PPPs for mini-grids and off-grid stand-alone solar solutions. This is especially important considering the dynamic nature of the off-grid grid sector, multiple actors in the sector and agility of its companies. Over the last decade, authors have emphasised the need to frame PPPs for energy access differently (Chaurey et al., 2012; Sovacool, 2013; Rehman et al., 2017; Pérez-Arriaga et al., 2019). For example, Chaurey et al. (2012) studied the role of innovation in partnerships for expanding energy access in low-income communities. Sovacool (2013) proposed a Pro-Poor public PPP, a special type of PPP, targeted at providing energy services to low-income households and communities that are usually not explicitly targeted by ordinary PPPs. The Pro-Poor PPP is characterized by a range of partners including public and private entities, MFIs, development banks and non-profit organisations, working to extend energy access and services (Sovacool, 2013). The Pro-poor PPP could be distinguished from conventional PPP models through partnerships that are explicitly targeted and tailored to meet the needs of low-income communities and incorporate additional partners like MFIs who can extend micro-loans for energy purchases and community-based NGOs (Chaury et al., 2012; Sovacool, 2013). While this definition of a pro-poor PPP highlights several actors in the off-grid sector needed to make PPP models work beyond the low-hanging fruit, in addition to MFIs, there is a need to consider other emerging financing mechanisms and models, and the ways in which these sector actors would need to work together to advance SDG 7, while advancing financial viability and sustainability objectives.

As part of more recent scholarship, authors who have applied an IDF framing to PPPs have argued for a territorial concession as the primary[22] mode and recommended approach for delivering integrated distribution models (see e.g. Jacquot et al., 2019; Pérez-Arriaga et al., 2019; Jacquot, 2021). A territorial concession could offer certain advantages for achieving the IDF objectives of inclusiveness and permanence, by contractually obligating the concessionaire[23] to electrify every household,

[22] Territorial concessions are the IDF's recommendation. Although the guiding principles of the IDF allow for different models or approaches, reports and studies on the IDF (see e.g. Jacquot et al., 2019; Pérez-Arriaga et al., 2019; Jacquot, 2021) have primarily considered territorial concessions as the primary mode for implementing the framework.

[23] Be it a private company, national utility or partnership.

commercial or industrial entity and social institution within a defined territory for a defined period (usually 20 years). However as demonstrated in the review above, mini-grid concessions have produced mixed results to date; whereas solar home systems concessions are largely regarded as unsuccessful (Hosier et al., 2017). Jacquot (2021) acknowledges that while main utility grid concessions have produced mixed results, mini-grid and solar concessions are yet to prove impactful on the African continent. This means that more consideration is needed into the design of PPPs to be able to deliver universal access where it is needed most, but in a way that is flexible to incorporate private sector business models within the PPP.

This thesis argues that there is a need for greater flexibility in the conceptualisation of partnership models, including variations of stricter concession models, within an IDF framing that can accommodate different types of off-grid business models and actors. This will be elaborated on in Chapter 6, which discusses key emerging partnership and financing models for addressing the viability gap and delivering energy access for unelectrified households and communities.

2.4 Financing electrification – closing the viability gap

2.4.1 The financing landscape for off-grid electrification

The concept of the viability gap discussed in the sections above is intricately linked with how electrification business models are financed. Successfully scaling an electrification business model cannot be done without finance that is appropriately structured for the stage of the business model growth and that is sufficient to be able to provide more households and businesses effectively and sustainably with electricity access. Furthermore, certain financing instruments like subsidies and concessional finance from DFIs can improve the financial viability for rural electrification models, which is especially needed in areas that are more challenging to electrify. This section will therefore focus on the role of electrification finance in closing the viability gap and scaling electrification business models, with a focus on the types on financing challenges and the finance required for different electrification modes.

Electrification finance remains a critical part of achieving universal access to electricity. Financing electrification in a viable and sustainable manner is challenging as the tariffs charged to customers are often not enough to cover the costs incurred to supply the power (Kojima & Trimble, 2016; Falchetta et al., 2022). There are several types of funding for off-grid electrification projects, namely, grants, private equity, commercial debt, and concessional development finance. According to Waissbein et al. (2018), commercial debt at a large scale, coupled with supportive policies and regulatory frameworks, is needed to enable the off-grid sector to scale. Public sector and donor funds are often insufficient which necessitates leveraging private sector investment (Williams et al., 2015; Pérez-Arriaga et al., 2018). Rural electrification finance is especially challenging to secure, due to the generally high-risk perception from both debt and equity funders (Phillips, Plutshack & Yeazel, 2020). Risks include project specific risk as well as investment risk and political climate. Examples of these risks are grid arrival, changes in approved tariffs, discontinuation of an operating subsidy and competition that is not regulated. A poor investment climate and perceived political risk results in projects not being able to attract the necessary investment for implementation (Williams et al., 2015; BloombergNEF & SEforAll, 2020). Often when funding is secured, it is with high interest rates and less favourable terms including shorter term debt, which makes keeping the tariff affordable, challenging. These hurdles need to be addressed through a sound policy and regulatory environment (Williams et al., 2015).

While concessionary finance from DFIs, impact investors and foundations along with supportive policy frameworks have helped to incentivise private led projects, a revenue risk still exists when serving rural and low-income end-users. If electricity consumption is too low, then mini-grid developers may not be able to recover the high upfront capital costs. Solar home system providers can expect longer payment periods and higher default rates. Ability to pay for electricity or energy services can serve as a barrier for low income customers (IEA, 2019). Affordability of systems thus needs to be strongly considered and addressed in and IDF framing to realise the IDF pillar of a *commitment to universal access and leaving no-one behind.*

However, even with cost reduction mechanisms in place, the viability gap will not be reduced completely. Pérez-Arriaga et al. (2018) argues that donor funding is useful to cover the viability gap for smaller projects but does not translate to a truly scalable solution. Private sector companies, some of whose models operated outside tariff regulation (e.g., solar home system companies), can liaise directly with customers for basic service provision, i.e., solar home systems providing lower tiers of service. Other entrepreneurs offer certain products or energy services at a cost just enough to displace the cost of kerosene or candles.

There are several types of subsidies. Subsidies can be provided directly to households to reduce the tariff or to project developers in the form of Capital Expenditure (CAPEX) grants or concessional finance (IEA, 2019). Subsidies can be in the form of a once-off CAPEX subsidy or a continuous tariff subsidy. Careful consideration of the potential implications of each of these approaches is needed when designing electrification programmes that encourage private sector investment (Williams et al., 2015). The IEA (2019) highlights that regardless of the type of subsidy in place, subsidies need to be consistently applied and targeted well.

A particular challenge with an on-going or continuous subsidy is long term sustainability and the threat that the subsidy could be discontinued (Williams et al., 2015; Perera, Johnstone & Garside, 2020; Ketelaars & Wheeldon, 2021). Potential risks with a continuous subsidy is that it will not be honoured for the period agreed on or that it will be withdrawn. If this regulatory uncertainty happens where there is freedom to set the tariff, then developers will set higher tariffs to recover their investments more quickly over a shorter space of time. If the tariff is completely regulated then it will serve as a disincentive for investment (Pérez-Arriaga et al., 2018). So regulatory bodies have a key role to play in ensuring that the tariff enables cost recovery and a return while keeping the tariffs affordable for end users.

Long-term finance is a critical part of electrification finance considering the long-term capital-intensive nature of rural electrification projects. In Sub-Saharan Africa, long-term finance is constrained and difficult to access. The sector is highly reliant on international development finance, which exposes project developers, utilities and governments to currency risks caused by currency fluctuations (IEA, 2019; BloombergNEF & SEforAll, 2020). This necessitates the development of the local financial sector, to be able to provide long term finance for power projects. Although access to finance from local banks has increased in the last decade, it still does not compare favourably with other developing economies.

2.4.2 Emerging financing models: results-based finance (RBF) and blended finance

The sections below discuss two emerging financing models, namely RBF and blended finance. RBF has emerged as an important instrument for financing off-grid electrification including mini-grids and solar home systems and is now one of the dominant funding instruments available. Various international development agencies have introduced RBF programmes with incentives for off-grid companies to expand energy access and serve more unelectrified customers, including the United Kingdom Foreign

Commonwealth and Development Office (FCDO),[24] the World Bank and EnDev (EnDev, 2021; TEA, 2022). Within the literature there is both increasing support for RBF as an energy access financing mechanism (Hüls et al., 2017; Phillips, Attia and Plutshack et al., 2020; SEforAll, 2022) but also a realisation that RBF should not be viewed as a panacea for energy access challenges (Johnstone & Garside, 2019). SEforAll (2022) argues that RBF provides an alternative to some of the existing models of procurement in energy access projects and is a model which has shown the ability to provide connections more efficiently and at a greater speed. Through this approach, governments and donors provide grant finance to private sector developers, and the private sector is paid on delivery of connections. In this model, risk is essentially shifted to the private sector, while incentives for connections are provided. However, Johnstone & Garside (2019) argue that the effectiveness of RBF in serving the intended hard-to reach markets would still need to be tested. They contend, 'It remains to be seen whether RBF stimulates sustainable energy access delivery to target markets, as opposed to delivering short-term access to the wealthiest citizens (Johnstone & Garside, 2019: 2).

A key consideration when looking at RBF financing is how it influences the risk pathways of energy projects and the respective risks for different sector actors (Hüls et al., 2017; Stritzke et al., 2021). As highlighted in the section above, risks are shifted from project funders to implementers, while the funder would still be exposed to a reputational risk if the projects are unsuccessful (Hüls et al., 2017). While this places the onus on the private sector to deliver results before disbursement and could incentivize greater accountability and performance, it still leaves a gap in the financing pipeline where private sector actors would be required to obtain other forms of finance to enable project operations to be able to deliver results. This often leads to delays in getting projects off the ground if the private sector is not able to secure the pre-financing required (EnDev, 2019, 2021). This again is a key consideration when developing financially inclusive models as part of an IDF framing that can reach households and segments of the population that are ordinarily harder to reach.

In addition[25] to RBF, blended finance is used as a tool to leverage public sector finance to attract additional private investment for off-grid energy access projects (Tyabji, de Cointet & Levinson, 2018; Johnstone & Garside, 2019). Leveraging public funds with the support of international donors and development partners can facilitate greater private sector investment into the sector, and investors

[24] Previously Department for International Development (DFID)
[25] Blended finance can also include RBF combined with other types of finance e.g., debt.

are thus advocating for blended financing instruments to de-risk and multiply private sector investment (Gomes, 2018). Gomes (2018) argues that to meet the funding needs required by energy enterprises in Africa achieve SDG 7 by 2030, larger, and more flexible blended finance vehicles are needed to provide early-stage funding at the scale needed. This type of blended finance can crowd in private capital and is important considering the move towards PPPs, and large-scale government and donor led projects. This model of finance is used in the KOSAP project in Kenya, where debt and grant finance are blended to reach underserved counties, which will be further elaborated in Chapter 6 (Martijn & Desiderato, 2021). Another example of combining RBF finance with commercial debt is SunFunder who provided a loan of USD 1.2 million to electrify a tea plantation in Kenya where the mini-grid company PowerGen was already part of an RBF programme which would provide 30% of the CAPEX on commissioning and operation of the mini-grid (BloombergNEF & SEforAll, 2020).

In 2019 SunFunder, a financial intermediary, closed on a US$42.5 million raise on a structured energy fund, which was one of the largest single raises at the time. SunFunder also served as one of the fund managers along with Netherlands Development Organisation (SNV)[26], for the RBF finance programme in the KOSAP project in Kenya, which will be elaborated on in Chapter 6. Another recent example is where OnePower Lesotho closed a deal in 2022 to develop a portfolio of 11 mini-grids with a total capacity of 1.8MW with funding from the EU- funded Electrification Financing Initiative (EDFI ElectriFI) and the REPP. Once completed this project envisages to provide electricity access to 20 000 people and seven health clinics (OnePower Lesotho, 2021). Blended finance as a form of aggregation is thus gaining traction as one of the models that can advance energy access and facilitate more scalable models for off-grid electrification, to achieve objectives of the IDF, particularly pillar 4.

The sections above have highlighted some key considerations for financing off-grid electrification and have established that to scale off-grid grid projects larger volumes of finance are needed. The sections have discussed the different types of finance including, grants, debt and equity, and that larger volumes of low-cost commercial debt are needed to scale the sector, albeit difficult to obtain for many off-grid solar companies due to the perceived and substantive risks in a nascent sector. The sections also emphasised the importance of a long-term perspective on finance for scaling the sector, beyond initial grant funding and the need to develop a local financing ecosystem to enhance the longer-term sustainability of projects. These are all key considerations for IDF sub-pillar *external finance*, as it

[26] Original founded as *Stichting Nederlandse Vrijwilligers*, a volunteer organisation in the Netherlands.

highlights key challenges and sustainability requirements for viable off-grid business models, as the sustainability of finance models also has a bearing on the level of *permanence* that can be achieved. It furthermore highlighted the key emerging models for financing off-grid electrification including aggregation and blended finance as well as results-based finance for scaling the sector. The next sections will examine more specific financing considerations for mini-grids and stand-alone systems.

2.4.3 Financing for mini-grids and stand-alone solar systems

Financing for mini-grids and stand-alone solar systems is important to review as these are the key technology foci areas of this study. This section will first discuss financing for mini-grids and stand-alone solar systems used to finance off-grid projects and the viability gap. Finance for mini-grids broadly includes grants, equity and debt (see Figure 2).

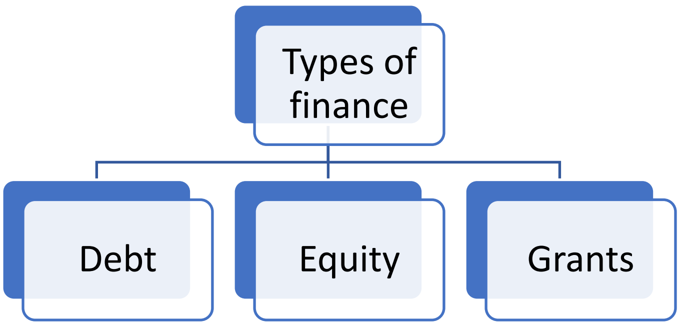


Figure 2: Types of finance – Author's figure (SEforALL and BloombergNEF, 2020)

Grants, blended with equity, are the most common form of funding for mini-grids (BloombergNEF & SEforAll, 2020). Grants are usually in the form of RBF or finance from host governments through DFI finance. Grants are typically used to fund part of the CAPEX and are not required to be paid back. However, these grants usually only cover a portion of the CAPEX and are competitive, with developers having to compete for funding (BloombergNEF & SEforAll, 2020). Grants have been the predominant mode of financing mini-grids to date. Of the 50.9 million US dollars disbursed to mini-grid developers[27] between 2013 and 2019, almost 80% came from grants (BloombergNEF & SEforAll, 2020). The dependence on grant funding can be attributed to the nascent nature of the mini-grid sector, where

[27] Grants and loans are not always directly disbursed to mini-grid developers. The funding mini-grid developers receive may only constitute a small percentage of the funds disbursed to public sector agencies (BloombergNEF & SEforAll, 2020).

business models are still being tested and scalable models have yet to be proven. Grants for technical assistance and off-setting part of the CAPEX can enable mini-grid developers to set up mini-grids.

Mini-grids are capital intensive in nature and in addition to grant funding, require debt and equity finance; and many find it challenging to raise either (Bardouille, 2012; Williams et al., 2015). The capital intensiveness increases the long-term revenue risks as large sums are invested for projects that may break even in the long term (usually 7 to 10 years), with the possibility that revenues will not be recovered if the project fails before the project breaks even (Williams et al., 2015). Equity finance involves private developers selling a percentage share in their company or mini-grid project to private investors to raise capital. In some cases, mini-grid developers will invest their own money from their balance sheet (BloombergNEF & SEforAll, 2020). As many private equity investors are cautious to invest in mini-grids particularly at the early stages, equity investments are not easily obtainable and commercial debt is out of reach of many early stage mini-grids Lepicard et al. (2017). According to BloombergNEF & SEforAll (2020) equity may be easier to access than grants and debt. This, however, may vary from developer to developer as those with better balance sheets and track records of projects may have a greater buy-in from early-stage investors.

With respect to debt finance, investors expect a return on investment in the form of interest payments and require minimising risk (BloombergNEF & SEforAll, 2020). According to Lepicard, et al. (2017) these risks of long-term investment may be attributed to competing with the grid, regulatory uncertainty, technology risks and low customer demand. With debt finance, developers are required to service their loan repayments regardless of whether the mini-grid performs well or not, and to repay monthly debt commitments before returns for equity investors. At present, commercial debt finance is lacking in the mini-grid sector and debt finance is mainly provided through concessional loans from DFIs, impact investors and foundations (Lepicard et al., 2017; Waissbein et al., 2018; BloombergNEF & SEforAll, 2020). Concessional debt however is usually provided to governments for larger scale electrification projects, of which mini-grids may be a part, and not directly to mini-grid companies, which can be seen in the case of the Kenyan KOSAP programme which is funded by a concessional loan from the World Bank (ESMAP, 2017).

Mini-grid financing can either be structured as corporate finance or project finance. Corporate finance refers to companies making use of cash available and existing credit lines to finance a project or raise additional equity or new credit lines (Yescombe, 2013). Corporate finance can be suitable for all types of mini-grids including smaller mini-grids. Financing mini-grids through corporate finance is usually less expensive and less time consuming, and investors can spread their risks across multiple projects (AfDB, 2016). Project finance is a long-term finance option (usually 15 – 25 years) that relies on the predicted future cashflows of a project to pay its debt and is carried out through a 'special purpose legal entity' whose only business is the project (Yescombe, 2013). Project finance may be suitable for larger mini-grids or clusters of smaller mini-grids with anchor clients, with long term revenues relatively secured, and is more commonly used in large scale utility projects (AfDB, 2016; BloombergNEF & SEforAll, 2020). Most mini-grids, however, do not have predictable cash flows to work for project finance, or ticket sizes that are large enough to justify the high capital costs and due diligence. Project finance loans under $20 million could be challenging to justify as the fixed costs are high, although loans of $5 – $10 million have been considered (AfDB, 2016).

As discussed in Section 2.2.4 subsidies play an integral part in making mini-grids viable and more affordable for end-users especially when serving end-users with low incomes. In relation to the point on grant finance, a subsidy can be in the form of a grant but can take different forms. There are different types of subsidies that can be used for mini-grid projects and these include CAPEX and Operational Expenditure (OPEX) subsidies. CAPEX subsidies are subsidies that offset some of the upfront costs paid during construction or during the project. OPEX subsidies offset some of the operational costs that are paid over time (Melnyk & Kelly, 2019; BloombergNEF & SEforAll, 2020). In addition to types of subsidies, Melnyk & Kelly (2019) distinguish between *input* and *output-based* subsidies. This is useful in quantifying the amount of subsidy required. Input-based subsidies are usually a percentage of the project input costs, while output-based subsidies are linked to certain performance-based metrics (e.g. RBF) where developers are compensated based on a certain number of connections. RBF is increasingly recognised as an important piece of the off-grid financing puzzle for mini-grids and a way to close the viability gap. According to Phillips, Attia & Plutshack (2020), RBFs hold considerable promise as a market mechanism for mini-grids in Africa, and have proven to be effective in other sectors. The above discussion on subsidies and RBF finance also draws an important link between the IDF principles of inclusiveness and external finance. The IDF is premised on being able to electrify the most difficult areas and extend energy access to all households/ communities and appropriate financial models which include subsidies play an integral role in this regard.

Linking RBF to the IDF, Nagpal & Pérez-Arriaga (2021) acknowledge that RBF is gaining traction through facilities like the UEF, taking more prominence in the mini-grid financing space (see Section 1.2). They also note that many of these models go hand in hand with a *light-touch*[28] regulatory approach and have enabled the deployment of mini-grids more quickly. They, however, contend RBF models do not ordinarily ensure the long-term sustainability of mini-grids or the permanence of finance. Here they argue that combining the traditional RBF models with IDF approaches could produce the best of both worlds. While Nagpal & Pérez-Arriaga (2021) provide recommendations and scenarios of how mini-grids could be considered within an IDF framing, this thesis builds on this through an empirical analysis of RBF programmes in Kenya and Rwanda (see Chapter 6). This thesis explores the challenges and opportunities for RBF programmes within IDF paradigms and uses the IDF as the framework through which RBF programmes can be placed within the broader IDF objectives. For example, it considers *inclusivity* and *permanence as well as financial viability of business models* and how RBF subsidies would need to be designed to facilitate these objectives.

CAPEX subsidies are often preferred by mini-grid developers as they reduce the initial investment and align with the cost- structure of mini-grids, which require substantial investment in electrification distribution and generation equipment. The insufficiency of public funding for electrification limits capital subsidies. However, the use of public funds to provide capital subsidies would enable limited public funds to go further by combining it with private sector investment (Williams et al., 2015). Thus, more public funding is needed in tandem with international development financing and private capital to help leverage more private funding. This also links to IDF sub-pillar 3 on *external finance* needed to develop viable electrification business models.

Turning to off-grid solar systems, the off-grid stand-alone solar sector faces unique financing challenges related to the value chain, particularly the complexity that consumer finance adds, and finance is considered as a significant barrier for off-grid market development and the diffusion of solar (Diecker, Wheeldon & Scott, 2016; Lighting Global, Global Off-grid Lighting Association [GOGLA] & ESMAP, 2020). For example, the PAYG model, which often involves vertically integrated[29] value chains, combines consumer finance with product design, distribution, and software platforms (Bardouille, 2012; Lighting Global, GOGLA & ESMAP, 2020). Most PAYG companies therefore serve several functions in one business model, merging technology provision with consumer finance. Not only do

[28] A light touch regulatory approach refers to an approach with minimal regulation or a more 'hands-off' approach from regulators provisions for simplification of licensing, tariff approvals etc. in the case of mini-grids
[29] Some companies have vertically integrated value chains where a single company would get involved be involved in every stage of the value chain from R&D through to consumer finance.

companies need to obtain capital for product development, manufacturing, and operations, they also need to manage the working capital requirements and accounts receivable. There is a move where some companies are only involved with some aspects of the value chain e.g., distribution and consumer finance, but consumer finance often remains a key part of most PAYG business models (Lighting Global, GOGLA & ESMAP, 2020). One of the key challenges many off-grid solar companies face is that customers pay over a period and must manage the risk of non-payment. This goes hand in hand with credit assessments and is an important consideration when serving low income unelectrified households and customers who do not have regular sources of income.

For off-grid solar companies Lighting Global, GOGLA & ESMAP (2020) distinguish between three different types of grants: grant windows, RBF and reward-based [30]crowdfunding. Similarly, Diecker, Wheeldon & Scott (2016) highlight that seed funding (i.e., grants), equity and debt are all needed to close the investment gap needed to fund the unmet demand for electricity access. To date, finance has mainly been in the form of grants and debt facilities by impact investors and development finance. Like mini-grids, commercial finance is yet to be a key part of the sector, except for smaller investments from local banks through Small Medium Enterprise (SME) finance (Lighting Global, GOGLA & ESMAP, 2020). Local currency credit is also particularly challenging to access. Grants play a particularly important role during the start-up phase where companies find it challenging to raise commercial finance. Grant windows are usually coupled with a specific focus or objective, e.g., serving last mile entrepreneurs and have specific dates by which applications need to be made. Grants enable companies to carry out projects that are higher risk, but that can serve as a catalyst for market development within the specific segment of the market that is targeted (Lighting Global, GOGLA & ESMAP, 2020). In the context of this study such catalytic funding is needed to for off-grid companies to reach beyond the low hanging-fruit, and serve more challenging markets, as universal access means building businesses that can sustainably serve the unreached more challenging to electrify market segments.

In the off-grid solar market, RBF is also recognised as an important mechanism for delivering grants and is an approach many international development partners like the FCDO, EnDev and the World Bank use to channel money into the sector. There are several benefits but also challenges associated

[30] Reward-based crowdfunding is a crowdfunding model where funders are offered a reward in the form of a product, service or token at the end of a successful campaign.

with RBF for off-grid solar. Looking at the advantages, RBF can incentivise off-grid development faster by improving affordability, especially when the end-users are paid the incentives. RBF can further serve to stimulate investment from other financiers in renewable off-grid technologies as commercial viability increases and affordability for end-users. Another important advantage, which is key in the context of this study, is the ability of RBF to direct the market to attract companies to underserved communities, allowing development organisations to direct their finance into specific geographies, particularly in areas where off-grid companies are not ordinarily be incentivised to invest (Lighting Global, GOGLA & ESMAP, 2020). This could in part address some of the challenges with off-grid solar business models highlighted in Section 2.2.3 above, where off-grid providers are concentrated in certain geographic and socio-economic clusters of the market. This would also enable off-grid investment to be spread out more evenly across different geographies, not excluding those in lower income segments who need affordable access to electricity the most.

The section above discussed key financing mechanisms for mini-grids and stand-alone solar systems. The section showed that grant finance is typically needed to finance these off-grid technologies and models and that options like RBF has been increasingly prominent as one of the ways to finance off-grid systems and the viability gap, by requiring results before funds are disbursed. It also showed the challenges of financing models including RBF and the need for sustainability and continuity in the financing pipeline. *External finance* is a key sub-pillar of the IDF, and within the requirement to provide an energy service that is long term and lasting, suitability and sustainability of finance is key. A key gap in the literature on financing models, presented above, is how combinations of grants (including RBF), equity and debt, and blended finance variations can be effectively incorporated into an IDF framing. Particularly, with this study's focus on RBF as one of the financing models used in both Kenya and Rwanda for mini-grids and stand-alone solar systems, an in-depth inquiry is needed into how such financing programmes and models can effectively be integrated into an IDF paradigm. Importantly, this study explores how RBF needs to be complemented with other types of finance, including other types of public, private and donor finance to strengthen the financing ecosystem.

2.5 Regulation for Energy Access

Business and partnership models require a well-suited regulatory environment to attract investment, manage risks appropriately and facilitate the objective of universal access. Considering the dynamic nature of off-grid markets, regulation needs to be suitably flexible and sufficiently robust for the type of technology (i.e., mini-grids and off-grid solar systems) and tailored to the structure of the off-grid markets. Section 2.5.1 will start by defining the role and function regulation in the context of energy access and then discuss specific regulatory considerations for mini-grids and off-grid solar systems in Sections 2.5.2 and 2.5.3.

2.5.1 Defining regulation for energy access

Off-grid energy providers do not operate in a vacuum and their operations are dependent on appropriate regulatory models. Pérez-Arriaga (2016) highlights the importance of regulatory models for energy access. Firstly, regulation gives the private sector confidence to invest in electrification, for example, by allaying fears of stranded assets and the loss of business because of the arrival of the grid (BloombergNEF & SEforAll, 2020). Secondly, regulation is responsible for establishing tariffs and necessary compensation mechanisms, thereby enabling the economic viability of supply companies (Bhattacharyya & Palit, 2016; Pérez-Arriaga, 2016; BloombergNEF & SEforAll, 2020). Thirdly, regulation should facilitate compatibility between centralised and distributed systems and the joint participation of multiple market players including incumbent utilities, and large and small private sector providers. Pérez-Arriaga (2016) further notes that in developing countries, context specific and relevant regulatory measures need to be applied and implemented by credible institutions. In this regard Pérez-Arriaga (2016) calls for the regulatory approaches employed in mature electricity markets, to be reinvented and tailored for local developing country contexts.

According to Brown et al. (2006) regulatory systems comprise the institutional governance of operation and investment in infrastructure, and the laws and procedures guiding this. Regulation is important for achieving universal access to energy as it:

- Gives the private sector confidence to invest in electrification, by allaying fears of stranded assets and the loss of business because of the arrival of the grid.
- Is responsible for establishing tariffs and necessary compensation mechanisms, thereby enabling the economic viability of supply companies.
- Should facilitate compatibility between centralised and distributed systems and the participation of multiple market players including national utilities, and large and small private sector providers (Pérez-Arriaga, 2016).

This is important as grid and off-grid solutions need to effectively co-exist, but are often competing, with national utilities usually entirely responsible for grid extension, and private sector companies implementing mini-grid projects or selling solar home systems (Pérez-Arriaga, 2016). Brown et al. (2006) distinguish between regulatory governance and regulatory substance. Regulatory governance refers to the legal design and institutional arrangements of regulatory system and processes of regulatory decision-making, which has a bearing on credibility, legitimacy and transparency of regulatory decisions. Regulatory governance deals with the *how* of regulation. Within hybrid power markets structures in Sub-Saharan African, regulators not only have to consider the pricing but also ensure the reliability of services, the viability of utilities and the creation of favourable conditions to attract investment into the sector. The governance of regulation deals with the institutional and legal frameworks that can facilitate independent regulatory decision making and enable these goals to be achieved. A legal framework is therefore required that clearly identifies roles and functions with respect to independence in decision making and financial and managerial aspects (Brown et al., 2006; Kapika & Eberhard, 2013). This is discussed in more detail in Chapter 4 which details the case study contexts for the study and the regulatory institutions.

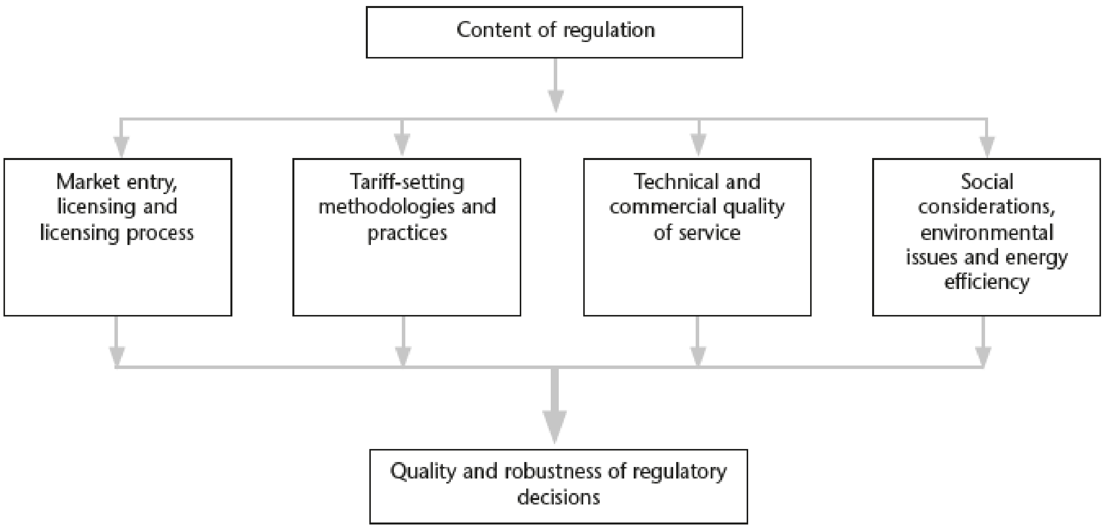


Figure 3: Content of regulation applicable to energy access (Kapika and Eberhard, 2013)

Regulatory substance on the other hand (see Figure 3) relates to the content of regulation including licenses, tariff supply and service standards (Kapika & Eberhard, 2013; USAID, African Union & Power Africa, 2020). Regulatory governance and substance jointly have an impact on pricing, the competitiveness of pricing, reliability of infrastructure services, financial viability and new investment in the sector. As the electricity supply sector is a natural monopoly, regulatory interventions are necessary to protect the interests of consumers with respect to fair tariffs and the quality of service, fostering competition, ensuring competitive pricing and market entry of new entrants, in the energy supply value chain. Regulators play an important role in tariff setting, particularly as tariffs under monopolistic conditions are susceptible to profit maximising on the part of distribution utility. Furthermore, in the context of increasing energy access in Sub-Saharan Africa, regulation plays an important role in role in enabling low-income households to access electricity through interventions like lifeline tariffs and other subsidy mechanisms (Kapika & Eberhard, 2013). The above elements of regulatory substance, i.e., tariff setting and licensing are both key considerations for off-grid energy access models, particularly for off-grid mini-grids, and as will be elaborated in Sections 5.2.1and 5.2.4. These regulatory considerations also play a key role in IDF pillars particularly *permanence* and a financially viable business model. Mini-grids in particular require clarity and a degree of certainty, without which developing a business model can be challenging. For example, in Tanzania, a changing regulatory environment resulted in mini-grid developers being required to charge the national uniform tariff (without a consistent subsidy to fill the gap) which had adverse implications for private mini-grid development and investment into the mini-grid sector as mini-grid developers were not able to recoup their costs and in some instances had to close their mini-grid sites (Zigah, Barry & Creti, 2023). In certain instances, tariffs are significantly below the cost of service, and in other instances tariffs are quite high in relation to the quality of service provided. The section below will delve into specific regulatory considerations for mini-grids and stand-alone solar systems.

2.5.2 Regulation for mini-grids

A key question when looking at regulation for mini-grids is, 'how much is enough'? Regulating off-grid mini-grids, as with other off-grid technologies, requires an intricate balance between regulation that is: (i) sufficiently robust to provide protection for end-users in terms of the tariffs charged and quality of service, and (ii) provide private sector mini-grid developers and their investors the required security and confidence that their investments would be secure. This requires reducing competition with the grid through demarcated areas for mini-grids as well as guidelines and compensation in the event of grid arrival (Bhattacharyya & Palit, 2016; Pérez-Arriaga, 2016). Regulation can furthermore allow for mini-grid developers to be part of regulated regimes where they could be eligible for cross-subsidisation if they charge a regulated tariff. A further consideration is the quality of service provided at the reduced tariff. Regulators also face the consideration of whether a lower quality service should be provided at the reduced tariff. This however could be regarded as discrimination (Maphosa & Mabuza, 2017). Striking the right balance between over-regulation and a regulatory approach that can advance SDG 7 and facilitate private sector participation for off-grid electrification, is challenging to achieve as off-grid markets in different sub-Saharan Africa countries have unique contextual factors that need to be considered. While key principles for sound regulation can be drawn on, each country would need an approach that works for the specific dynamics[31] of the off-grid sector and specific goals for off-grid electrification.

There are two main schools of thought emerging from the literature. On the one hand a *light-touch* regulatory approach would entail minimal regulation for private sector mini-grid developers, where the licensing approach is simplified or involves non-regulated tariffs (Bhattacharyya & Palit, 2016; Waissbein et al., 2018). This type of regulation could be seen as advantageous as it would be less onerous on private developers and enable them to move with the necessary speed while allowing flexibility to test different business models, including customer payment models (Waissbein et al., 2018). For example, USAID, African Union & Power Africa (2020) outlines various tariff setting methodologies and highlights how counties like Zambia and Nigeria apply both an individualised cost based tariff and a willing buyer-willing seller model. In the former case the regulator determines a tariff required for cost recovery, dependent on each individual mini-grid ,which would apply to all customers/households of that mini-grid and in the latter, the mini-grid developers would need to negotiate the tariff with end-users. In Kenya, for example, both a uniform tariff to government owned mini-grids as well as an individualised cost based tariff that is subject to regulatory approval is applied. However, this light touch approach would not afford private developers the required certainty of a concession and would also not provide cross-subsidies that regulated regimes may offer. This implies having to charge higher tariffs that are closer to cost reflective tariffs, which could be a problem with affordability especially among low-income and income constrained households. Developers would need to find other ways of closing the gap (e.g., through grants discussed above).

On the other hand, a *heavy-touch* or comprehensive approach to regulation could entail a concession[32] and regulated tariff. This could also entail more intricate licensing approaches to apply for a concession and charging a tariff that is closer to the grid tariff, which is usually not cost reflective. However, such approaches may also offer subsidies to account for the lower tariff (Waissbein et al.,

[31] This could include the number of off-grid private sector developers, and whether a ‘free market’ open approach to mini-grid development is in place or if certain providers are granted concessions for certain geographic territories.

[32] While this approach could entail a concession it is not necessarily the case

2018). Concessions can offer more certainty against grid arrival, by providing a potential exclusive concession, giving private developers the right to develop mini-grids over a specified time period and make allowance for compensation in the event of grid arrival. This certainty could in turn be used to attract more debt financing (Waissbein et al., 2018). Conversely, there is a caution that regulation that is too onerous may have the exact opposite effect. If regulation is excessive, too stringent or poorly administered, it could have the effect of stifling investment in the sector and resulting in unforeseen delays which create extra cost (Tenenbaum et al., 2014).

In practice, regulatory approaches may fall somewhere in between the light and heavy touch approaches described above. For example, there could be a regulated tariff for mini-grids without a strict concession. In Kenya for example, mini-grid companies are required to obtain regulatory approval for tariffs charged to customers, which don't have to be the grid tariff, but do not strictly follow a territorial concession approach, as only one company, Power Hive, has been granted a concession thus far. Bhattacharyya & Palit (2016) argue that mini-grids cannot be advanced in a regulatory vacuum and regardless of whether a light-touch or more comprehensive regulatory approach is chosen, all forms of regulation should (i) facilitate clarity about service areas or territories, (ii) provide protection for investors against grid extension (iii) ensure quality and reliable levels of service, (iv) facilitate transparent flow of information and (v) financial sustainability thought the tariff (and subsidy support). Considering the above, they do however recommend a light-touch approach which involves minimal supervision but provides clarity with respect to the service areas and the tariffs charged, with suitable service standards. It is also worth noting that while Bhattacharyya & Palit (2016) refer to the *light-touch* approach, they conceptualise a light touch approach in a way that is slightly more robust than the UNDP definition above. In this way, elements of a light- touch approach can be enhanced through mechanisms that build in more robustness and provide the private sector and end-users necessary protection and assurance of minimum levels of quality of service.

2.5.3 Regulation for off-grid solar systems

Similar to mini-grids, regulation also plays a key role in advancing the deployment of off-grid solar systems. While the purpose of regulation for off-grid stand-alone systems is similar to mini-grids in terms of providing clarity to the sector and favorable conditions for different market actors, and ensuring quality levels of service for end-users, in contrast to mini-grids, solar home systems require different degrees or types of regulation to mini-grids. According to GOGLA (2017) regulations for off-grid solar products are needed to provide clarity on market entrance and exit, provide for minimum quality standards, subsidies and duty exemptions to support the diffusion of off-grid solutions.

From the above, appropriate regulatory frameworks allow the benefits of the technological advances of off-grid solar stand-alone to be maximised. According to the Regulatory Indicators for Sustainable Energy (RISE)[33] scorecard for developing off-grid solar, countries are rated highly for favourable regulatory environments if:

a. A national programme is in place that promotes the adoption of stand-alone technologies;
b. Subsidies or duty exemptions are provided;
c. There are no legal restrictions on the price stand-alone system retail providers can charge;
d. International quality standards are formally adopted (GOGLA, 2017).

Shifts to combinations of private sector led off-grid business models in tandem with government and donor led private sector approaches, are increasingly needed to close the electrification gap, having a national electrification programme that drives the adoption of off-grid solar at a larger scale is useful as a key policy and regulatory approach to drive the adoption of solar (GOGLA, 2017). Several countries have incorporated off-grid stand-alone solar into their national electrification programmes including Kenya, Rwanda, Togo and others. In Kenya off-grid solar systems are part of the national Kenya Off-grid Solar Access Project (KOSAP) (IEA, 2017), which involves an RBF grant window for Kenyan solar companies to provide off-grid products to off-grid counties. In Togo for example, BBOXX entered into a partnership with the French Utility, *Électricité de France (EDF)* to promote the distribution of off-grid solar at a much larger scale, with a focus on solar irrigation to stimulate productive uses of electricity (BBOXX, 2020).

Subsidies, as highlighted in Sections 2.3 and 2.4, are an integral part of closing the viability gap and improving affordability of systems for end users. Duty exemptions are particularly useful as part of an enabling environment for off-grid stand-alone solar. For example, Kenya's light touch approach with favourable regulatory environments for off-grid solar companies has contributed to the rapid diffusion of off-grid solar systems (Hansen, Brix & Nygaard, 2015; IEA, 2017), contributing to Kenya being the leading market for off-grid solar products in East Africa and the Continent. Such exemptions are also important tools in closing the affordability gap by reducing the costs of importing products and enabling off-grid companies to pay lower prices (Diecker, Wheeldon & Scott, 2016). However as

[33] The Regulatory Indicators for Sustainable Energy Global Scorecard for Policymakers (RISE) ranks 55 countries, where access deficits exist, on eight core indicators for energy access

Rehman et al. (2017) point out mechanisms should also be in place to ensure that the subsidies or benefits companies receive through tax exemptions are actually passed to the end user and that they can benefit from more affordable energy services.

Regarding the third point on not regulating the price of off-grid solar, while this is cited as a favorable regulatory condition (GOGLA, 2017), caution is required as a complete lack of oversight into the prices for off-grid solar systems could lead to end-users being overcharged in comparison to the level of service these off-grid solar systems can provide. While companies need to be able to cover the costs of off-grid systems associated with manufacture or import, distribution, payment platforms and consumer finance, and make a profit over time, end users also need to be cushioned against arbitrarily high prices. There may be instances where solar home systems are priced higher or on par with mini-grid or grid tariffs but offer a lower level of service (Pérez-Arriaga et al., 2019). This is especially important for low-income unelectrified and under-electrified households. This also links to the idea of how institutional oversight of the actors in the off-grid sector links with regulation and raises the question of what role regulatory and other institutions might need to play going forward, within more integrated electrification paradigms. This relates strongly to the IDF pillars where strong institutional oversight is a key tenet of *achieving universal access and leaving no-one* behind and *how efficiently grid and off-grid technologies are integrated*.

Quality standards are an essential part of the regulatory environment for off-grid solar. As previously mentioned above, in addition to favorable subsidies for off-grid solar products, regulation of solar products through quality standards is a key aspect of promoting quality products and gaining trust in the market (Hansen, Brix & Nygaard, 2015). Several countries (notably many in East Africa) including Kenya, Uganda, Ethiopia and Rwanda have adopted quality standards, as a minimum mandatory requirement in Kenya and Uganda, and on a voluntary basis in Ethiopia and Rwanda (Diecker, Wheeldon & Scott, 2016). More recently Rwanda has adopted minimum standard requirements for off-grid solar products, requiring a certain basic tier of service (partly aligned with ESMAP's service tiers) but beyond that imposes certain minimum service levels in terms of the number of hours of lighting, and being able to power certain appliances (EnDev, 2019).

The above shows that for off-grid electrification sound regulatory principles need to be in place to facilitate off-grid solar diffusion, but examination of the literature demonstrates that a one size fits all approach cannot be used. Advancing energy access needs to balance robust regulation, with the benefits of light touch approaches. Exactly how that balance needs to be stuck, particularly within the context of more integrated distribution paradigms (as set out in the IDF) is an area of further enquiry through an empirical investigation, in Chapters 5 and 8.

Sections 2.2 to 2.5 above highlighted key considerations for business models, viability, financing and regulation for mini-grids and off-grid stand-alone systems, in relation to the IDF as the key conceptual framework for the study. Regulation, appropriate financing mechanisms to address the viability gap, flexibly designed PPPs for mini-grids and stand-alone systems are key aspects of achieving the universal access objectives and the business models that can support the achievement of these objectives. Careful consideration is thus needed in the design of the business and partnership models that will be used to achieve universal access objectives, the suitability and sustainability of financing and the type and design of subsidy mechanisms that will be used to fill the viability gap. Within a mix of market-led and subsidy-led paradigms off grid PPP models combine, a balance between inclusivity and viability objectives should be maintained, to advance inclusivity and viability objectives when working towards universal access targets. Section 2.6 below highlights some of the key gaps and findings in the literature.

2.6 Conclusion: Towards the operationalisation of the IDF for off-grid partnership and financing models

The literature review first sought to conceptualise business models and position mini-grids and stand-alone solar business models in the framing of the IDF, also considering emerging PPP models for these off-grid technologies. Section 2.2 introduced key definitions and concepts of the IDF, with a primary focus on business models and the viability gap. As highlighted above the IDF framing integrates important aspects of the business model, financial and regulatory arrangements needed to provide energy access, with key principles of (*1) a commitment to universal access (*2) *efficient and coordinated integration of on-grid and off-grid solutions*, (3) *a financially viable model and (4) a focus on development*. The literature review has highlighted key insights on the theoretical framing of the IDF and research questions, but also key gaps. These will be summarized below. Section 2.2.3, discussed specific business model challenges for off-grid stand-alone systems and mini-grids. Affordability was identified as a key barrier impacting the viability gap of off-grid stand-alone systems and mini-grids. A gap identified in the framing of inclusivity in the IDF is the need for greater emphasis on *affordability* coupled with *geographic inclusivity* as shown in Figure 4 below. Figure 4 below presents the IDF framework (first presented Section 2.2) with additions to framework, informed by the literature review, shown in the dark blue blocks below. These include affordability and geographic inclusivity for under the sub pillar of *inclusiveness*, the need for the mix of grants, equity and debt and RBF finance as a tool to scale off-grid solar systems.

For off-grid stand-alone models, off-grid companies in Sub-Saharan Africa, including Kenya and Rwanda, find it challenging to build sustainable business models and to be adequately incentivised to venture out into the more challenging areas. Many companies have catered for households and regions where ability to pay is higher and sales have been concentrated in certain market segments that have been relatively easier to electrify. For mini-grids, developing viable and scalable models for mini-grids is still challenging due to regulation and recovering costs. From the literature, affordability is a crucial aspect of the viability gap for both mini-grids and stand-alone solar systems, and therefore needs to be addressed to develop inclusive energy access models. In the IDF, the first pillar *universal access (i.e., inclusiveness)* specifies an entity (public, private or PPP) for delivering energy access within designated territories. While a designated service provider under a stricter territorial concession addresses *geographic inclusivity*, there is a knowledge gap on the incentive structure to steer private sector off-grid investment and operation into regions that are harder to electrify, when variations to concession models are used. This study helps to address this knowledge gap, through an empirical enquiry of Kenya and Rwanda in Chapters 5 and 6.

The literature called for new and more integrated approaches to PPPs and off-grid development and that more flexible PPPs would be needed to account for dynamic off-grid models that would need to be integrated into an IDF paradigm. A gap identified in the literature is how existing off-grid private sector business models and PPPs would need to be adapted to be integrated into an IDF framing. One of the key modalities for achieving the objective of a *commitment to achieving universal access* (i.e., *inclusivity* and *permanence)* in the IDF is a territorial concession (Jacquot et al., 2019; Pérez-Arriaga et al., 2019; Jacquot, 2021). However, this thesis argues that the IDF can be implemented in contexts where a strict territorial concession is not the main modality for achieving universal electricity access targets. Alternatives to territorial concessions are important to consider as increasingly countries are adopting a range of delivery models to achieve their electrification objectives. For example, in Kenya the KOSAP project, a flagship for achieving Kenya's off-grid electrification targets, is implementing a PPP for mini-grids in within pre-defined service territories for previously marginalised counties (Power Africa, 2020). In Rwanda, off-grid solar companies are partnering with the nationality utility through an *Imihigo* (or performance contract), to meet certain performance targets. As highlighted in Section 1.2. an important gap this study identifies, and fills is applying the principles of the IDF in case study sites where a strict territorial concession (i.e., the main approach the IDF recommends) is not the main approaches being used in Kenya and Rwanda's off-grid sector. Tangible examples of how the IDF applies to PPPs and RBF Kenya and Rwanda will be discussed in Chapters 6 and 7.

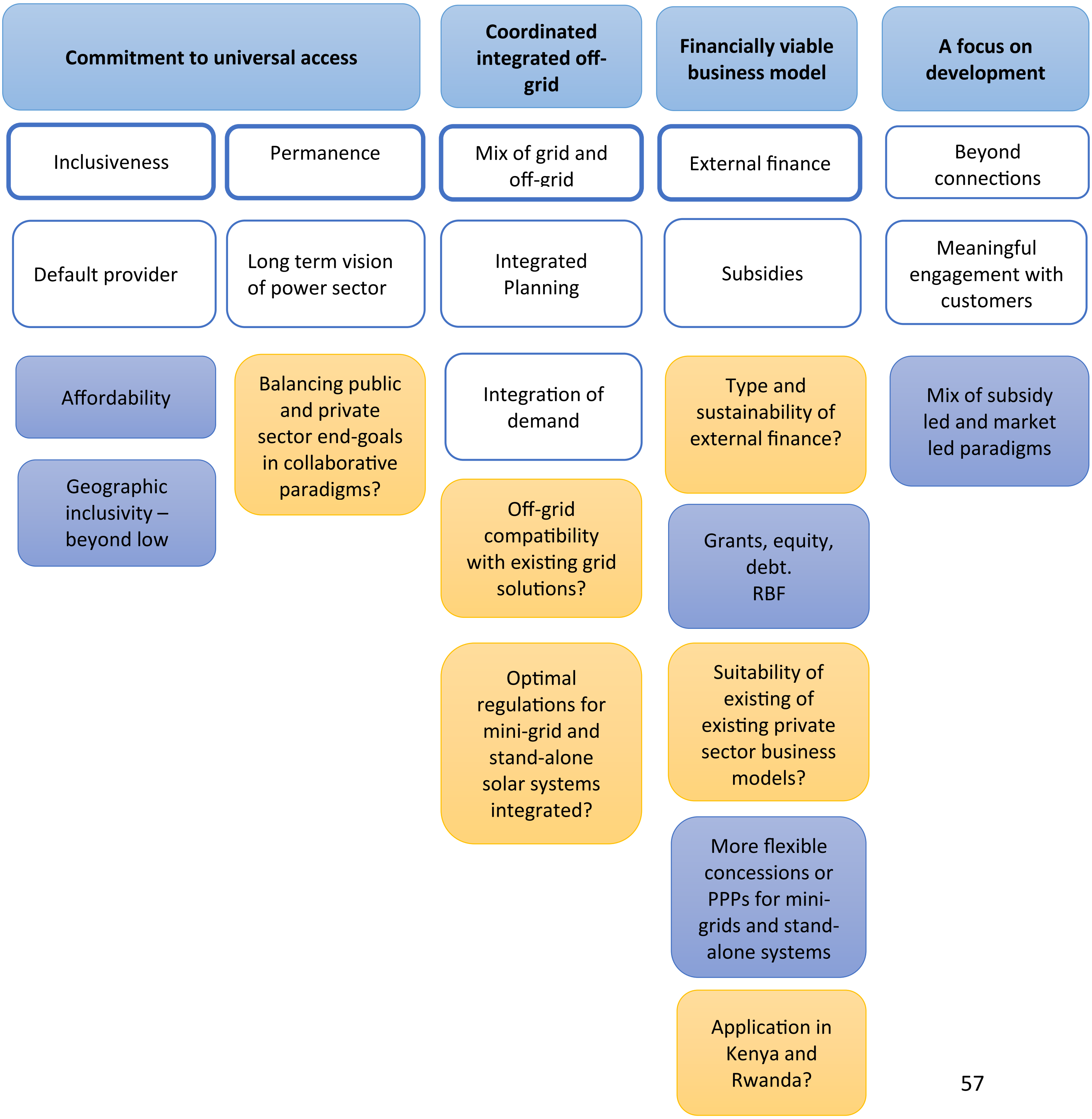


Figure 4: IDF (V2) (Author's figure)

However, within these programmes there are still many unknowns about the impact of these kinds of partnership models and how public and private sector mini-grid developers and utilities would need to work more closely and effectively together to further the broader objective of SDG 7. There is furthermore a need to specifically examine emerging business models in the off-grid sector through the framing of the IDF.

With respect to financing, which links closely to the IDF pillar of *external resources*, Section 2.4 identified the need for a long-term perspective for a financing pipeline and continuity of funding beyond initial grant funding rounds and disbursements. It highlighted key emerging models including RBF and blended finance to (i) achieve greater scale in the sector and (ii) incentivise and subsidise companies to develop models in the more challenging areas through performance-based CAPEX grants. However, there are also challenges in RBF models, such as incentivising connections and the sustainability of finance, and the pipeline of funding pre- and post-disbursement. Emanating from the findings of the literature review on these financing models it is necessary to develop a longer-term view of energy finance in the sector and design financing instruments with continuity in mind, to support the longer-term financing needs of the sector.

Lastly the regulatory aspects discussed in Section 2.5 form a key part of the framing of the IDF and a key gap identified here is the balance between the *heavy* and *light* touch approaches that may be needed to deliver scalable models for off-grid energy access. However, it is unknown what the balance between a light touch and heavy touch would be for off-grid mini-grid and stand-alone system models in Kenya and Rwanda, when operationalising the IDF as a framework.

Thus, notwithstanding the excellent conceptual base the IDF presents for rethinking business models, financing approaches and regulatory design of electrification programmes, further empirical case studies are needed to apply the pillars to current electrification programmes outside of territorial concessions. More granular empirical data is needed on how the conceptual principles of the IDF can be operationalised in varying and dynamic off-grid sector programmes in Kenya, Rwanda and many other countries in sub-Saharan Africa using RBF models and variations of PPPs to facilitate universal energy access. Building on the identified gaps in the literature and using the framing of the IDF, this study will unpack the viability gap and country specific contextual factors including policy, financial and regulatory considerations for developing business models that can achieve SDG 7. This will be done through the empirical case studies of Kenya and Rwanda (see Chapter 5). It will further use examples of existing national electrification and donor funded programmes to illustrate the dynamics of partnerships and coordination in these programmes. This exploration will enhance the applicability of the IDF to current sector programmes by assessing how the principles can be applied using the framing, which will in turn feed back into the expanded IDF framework and pillars presented in Chapter 8. Specifically, it will highlight some of the challenges and opportunities for delivering more inclusive electrification, adopting a long-term vision of the power sector, through a combination of off-grid technologies and external financial resources (see Chapters 6 and 7).

Chapter 3 Methodology

3.1.Introduction

Chapter 2 analysed the literature on business and partnership models, finance and regulatory approaches needed to advance SDG 7, and introduced the theoretical framing of the IDF, which serves as the main theoretical framing of the thesis. It furthermore highlighted key gaps in the literature including how business models, financing, regulation and partnerships need to evolve within more integrated paradigms to advance SDG 7, the need for continuity of finance and appropriate regulations for mini-gird and stand-alone solar systems which provides the rationale for an empirical study. This chapter outlines the qualitative research methods used to carry out the empirical investigation. According to Biggam (2011) qualitative research methods are appropriate when conducting in-depth exploratory studies, as in the case of an in-depth inquiry of the IDF in Kenya and Rwanda's off-grid context. Importantly the combination of the research strategy, objectives and data collection methods determines whether a study is qualitative or quantitative (Biggam, 2011). This links back to the overarching aim of this study, which is, to explore how the principles of the IDF can be applied to partnerships and financing models for mini-grids and stand-alone solar systems in Kenya and Rwanda and operationalised in these countries to facilitate the achievement of SDG 7. Qualitative methods are consistent with the exploratory nature of the study to be able to provide in-depth insights and sector expertise.

Section 3.2 sets the premise of Chapter 3 by detailing the epistemological basis of the study. Section 3.3 explains the case study research strategy. Section 3.4 then describes and justifies the data collection instruments, while Sections 3.5 and 3.6 detail the sampling approach and data analysis respectively. Section 3.7 concludes with some limitations to the study.

3.2.Epistemological underpinnings of the research

Before delving deeper into the research methodology of this study, it is important to understand the philosophical basis or epistemology of the study (Ritchie et al., 2003). Brown et al. (1993) defines epistemology as a division of philosophy which focuses on the validity of knowledge and different types of knowledge. Epistemology is important to consider as it has an impact on the suitability of the research methods, in relation to the nature of the study. Ritchie et al. (2003) state that epistemology has an impact on how research will be carried out. There are two main epistemological positions a researcher can adopt, namely positivism and interpretivism (also referred to as constructivism). According to a positivist paradigm the social world is not affected by the researcher (Ritchie et al., 2003) and knowledge is created by carefully observing reality from an objective perspective (Creswell, 2014). In a constructivist or interpretivist paradigm, it is acknowledged that researchers and the social world have an impact on each other, and that research findings are to a degree, invariably impacted by a researcher's experiences and viewpoints (Ritchie et al., 2003). Creswell (2014) highlights that constructivism is often combined with interpretivism and is usually adopted in qualitative research studies. In a constructivist or interpretivist viewpoint, interpretation is a key part of knowledge building and the researcher's interpretation of the social phenomena being observed is an integral part of generating findings. The researcher in this study adopts an interpretivist perspective and utilises the complexity of views and experiences to build on the theoretical framing of the IDF, considering multiple, often nuanced perspectives from a range of key actors in Kenya and Rwanda's energy sector. In an exploratory study of off-grid energy developments in Kenya and Rwanda, the analysis would involve the interpretation of the researcher to generate new theoretical perspectives on, for example, the IDF.

3.3. Research strategy and approach

This research study uses a case study research strategy. According to Biggam (2011), case study research is suitable when conducting studies that are of an investigative and in-depth nature. Harrison et al. (2017) contend that case study research offers both flexibility but also the necessary rigor to generate in depth insights across a range of disciplines. Yin (2009) defines case study research as:

> An in-depth empirical investigation of a modern-day phenomenon (*the case*) in the context of the real-world, particularly when there is not a clear boundary between phenomenon and context.

The selected case study research strategy is appropriate as this study is an explorative enquiry into the business and regulatory models for electricity in Kenya and Rwanda. This research strategy is consistent with the definition of Yin (2009) as it investigates a contemporary phenomenon, i.e., business and partnership models for off-grid electrification in Kenya and Rwanda in relation to the regime and institutional actors in which they operate (Bolton & Hannon, 2016), which also forms part of the broader context of the study. Yin (2009) argues that the boundaries between phenomena and context not being clearly evident, clearly distinguishes case study research from other research strategies including experiments (where the phenomenon and context are deliberately separated and the context controlled in a laboratory setting) and surveys (which can be devoid of context). The case study research strategy is furthermore consistent with the overall aims and objectives of the study and the research questions. This includes research questions that align with the exploratory case study design; research questions 1-3, for example are 'what[34]' or 'which' questions seeking in-depth insights on the drivers of the viability gap, approaches to address them and how they relate to conceptual framing of the IDF. These are explored through an exploratory case study.

Yin (2009) further distinguishes between three different types of case studies namely: (a) explanatory or causal case studies, (b) descriptive case studies, and (c) exploratory studies. According to Yin (2009), an exploratory case study is used when a study does not have a pre-defined outcome and the researcher seeks to draw in-depth insights about a phenomenon. An explanatory case study is a case study whose purpose is to explain how or why some conditions came to be. A descriptive case study's purpose is to describe a phenomenon (*the case*) in its real-world context. This study uses an exploratory case study of off-grid partnership and financing models in Kenya and Rwanda through an IDF lens.

3.3.1. Case study research design

When a single research study contains more than a single case, the study uses a multiple-case study design (Yin, 2014). Hence, this research study uses a multiple case study design with embedded units of analysis (see Figure 5). Multiple case studies often produce more compelling evidence and allow for more robust analysis by cross-referencing cases and identifying similar or contrasting themes (Yin, 2014). The three embedded units of analysis in each of the case studies are: drivers of the viability gap, emerging partnership (and financing) models, the application of the IDF.

[34] According to Yin (2009) questions that start with 'what' or 'which' are usually used in exploratory case studies.

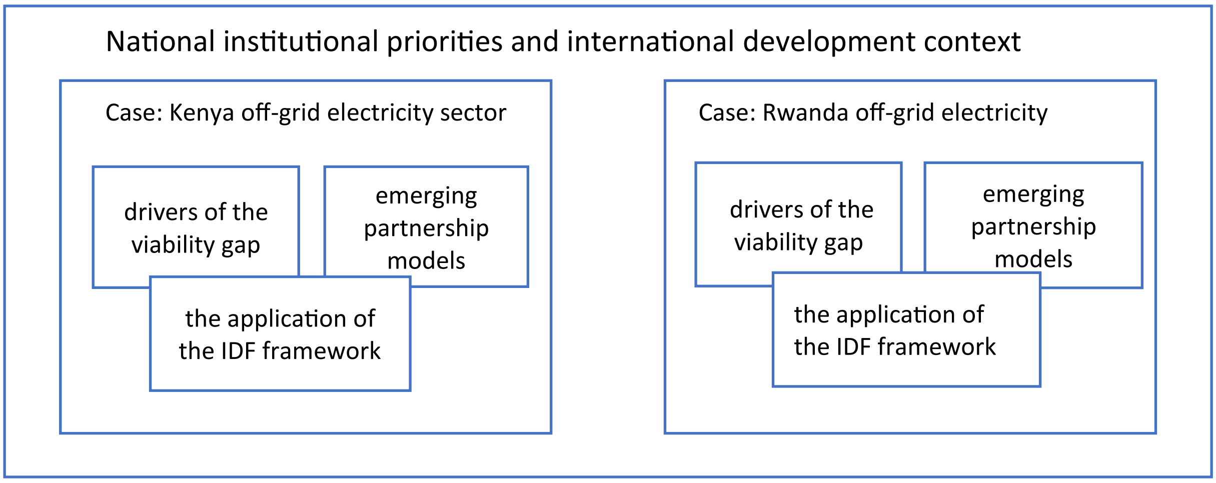


Figure 5: Embedded multiple case study design

The cases in multiple case study design are Kenya and Rwanda's off-grid electricity sector (see Section 1.3 on the rationale for Kenya and Rwanda case studies). These units of analysis are explored in Chapters 5 - 8.

3.4. Data collection Instruments

Semi-structured interviews were used as the main data collection instrument, with document analysis to triangulate the findings from the semi-structured interviews. According to Yin (2014), interviews are one of the most important sources of evidence for case study research. Semi-structured interviews have been selected as they provide sufficient structure for the dimensions of the research study to be adequately addressed, while giving respondents the opportunity to add meaningful insights (Galletta, 2013). Similarly, Dunn (2005) highlights that semi-structured interviews provide some form of pre-determined structure but also the necessary flexibility. In this study questions were guided by a semi-structured interview schedule, which provided the broad structure to guide the discussion, while allowing an opportunity to ask the questions in a slightly different order in each interview, guided by the flow of the discussion and allowing for probing of key points of interest during the interview. Table 3 provides an overview of the topics and sub-topics covered in the semi-structured interviews. The full semi-structured interviews schedule is included in Appendix B. In this study most of the interviews lasted approximately an hour, in line with Adams (2015) who recommends an hour as an acceptable interview duration.

Table 3: Example excerpts of topics covered in semi-structured interviews

Topic	***Sub-topic***
Electrification business model viability	Key factors impacting viability and scalability for • mini-grids • off-grid solar home systems Probing questions on: • Affordability (*aligned with IDF pillar inclusivity*) • demand and demand stimulation • the role of tariffs (cost reflective vs grid parity) and subsidies (*aligned with IDF pillar on financially viable business models)* • the role of the regulatory environment (licensing, tariffs, grid arrival compensation, standards for off-grid solar systems *(aligned with IDF pillars permanence and a combination of electrification modes)*
Sustainable finance for electrification	Financing electrification models sustainably (*aligned with IDF pillar on financially viable business models)* • Role of DFI funding and role of subsidies • Creating larger pools of off-grid funding for mini-grids • Types of funding that can bridge the affordability gap for solar home systems
Public-Private Sector Roles, Collaborations	• The respective roles of the utility and private sector companies in a country's electrification • PPPs for mini-grids and off-grid solar • Compatibility of market-based approaches with more coordinated approaches

Credibility and validity of data are important considerations in qualitative research methods and the use of interview data, due to the challenge of subjectivity of respondent answers. Credibility and validity of the data are strengthened through triangulation (Biggam, 2011). Briggs, Coleman & Morrison (2012) define triangulation as a way to compare and corroborate different data sources to verify the accuracy of the sources. It is an essential means of cross-checking its validity. Data source triangulation is a method used to validate the data by cross-referencing one data source with others (Briggs, Coleman & Morrison, 2012).

This study used data triangulation through published and unpublished documents to corroborate the findings from the semi-structured interviews. It also used respondent triangulation which is a sub-type of data triangulation (Briggs, Coleman & Morrison, 2012). Respondent triangulation was important as it allowed for different and nuanced perspectives across the respondent categories, which served the objectives of the study as integrated distribution paradigms depend on a range of stakeholders in the public and private sectors as well as international development partners. As such, multi-stakeholder perspectives were also key during the sampling. Furthermore, credibility was enhanced through interviewing energy experts in their respective fields as well as senior employees of utilities, national ministries and energy companies, whose answers were informed by extensive experience in their respective fields in the energy sector.

3.5.Sampling approach

The study adopted a two-stage sampling approach, namely purposive and snowball sampling. Purposive sampling is a non-probability sampling technique, where participants are selected based on specific criteria including expert knowledge, the spectrum of respondents required to answer the research questions and their willingness and availability to participate in the research study (Oliver, 2006). In a case study a purposive sampling approach is particularly suitable, as decisions need to be made about the participants who could provide the most relevance and depth to the research study. Purposive sampling offers the advantage that the researcher can decide which respondents to include in the study to best provide answers to the research questions (Oliver, 2006). Random sampling was not a suitable approach for this study because the selected respondent organisations were specifically selected on specific predetermined criteria. Secondly, snowball (referral or chain) sampling was used to identify further study participants. This sampling technique used referral from study respondents, experts and practitioners to identify other potentially suitable respondents to include in the research study. This was a particularly useful strategy to include respondents who could add meaningful insights, who may have been excluded during the initial purposive selection.

It is however acknowledged that purposive sampling, as with all sampling approaches, has potential challenges which need to be addressed to ensure the validity of the data, particularly due to the subjective nature of respondent selection. Snowballing helps to address the limitation of bias or subjectiveness in respondent selection by bringing to the attention of the researcher interviewees (sector experts) they ordinarily would not have selected or necessarily been aware of. To overcome this potential challenge the selection of interview respondents was aligned with and the overall aims of the research (Oliver, 2006). In this research study, an internal consistency was maintained by ensuring that the selection of respondents was informed by the overall aims of the research study and is consistent with the overall research strategy.

Respondent organisation categories

A total of 49 semi-structured interviews were conducted, across various respondent categories including national Ministries of Energy, national utilities, private sector mini-grid developers, private sector off-grid solar companies, international development partner organisations, energy consultants, mini-grid developer associations and energy experts (see Table 4). This multi-stakeholder perspective drawing on expertise in the public, private international development partner spheres was critical to the study, to be able to the explore and apply the principles of integrated distribution models and partnerships needed to advance SDG 7 in the public and private sector. International development partners (including managers of RBF programmes) and industry associations represent the perspectives of multiple private sector companies who they fund or provide technical assistance to. These organisations were thus invaluable for gaining collective industry perspectives. Tables 5-7 present the list of respondent organisations. This also further served as a form of respondent triangulation which Briggs, Coleman & Morrison (2012) describe as a sub-type of data triangulation.

Table 4: Reasons for selecting different respondent categories

Respondent category	***Rationale for respondent category***
Energy utilities	To gauge utility perspectives on forming partnerships with off-grid companies and working more collaboratively with off-grid providers and development partners within IDF paradigms
Energy ministries	To get in-depth insights on current national electrification programmes, particularly those that that involve off-grid programmes and emerging PPPs
International development partners	To draw on in-depth experience in with working directly with many off-grid companies in the funding programmes, international development partners offer a depth of experience in financing off-grid energy projects, running prominent funding programmes (e.g., RBF) working closely with the companies in the portfolios they support. They provide insights into the country and international contexts in which the efforts are happening.
Mini-grid companies	To offer insights to drivers of viability gap and how current developments and partnerships could affect their viability. As well as to gauge their perspectives on new potential partnerships with other players in the in the off-grid sector.
Off-grid solar companies	To offer insights to drivers of viability gap and how current developments and partnerships could affect their viability. As well as to gauge their perspectives on new potential partnerships with other players in the in the off-grid sector.

Industry associations	To offer insights on experiences with a range of off-grid companies with whom they directly work. These associations serve as a collective voice for several companies.

The initial 26 in-person interviews were conducted over five weeks, split between a three-week fieldwork visit to Nairobi, Kenya in August 2018 and a two week visit to Kigali, Rwanda in April/May 2019. An additional 23 interviews, including 3 follow-ups, were conducted in person and virtually (e.g., via Skype and Microsoft Teams) between 2018 and 2023. Follow-up and additional interviews, conducted between 2020 and 2023, served to include updated perspectives in terms of the latest sector developments since the initial set of interviews were conducted, as well as delve deeper into some of the emerging themes where relevant. Additionally, during the research visits, the researcher attended two key sector engagement events at the Strathmore Business School in Nairobi, and another organised by the Energy Private Developers (EPD) in Kigali. These sessions were invaluable in being able to listen in on key discussions in the off-grid sector development and to set-up additional interviews with some of the stakeholders present, which formed part of the snowball sampling discussed above.

Table 5: Respondent organisations - Kenya

Respondent category	Respondent designation	No of interviews	Follow-up interview
Energy utility	Senior representative	3	
	Engineer	1	
Regulator	Senior representative in the Electricity Directorate	1	
Energy Ministry	Senior representative in the Directorate	2	
Rural Electrification Authority	Engineer	1	
International development partner organisations	Senior Energy advisor	1	1
Private sector mini-grid developer	Manager	1	
	Company representative	2	
Private sector off-grid solar company	Senior representative	1	
Mini-grid industry association	Senior representative	1	
	Representative	1	

Expert Academic Interviews	Lecturer[35]	1	
Total Kenya		**17**	

Table 6: Respondent organisations - Rwanda

Respondent category	Respondent designation	No of interviews	Follow-up interviews
Energy utility	Senior Representative (Head of investment)	1	
Energy Ministry	Senior Engineer	1	
Private sector association	Head of operations	1	
International development partner (RBF fund manager)	Lead advisor for off-grid projects	1	
	Mini-grid development market advisor	1	
	Off-grid advisor	1	1
	Country Manager & Business development coordinators	1	
	Mini-grid advisor	1	
International energy research consultancy	Representative	1	
Private sector mini-grid developer	Head of company	2	
	Manager	1	
	Senior representative	1	
Off-grid solar company	Consultant	1	
	Company representative	1	
Independent energy consultant	Energy expert/consultant	2	1
Private sector industry association	Senior representative	1	
Total Rwanda		**20**	

Table 7: Non-country specific expert interviews

Respondent category	Respondent designation	No of interviews	
Independent expert interview	Mini-grid/Energy expert	2	
	Renewable energy project developer	2	
International development partner	Senior representative	2	
	Energy expert	1	
	Representative	1	
	Mini-grid expert	2	

[35] The respondent previously worked in an energy utility and thus also contributed an industry perspective

Investment Fund (investor in productive use of energy projects)	Partnership lead	1	
Mini-grid Innovation Lab	Senior representative	1	
Total		**12**	

All interview respondents were asked for permission to conduct and record the interviews and were provided with a copy of the Informed Consent Form via email, as per the guidelines for Ethics in Research and the ethics approval obtained for this study (see Appendix A). All of the respondents except for two consented to an audio recording. Recorded interviews were transcribed by the researcher and anonymised, by assigning an anonymous code to each interview (see Appendix C). Audio recordings were safely stored, with only the researcher having access to these recordings. As per the consent, audio recordings and transcriptions will continue to be safely stored for a period of three years after the study before being discarded.

3.6. Data analysis

After transcribing the interviews, the transcripts were thematically analysed. Thematic analysis involves breaking down the data according to key themes and then comparing and contrasting the various responses across the respondent categories (Biggam, 2011; Creswell, 2014). Braun & Clarke (2006) state that a theme captures essential aspects of the data as it relates to the research questions and draws out a pattern in responses. Data analysis was facilitated using NVivo 12, a software programme for qualitative data analysis, which was primarily used for organising and coding the data. NVivo 12, enabled the researcher to code the transcribed data under various nodes, allowing for visualisation of the coded data in one programme and reducing the time taken to code. Software programmes such as NVivo do not analyse the data per se, but facilitate data analysis through coding, thereby enabling the systematic identification of emergent themes.

Assigning codes to the data is a key part of the thematic analysis process. A code is defined as a phrase or word which is assigned to sections of the qualitative data to capture key aspects of the data (Saldana, 2009). According to Boyatzis (1998) thematic analysis is a process of identifying and analysing patterns in the data, which involves assigning codes to sections of raw data collected during fieldwork interviews (e.g., interview transcripts), keeping in mind how it relates to the overall research aims and emergent themes in the data. Creswell (2014) highlights that a code can either be developed from (i) emerging themes in the data, (ii) by using predetermined codes and aligning the empirical data to these or (iii) a combination of predetermined and emergent codes. In this study a combination of predetermined or *a priori* and emergent codes were assigned to the data. In this respect a priori codes structural were applied to organise the data into different themes as per the broad interview categories in the semi-structured interview schedule (deductive coding). After becoming familiar with the data, emerging themes were further identified (an inductive coding approach).

Creswell (2014) contends that beyond simply identifying themes in the process of coding, during the qualitative analysis process, researchers can build in additional layers of complexity into their research by drawing interconnections between themes and building a storyline or narrative around those themes or develop themes into a theoretical model. Themes can be analysed for individual cases or across different case studies in a multiple case study design (Creswell, 2014). In this study, themes were analysed across the two case study contexts in Kenya and Rwanda with respect to the embedded units of analysis described in Section 3.3.1. To produce new empirical insights emerging themes were also analysed in relation to the theoretical framing of the IDF presented in Section 2.6 of the literature review which is the main theoretical framework for the study. In line with the principle of triangulation, Creswell (2014) highlights that themes should show varying perspectives and should be supported by quotes and evidence to reflect balanced perspectives. If themes result from several converging data sources, this could add to the validity of the study through data source triangulation (Creswell, 2014). However, themes consisting of diverging perspective were also considered as these also help to build a more nuanced picture of emerging off-grid market developments in Kenya and Rwanda.

The data collection and analysis process was iterative, as initial reflection and analysis began before all interviews were conducted. The first round of analysis commenced after the initial round of interviews in Kenya were completed. An initial analysis of the Kenyan data was written up before the second research visit for data collection in Rwanda. It was important to begin reflecting on the interviews and analysing the data shortly after each visit as this helped to keep the researcher connected to the data, and to identify important initial themes that could be further explored in subsequent interviews. The initial findings from the Kenyan interviews further helped to refine the semi-structured interview schedule and probe a bit more into some pertinent themes when conducting the second set of interviews in Rwanda as well as follow up interviews for Kenya to ensure a balanced perspective. This is in line with the iterative nature of the research design and data collection. Follow-up interviews were a part of the iterative nature of the research design, allowing for responsiveness to findings from expert interviews, and the latitude to explore key emerging insights on key sector developments and emergent themes.

Table 8 below provides examples of the codes used when coding the data from the interview transcripts.

Table 8: Example of codes used

Code	***Selection from transcript***	***Respondent code***
Evolving utility business model	…we are revising our strategic plan, we are revising our business model, because remaining with the same traditional business model will not help us in a competitive environment.	Utility K1
Off-grid modalities	We cannot really undervalue the role of micro-grids in universal energy access and the private sector as well. We have to involve the private sector…	IDO K1
Partnerships	Of course, there are several levels to partnerships, that I'd see	Mini-grid K(SC)
Tariffs	I would say it's a big conflict of tariff parity, the thing is where we are installing these mini-grids is also where the government mini-grids are existing	IDO K1

3.7. Limitations

Although there are several advantages of case study-based research, this study acknowledges some of the inherent challenges of using a multiple case study design as a research strategy, particularly with respect to generalisability due to non-probability sampling techniques used (Falk & Guenther, 2006; Biggam, 2011; Yin, 2014). Generalisability according to Yin (2014) means that the findings of a study can be generalised beyond the immediate study. While the multiple case studies of Kenya and Rwanda may provide findings and lessons that may be applicable more broadly to other countries in Sub-Saharan Africa, the main purpose of case study research is not generalisability (Falk & Gunther, 2006), but a rich and in-depth understanding of the phenomenon being researched (Biggam, 2011). It is, however, important to note that generalisability is not the purpose of this study, but rather it is used to identify key findings that can be generalisable as will be elaborated in the section below.

Furthermore, qualitative research generalisability should not be viewed in the same way as for quantitative research (Falk & Guenther, 2006; Biggam, 2011). Relatability or transferability are more relevant for qualitative research (Blaikie, 2010; Biggam, 2011). In this study it is more important to consider how relatable or transferable the study's findings are to other countries in Sub-Saharan Africa (and the global South), and how relevant findings can be distilled into key lessons and principles that can advance SDG 7 in other countries This is especially important where there are areas of overlap in the market dynamics of those countries in terms of incorporating the private sector into national electrification programmes, and the challenges opportunities for building partnerships for off-grid electrification and forging synergies between a range of players in the off-grid sector.

A further limitation pertains to the subjectiveness of analysing the qualitative data, within an interpretive or constructivist paradigm mentioned in Section 3.2. While the researcher in this study has made a conscious effort to provide a balanced an objective analysis of the qualitative interview data, which is corroborated by data source and respondent triangulation (by including a wide range of stakeholder perspectives from the public sector, private sector and development partner domains), it is acknowledged that when interpreting data and building new theoretical perspectives, a degree of subjectivity may still be present, as new important perspectives are subject to the researcher's interpretation, perspectives and prior knowledge on the subject area. In this respect a potential limitation of the sampling approach is the potential bias weighted towards private sector and development partner perspectives, with more interview respondents in these categories. To address this, the researcher included a balance of quotes from the private sector, public sector and development partners in the analysis chapters. This includes, for example, balancing perspectives on tariff regulation, regulatory clarity or certainty or how public sector actors would work with private sector actors. With regard to positionality, the researcher in this study has a background in energy and development, qualitative (social science) research methods and has had the opportunity to work on interdisciplinary energy access projects in the Sub-Saharan African energy sector. She has gained significant exposure to varying sector perspectives through her work, qualitative post-graduate research and draws on analytical critical thinking from her undergraduate engineering degree. Drawing on her qualitative research and analytical background, the researcher considered the perspectives of varying stakeholders in the energy sector to provide a balanced view of the research topic in question and highlighted nuances in interview responses, where relevant. Triangulation of data sources and respondents helps to address the challenge of subjectivity in qualitative research.

3.8. Conclusion

This chapter has highlighted the qualitative methodology used to undertake the empirical investigation including the epistemology, case study research strategy and design, semi-structured interviews, thematic analysis and limitations. These form part of conducting the empirical study to answer the research questions presented in Section 1.4, in accordance with the exploratory nature of the study and the analysis presented in Chapters 5-8. Chapter 4 will present a foundational chapter on the policy, regulatory and institutional context of Kenya and Rwanda, upon which the other analysis chapters build.

Chapter 4 – Policy, regulatory and institutional context

4.1 Introduction

Chapter 4 provides an overview of the Kenyan and Rwandan case study contexts with respect to key policies and regulations and energy access programmes that facilitate the goal of universal access to electricity. As highlighted in Chapter 2, business models, financing and the regulatory environment are key interrelated concepts in the framing of the IDF, that influence the viability and scalability of off-grid electrification models. The IDF pillars, introduced in Section 1.4 and expounded in 2.2.1, are impacted by the policy, legislative and regulatory environment in the country of operation.

Sections 4.2 and 4.3 on Kenya and Rwanda respectively, start with an overview of key policies and legislation that have shaped the Kenyan and Rwandan energy sectors and energy access specifically. These sections further highlight the implications of recent developments in energy policy and legislation on the types of models present and emerging in Kenya and Rwanda's electricity sectors. Key electrification strategies and programmes are discussed. This chapter primarily draws on the insights of key policy documents, regulations, legislation, and grey literature while also incorporating insights from the semi-structured interviews and is one of the more descriptive chapters laying the foundation for Chapters 5, 6 and 7.

4.2 Kenya's electricity sector

4.2.1 Towards universal access to energy in Kenya: policy and progress

As 2022 was the year Kenya earmarked for universal energy access it is apt to reflect on its progress, milestones and challenges to achieving universal access. Although Kenya has not achieved this initial target it has made significant progress in closing its electrification gap. The timeframe for achieving universal energy access in Kenya has subsequently been updated to 2030 (Hako, 2023). Kenya has emerged as a leader in East Africa, and the continent, in terms of increasing electricity access within a short timeframe. Between 1990 and 2010 Kenya saw a steady growth in the number of grid connections, increasing the access rate from 7% in 1990 to about 22% in 2010 (Godinho & Eberhard, 2019). Thereafter, Kenya embarked on an accelerated electrification drive where the utility Kenya Power's growth in connections averaged 22% between 2009/2010 and 2016/ 2017 (KNES). A sharp increase in annual grid connections was seen post 2012, when the new government adopted ambitions for universal access and implemented key electrification programmes. This has largely been attributed to grid electrification programmes like the Last Mile Connectivity programme. According to Power Africa (2019a) Kenya had the third fastest rate of electrification globally in 2019, and the fastest electrification rate in Africa, measured in terms of the annualised increase in grid connected customers from 2010 to 2017. It has also been a forerunner in the region for off-grid solar systems[36], like solar home systems (Ministry of Energy, 2018) with a dynamic market for off-grid solar home systems enabled through the proliferation of mobile money platforms like MPESA[37]. In 2021 Kenya had an access rate of 76.5% (World Bank, 2021) and access is currently estimated at 78% (Hako, 2023). As shown in Figure 6, energy policy and legislation have played a key role in the trajectory of Kenya's energy access rates and structure of the electricity sector.

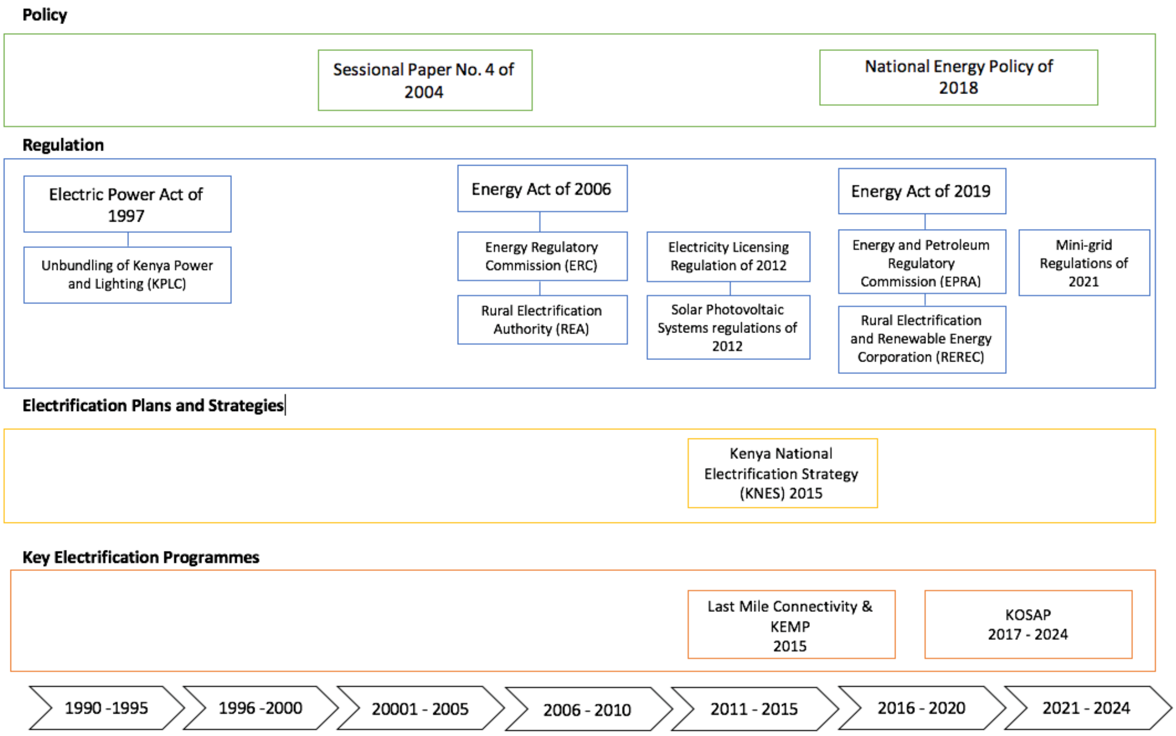


Figure 6: Graphic overview of key policies, regulation and electrification planning in Kenya (Author's figure)

The Energy Policy of 2018 is the key overarching policy governing Kenya's electricity sector, with universal access to electricity prioritised in the policy landscape. Its objective is to facilitate the affordability, sustainability, and reliability of power supply, guided by least-cost planning. The Energy Policy further provided for the Kenya National Electrification Strategy (KNES) which will be discussed further in Section 4.2.2 below. Among Kenya's earlier policies and legislation, the Sessional Paper of

[36] It is estimated that 1 in every 3 off-grid households in Kenya owns a solar home system (off-grid solar product) and that the Kenyan sales in off-grid solar constitutes a quarter of sales in Sub- Saharan Africa (ESMAP, 2017)
[37] MPESA is a widely used mobile money platform in Kenya, introduced by Safaricom in 2007

2004 and the Energy Act of 2006 were instrumental in promoting a vision for increasing access to energy. In the Sessional Paper of 2004 and the Energy Act of 2006, the Ministry of Energy detailed its vision 'to promote equitable access to quality energy services at least cost' and the aim to expand rural electrification to 40% in the period 2004-2024 (Ministry of Energy, 2004: VII).

4.2.2 The Kenya National Electrification Strategy

National electrification planning is a central part of achieving universal access to electricity, as it provides a strategy and tangible targets. The KNES is the culmination of a least cost geospatial electrification planning process, which serves as a key practical roadmap for achieving universal access to electricity (Ministry, 2018). This document plays a key role in mapping the mix of grid and off-grid technologies and how efficiently they are coordinated in line with IDF pillar 2. A recent ESMAP report highlights that Kenya, along with Rwanda, was one of the first countries in Africa to adopt Geographic Information Systems (GIS) in their geospatial planning for mini-grid development (ESMAP, 2022). KNES highlights that achieving universal access to electricity presents a dual challenge of expanding the grid to areas where technically appropriate and within reasonable costs and finding appropriate off-grid solutions to meet the needs lower income, more remote populations. It also outlines the roles of multiple electrification modes including grid extension, intensification and densification and off-grid options including micro-grids and stand-alone systems. It further outlines the roles and functions of the relevant implementing institutions including Kenya Power, the Rural Electrification and Renewable Energy Corporation (REREC) (previously the Rural Electrification Authority) and the private sector, with the Energy and Petroleum Regulatory Authority (EPRA) playing a key oversight role in electrification in the country (Ministry of Energy, 2018).

Least cost electrification planning for the KNES estimates that 269 000 households could be connected through grid expansion, 2.77 million connections through grid intensification and densification, 35 000 connections through mini-grids and 1.96 million connections through solar home systems (see Figure 7) (Ministry of Energy, 2018). Mini-grids[38] and solar home systems are currently being deployed through KOSAP, with the full potential achieved through this project. From the grid and off-grid targets above, the largest potential for increasing connections is through grid intensification and densification which can be considered as low-hanging fruit of electrification and off-grid stand-alone systems. This

[38] In August 2023, a tender notice was released for the development/construction of mini-grids under KOSAP.

could be attributed to the sizeable percentage of unelectrified under-the-grid households in Kenya; approximately 50% of households in Kenya are under the grid, but are not connected to the grid (Chuhan-Pole et al., 2017). With respect to off-grid connections, there is significant potential for the deployment of solar home systems. In contrast, grid expansion and mini-grids play a relatively smaller role proportionally in the electrification planning process. The Electrification Strategy further outlines that 120 microgrid sites (which was subsequently expanded to 137) have been approved for development under KOSAP (see Figure 7below).

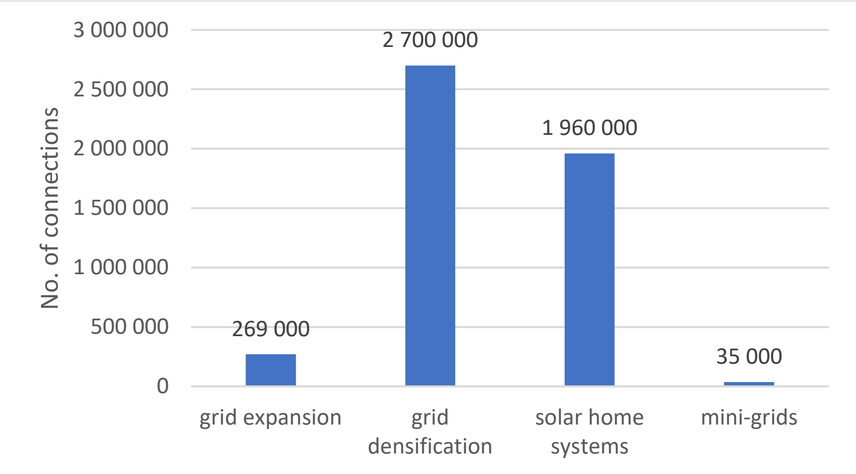


Figure 7: Potential for new grid/ off-grid connections Source: Author's figure created from (Ministry of Energy, 2018)

To achieve universal access targets, significant sectoral investment is required. Table 9 highlights the annual investment required over five years to achieve universal access. Proportionally, grid densification has the highest investment requirements, while mini-grids [39] have the least (Ministry of Energy, 2018).

Table 9:Investment required for universal access over 5 years ($ millions) (Ministry of Energy, 2018)

Intervention	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Grid Expansion	$36.4	$61.6	$62.0	$110.5	$111.0	$381.5
Grid Densification	$23.9	$141.0	$340.3	$294.8	$442.4	$1,242.4
Grid Intensification	$82.2	$340.4	$154.6	$34.0	$22.2	$633.4
Mini-Grids	$5.8	$3.1	$8.4	$7.5	$8.3	$33.1
Solar Home Systems	$91.5	$91.5	$91.5	$91.5	$91.5	$457.5
Total	$239.8	$637.6	$656.8	$538.3	$675.4	$2,748.9

[39] This does not account for private mini-grid investment costs.

Despite strides made in electrification, key challenges highlighted in KNES include: (i) high connection costs; (ii) high costs of supplying electricity to rural and peri-urban households; (iii) lack of appropriate incentives to attract private investors; and (iv) inappropriate technical standards given the nature of settlements (Ministry of Energy, 2018: 16). In addition, low affordability and consumption have been highted as key overarching challenges affecting both grid and off-grid connections (Power Africa, 2019a; Taneja, 2019). The figures show the important need for off-grid technologies to achieve targets.

4.2.3 KOSAP – A key national off-grid electrification project

KOSAP is an important project for this study and will be explored in relation to its RBF component for stand-alone solar in Chapter 6 and PPPs for mini-grids in Chapter 7. KOSAP, initiated by the Ministry of Energy and the World Bank, is currently the main programme in Kenya for achieving off-grid electrification targets as highlighted in the KNES. KOSAP aims to promote the uptake of off-grid solar projects in 14 identified underserved counties among households, enterprises and community facilities. The significance of KOSAP is that it specifically targets geographically dispersed and distant counties in Kenya, which to date remain largely unelectrified, and areas where a viable business case for mini-grids, would be difficult for the private sector on their own due low ability to pay, insufficient demand and few anchor loads or productive uses (Power Africa, 2020). As discussed previously in Section 2.6 and to be elaborated on in the context of KOSAP in Section 7.3.1, a key aspect of the IDF framework is *inclusiveness*. This necessitates electrifying all parts of a country, including the most geographically and socio-economically challenging. As will be illustrated in Chapter 7 when looking at the IDF principle of inclusive, KOSAP fosters inclusiveness in part and there are still shortcomings as there will be unelectrified sites left outside of KOSAP (Utility K1).

KOSAP is an example of how the Ministry is directing off-grid investment to encourage development in these underserved regions. Within the IDF pillar of *external resources,* Pérez-Arriaga et al. (2019) explain that private developers need external funding including donors, DFIs and equity investors to invest in off-grid projects. Chapter 7 will elaborate on the KOSAP model showing how the private sector will be remunerated in the PPP and the roles of the respective stakeholders in the value chain. While the KOSAP project has been described in the grey literature, (see e.g. ESMAP, 2017; Power Africa, 2019), in the academic literature only a few authors have written about the KOSAP project (see e.g. Pedersen, 2016; Harrington, 2020). This study will delve deeper into the KOSAP project as a mechanism used for developing larger scale deployments of mini-grids in partnership with the government and how it achieves the pillars of inclusiveness, permanence and external resources through a combination of electrification modes.

A respondent from the Ministry of Energy commented:

> KOSAP is one of our latest innovative approaches – because it's looking at how public (sector) funds can leverage private sector [funds] and support the private sector to multiply the rate of electrification (ME K2).

A respondent from the utility also explained:

> The KOSAP programme also has rooftop solar projects, it's not all about mini-grids, there is also provision of rooftop solar and then for those very very far off the mini-grid and so on- then they are given rooftops – they can also have access to electricity. So, if you combine all of this grid extension through the Last Mile, then you do this KOSAP, you would see us move towards 2022 agenda (Utility K1).

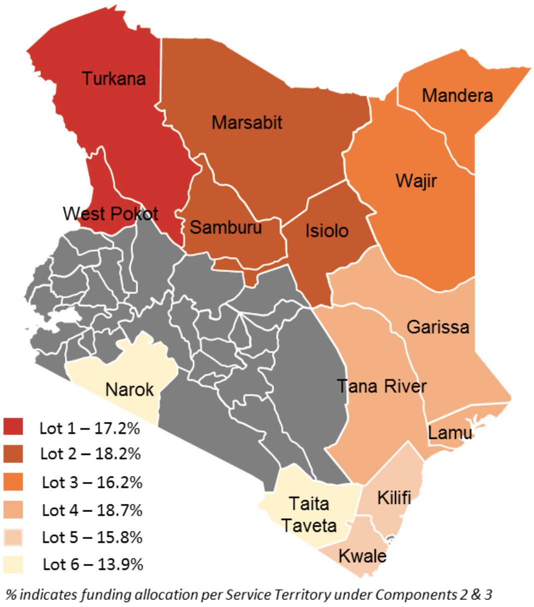
This project is also a key example of PPPs and emerging financing models to address the viability gap and will be discussed in more detail in Chapter 6.

4.2.4 The role of the off-grid sector in Kenya's electrification landscape

4.2.4.1 Mini-grids

In recent years Kenya has seen significant interest in mini-grid development and is viewed as a hub or test bed for mini-grid projects in Sub-Saharan Africa (ESMAP, Ministry of Energy & African Mini-grid Deverlopers Aassociation [AMDA], 2023). While still serving a relatively small percentage of customers compared to the number of customers served by the main grid, mini-grids are set to play an important role in reaching universal access to electricity (Power Africa, 2019a; ESMAP, Ministry of Energy & AMDA, 2023). Kenya has a range of private mini-grid developers including PowerGen, SteamaCo, Renewvia and RVE.SOL. According to ESMAP, Ministry of Energy & AMDA (2023) there are currently over fifty private mini-grids that are operational and one hundred and fifty under development.

Mini-grids are more likely to be successfully deployed if they are incorporated into national electrification planning (USAID, African Union & Power Africa, 2021; ESMAP, 2022). Having a clearly defined place and role for mini-grids in the national electrification plan could reduce regulatory risk and uncertainty and facilitate investment in the sector. This is essential for de-risking mini-grids and increasing investment into the sector. The regulatory framework and environment for mini-grids plays a critical role in both the sustainability and *permanence* of mini-grid projects, by creating an environment for mini-grid developers to be able to continually invest and expand their investments in current and new projects. It also directly links to the IDF pillar of *external finance as* the regulatory environment plays an important role in bringing in investment into mini-grid projects. The above all have an impact on the viability of mini-grid projects and the scale that can be achieved. As noted in Section 4.2.2, the KNES accounted for the sites that would be developed under KOSAP in a PPP with the utility Kenya Power and REREC (Ministry of Energy, 2018). The role that mini-grids are envisaged to play in national electrification planning will also impact the level of scale mini-grids can achieve. However, the 35 000 projected connections in the KNES only include the 137[40] micro-grid sites under the KOSAP PPP model and not private sector models (see Figure 8).



Lot/ Service Territory	County	Mini-grid Sites
1 Northwest	West Pokot	26
	Turkana	
2 North	Marsabit	29
	Samburu	
	Isiolo	
3 Northeast	Mandera	32
	Wajir	
4 East	Garissa	23
	Tana River	
	Lamu	
5 Southeast	Kilifi	1
	Kwale	
6 South	Taita Taveta	10
	Narok	
	Total	121

Figure 8: Map of KOSAP mini-grid sites (Lots) in Kenya (Ministry of Energy, 2018)

While the KNES does not explicitly mention the potential for mini-grid deployments under a pure private sector model (and PPP models outside of KOSAP), an interview respondent from the utility commented:

> When we moved into our Kenya National Electrification Strategy, we are now looking at the private sector giving us what models can be sustainable so that they can start off, identify sites, give us a Power Purchase Agreement (PPA) framework that they can be able to develop and then thereafter how will they be able to recoup their investments so then that one now comes in beyond KOSAP (Utility K1).

[40] The number of lost has been updated from 6 to 8 in 2023 bid issued by Kenya Power for the tendering of KOSAP mini-grid sites

This indicates that in principle there is an openness from the utility to accept proposals beyond KOSAP. The section above provided an overview of mini-grids in Kenya's off-grid sector and the importance of being into national electrification planning. This links to the IDF framing, particularly pillar 1, *A commitment to universal access including* sub-pillars on *permanence* and *a long-term vision of the power sector*, and Pillar 2, *coordinated and integrated grid and off-grid technologies.*

4.2.4.2 Off-grid stand-alone systems

With respect to off-grid connections, the KNES highlights that there is a significant role for off-grid solar home systems in closing the electrification gap. The KNES also highlights the high penetration solar home systems have achieved, and the role that off-grid solar home systems can play in achieving universal access. In Kenya, the MPESA (a mobile money payment platform) has been integral to the pay- as- you- go models (Ministry of Energy, 2018). However, consideration is needed for the level of access that can be achieved with off-grid solar home systems, which are limited in terms of the tiers of access or productive uses. While solar home systems have had a significant penetration in Kenya, and are acknowledged as a key part of national electrification planning, in many cases these are entry level and transitory solutions. Due consideration should be given to transitioning households with solar home systems to mini-grids and the grid where appropriate, or providing households with higher tier options, even if they choose to have solar home systems as a back-up (OGSK1).

4.2.5 Key regulations for mini-grids and stand-alone solar systems in Kenya

As argued in Section 2.5, a country's regulatory framework needs to be predictable but provide sufficient flexibility. A recent ESMAP report highlights that the aim of a regulatory framework for mini-grids should be to promote quality service at the lowest possible tariffs for cost recovery and that this needs to be considered throughout the development of the different stages of a country's mini-grid sector, with consideration to subsidies and the national electrification strategy (ESMAP, 2022). A key recent development from the Energy Act of 2019, is the Energy (Mini-grid) Regulations of 2021. These mini-grid regulations apply to all 'Mini-Grids with installed capacity of up to 1 MW including Public Mini-Grids, the owners, operators, and users of the Mini-Grids as well as all other private or public stakeholders' (EPRA, 2021: 1). These regulations are an important development in Kenya's mini-grid market, as a clear and enabling policy and regulatory environment is imperative for creating a conducive climate for mini-grid developers to develop projects and secure investment into mini-grid projects as discussed in Section 2.5.2. As mentioned, regulation for mini-grids need to be sufficiently robust to protect end-users with respect to the tariffs charged and quality of service provided and give the private sector the confidence to invest (Bhattacharyya & Palit, 2016; Pérez-Arriaga, 2016; Waissbein et al., 2018). This is a key aspect which affects the viability gap for mini-grids and will be further discussed in Chapter 5.

Within a rapidly changing environment, private sector participation in mini-grids often precedes the development of a regulatory framework for the sector, and regulations often need to be developed in consultation with other stakeholders and partners. In this regard, in 2018, the German Development Coorporation (GIZ) as a development partner in Kenya, has worked closely with the regulator to develop the mini-grid licensing framework. As one development partner explained:

> We worked with the Ministry of Energy and the Regulator to see where there is a need to make it very clear, so the business of mini-grids is a straightforward process. So together we have developed what we call the mini-grid regulations, based on the current law. Once that is out it would be a good step forward in the mini-grid industry, because the law will be there, everything will be clear (IDO K1).

In addition to developing mini-grid specific regulations, Kenya has also embarked on hybridising existing diesel mini-grids into solar diesel hybrid mini-grids. Kenya furthermore plans to develop future public mini-grids as part of the Kenya Electrification Modernization Programme (KEMP), which also include tendering of new mini-grid sites. These initiatives in conjunction with KOSAP are set to revive the mini-grid sector (Power Africa, 2019).

The new mini-grid regulations also make provision for the arrival of the grid and provide a few options in the event of grid arrival. With respect to these regulations and how they are being developed a development partner commented:

> The mini-grid regulation addresses that (i.e., grid arrival) and that's one of the main highlights of the regulations, because it gives three options when the grid arrives. One of the options is when the grid arrives there will be a small generation PPA, power purchase agreement, that is the mini-grid operator will remain in place at this generation system and sign a Power Purchase Agreement with the utility, to feed into the grid, then he will sell of the distribution network, to the utility (IDO K1).
>
> The other model will be the utility to buy off the mini-grid, the whole system. They buy off the generation and distribution system at a fair price and that will be negotiated in the presence of the regulator, so that its fair deal to both of them (IDO K1).

The first two options mentioned are quite different as the first option still allows mini-grid developers to generate electricity and serve in effect as a small power producer. The second option involves the utility buying the whole system from the developer, in which case the developers will not be involved in any aspect of mini-grid development on that site going forward and just be compensated for portion of their assets. Interestingly the third option below is almost a reverse of the first option where the developer would purchase power from the utility and remain as a distributor of the power.

> The other option would be for the mini-grid developer to buy energy from the utility in bulk. The grid has arrived, I remain the distributor in that locality, but I buy from the utility. That's a good one because instead of adding batteries to my mini-grid, I get power from the utility, and I continue (powering) my customers in that area (IDO, K1).

Notwithstanding the importance of these mini-grid regulations for the sector, it has received critique for not fully detailing exactly how private developers would be compensated in the event of grid arrival. For example, a roundtable held this year with AMDA, Renewable Energy Performance Platform (REPP) managed by Camco and other off-grid sector representatives, found that while the draft regulations incorporated a wide range of stakeholder views, there is still a need for more clarity on compensation mechanisms for private mini-grid developers in the event of grid arrival and for further engagement and to sensitise investors and the broader public about what these regulations would mean for the mini-grid industry (ESI, 2021).

Turning to off-grid solar home systems, the Energy Act of 2019 also provided for the revision of the 2012 Energy (Solar Photovoltaic Systems) Regulations (Energy Act 2019), to guide the installation and import of PV systems. These regulations required all solar PV installers to obtain a license from EPRA, based on different capacities of the solar PV system (EED Advisory, 2018). According to EED Advisory (2018) there was still a grey area in the regulatory framework for solar home system providers. This could be the result of the period in between the revision of the solar home system standards, as well as the changing regulations on solar Value Added Tax (VAT) exemption. EPRA reviewed the 2012 solar PV regulations in consultation with different stakeholders to identify gaps in the regulation and to update it in accordance with the Energy Act of 2019. In 2021, EPRA published an impact statement detailing the impact of the regulations on the solar industry. The statement highlighted that the regulations played a significant role in streamlining Kenya's solar PV industry and establishing 700 licensed solar technicians and 500 registered solar companies.

In the last few years Kenya's VAT policy on off-grid stand-alone solar has also changed several times. In June 2020, the 2020 Finance Bill was passed, which introduced a 14% VAT on off-grid solar products, altering the previously favourable VAT regime on off-grid solar products. In response to this development, the Global Off-grid Lighting Association (GOGLA) issued a statement highlighting how this would negatively affect the diffusion of off-grid solar products (GOGLA, 2021). This included increasing the prices of off-grid solar products which negatively impacts affordability especially for low-income customers, which will be further discussed in Section 5.3.3. In 2021, the Finance Act of 2021 was passed and reintroduced the VAT exemptions on renewable energy products including solar as well as wind and clean cooking technologies (GOGLA, 2021). This also illustrates the advocacy role industry associations play on behalf of the solar industry and lobbying on behalf of certain stakeholders.

4.2.6 The role and interaction between key institutional actors in Kenya's off-grid sector

The evolving policy and regulatory context in which the off-grid sector in Kenya is developing, made provision for several public sector entities including the regulator, EPRA and electrification agency REREC. In addition, international development[41] partners have also worked with the government to shape the regulatory environment and have directed funding into the sector. As mentioned in the sector above, industry associations have also played a key role in lobbying for favourable conditions on behalf of the private sector, as illustrated in the reversal of the VAT decisions on solar products. Table 10 presents a summary of the key institutional actors in Kenya's off-grid sector.

Table 10: Key institutional actors - roles in off-grid sector (Author's table)

Name of Institutional Actor	Key role and function for off-grid electrification
Ministry of Energy	Responsible for direction and oversight into key sector policies to guide the off-grid sector
Kenya Power	Working with REREC to develop public mini-grids – retailing electricity from public mini-grids to the customer
REREC	Working with Kenya Power to develop public mini-grids, electrification of rural social institutions like schools and clinics

[41] For example, the KNES was developed in consultation with the World Bank and other international development partners (Harrington, 2020).

EPRA	Regulatory oversight in the off-grid sector; licensing of mini-grids; approval of tariffs; oversight of quality standards for off-grid solar; guidelines for solar PV installers
Private mini-grid developers	Developing private sector mini-grids; various functions in the value chain (build, own, operate and maintain)
Private sector stand-alone system companies	Selling and installation of off-grid solar PV stand-alone systems (pico-solar and solar home systems)
International development partners	Financing large scale national electrification projects; technical advisory to the Ministry of Energy and Regulator
Industry associations	Advocacy; lobbying on behalf of the private sector; a collective voice for private sector organisations

Ogeya, Senyangwa and Lambe (2021) highlight that there are several actors in Kenya's off-grid mini-grid sector which include a mix of public sector and private sector actors. Industry association actors including KEREA, AMDA and GOGLA, are well coordinated (Ogeya, Senyangwa and Lambe, 2021). For example, ESMAP (2022) highlights how industry associations like AMDA can facilitate collaboration and can also serve as intermediaries between local and international entities. AMDA has a membership of 40 mini-grid developers operating a portfolio of mini-grids in Sub-Saharan Africa (ESMAP, 2022), with a significant membership in Kenya and East Africa. The association furthermore represents a unified voice for its members while also negotiating deals on behalf of members and suppliers. AMDA also collects data from their members which a data driven allows for data driven opportunities.

Several of the same institutional actors also play a key role in Kenya's off-grid stand-alone sector. Harrington (2020) explored the role of institutional intermediaries, with a specific focus on the 'last mile' off-grid solar market segment in Kenya and noted the role of organisations like GOGLA and KEREA as intermediaries between the policy sphere and the private sector, and facilitating compliance with regulation (Harrington, 2020). Harrington (2020) also acknowledges coordination between the private sector, non-profits, international donor organisations and financial institutions in Kenya. While there is a degree of coordination within the stakeholder categories e.g., within the public sector between Kenya Power and REREC, who have a long history in working together to develop mini-grids, between development partners (donors) themselves, and between industry associations like KEREA and GOGLA, coordination between different categories of institutional actors (i.e. public, private and donor) can be strengthened. This is important when considering more integrated electrification paradigms and the key tenets of the IDF introduced in Section 2.2. Furthermore, while there is coordination in electrification planning at a high national level more is needed at the granular level of business models and sector actors on the ground.

Taneja (2019), however, offers a critique that multi-lateral donors and investors are often competing to meet electricity needs and targets in Kenya, which places different technologies against one another for the same consumer mini-grid market, as opposed to acknowledging the respective strengths of the different technologies and meeting needs in an integrated manner. This results in individual entities, specialising in technologies i.e., grid, mini-grids or solar home systems but applying this universally not necessarily where the technology is the best fit for certain consumer segments. KOSAP is deploying mini-grids in low-density parts of North and Northeast. Rather technologies should not just be chosen by region, but by should be matched to the individual communities where they can provide the lowest cost and sufficient supply (Taneja, 2019). Therefore, notwithstanding the positive steps that have been made to coordinate parts of the off-grid sector, this thesis will look deeper into the principles of the IDF to explore how more integrated electrification paradigms can be applied to aspects of financing, partnerships and off-grid business models.

The above has shown key policies, regulation, legislation and policy in shaping Kenya's electricity sector and the role of off-grid technologies. Kenya has combined grid and off-grid electrification modes in its approach to achieving universal access, reflected in its Energy Policy and the KNES, and has made notable progress in increasing its electrification access. Policies and legislation have a key role in achieving IDF pillars and have a direct bearing on *inclusiveness* and *permanence* and the long-term vision of the power sector. It impacts the prioritisation of the mix of grid and off-grid technologies and ultimately how external *finance is directed in the sector*. The off-grid sector, particularly off grid solar home systems, and micro-grids have been highlighted as important for closing the access gap going forward. While these developments auger well for off-grid participation, there are still issues around clarity of mini-grid development licensing which should be made clearer in the mini-grid specific regulation. It also has a direct impact on the regulatory landscape guiding off-grid development and the viability gap for off-grid business models. The above section discussed the policy, regulatory and institutional environment as well as key electrification programmes for Kenya. Section 4.3 will discuss the same for the Rwandan context.

4.3 Rwanda's electricity sector

4.3.1 Towards universal access to electricity in Rwanda – policies and progress

Comparable to Kenya, the Government of Rwanda embarked on an ambitious [42] electrification rollout and aims to achieve universal access to electricity by 2024. Increasing access to electricity is a key objective for the government of Rwanda (EDCL, 2022). According to the national utility the Rwanda Energy Group (REG) the cumulative energy access rate is 74.5% with 50.9% of households being connected to the national grid and 23.6% accessing electricity primarily through off-grid solar systems (REG, 2023). Beyond 2024 it is envisaged that 70% of households will be connected to the national grid and 30% through off-grid solutions, which has a direct impact on the technologies that are being prioritized in national electrification planning and the types of partnerships that are formed between the public and private sector entities providing electricity. The Government of Rwanda demonstrated their commitment to achieving universal access, through policy and regulation and key electrification programmes (see Figure 9); most notably the Energy Access Rollout Programme (EARP) and Sector Wide Approach (SWAp), which were instrumental in Rwanda's rapid electrification scale up from a very low access rate; approximately 6% post the genocide.

[42] Rwanda's universal electrification target forms part of the National Strategy for Transformation (NST1), priority area number 5. The Energy Sector Strategic Plan (EESP; 2017/ 18 – 2023 -24), guides the implementation of the power sector agenda of the NST 1.

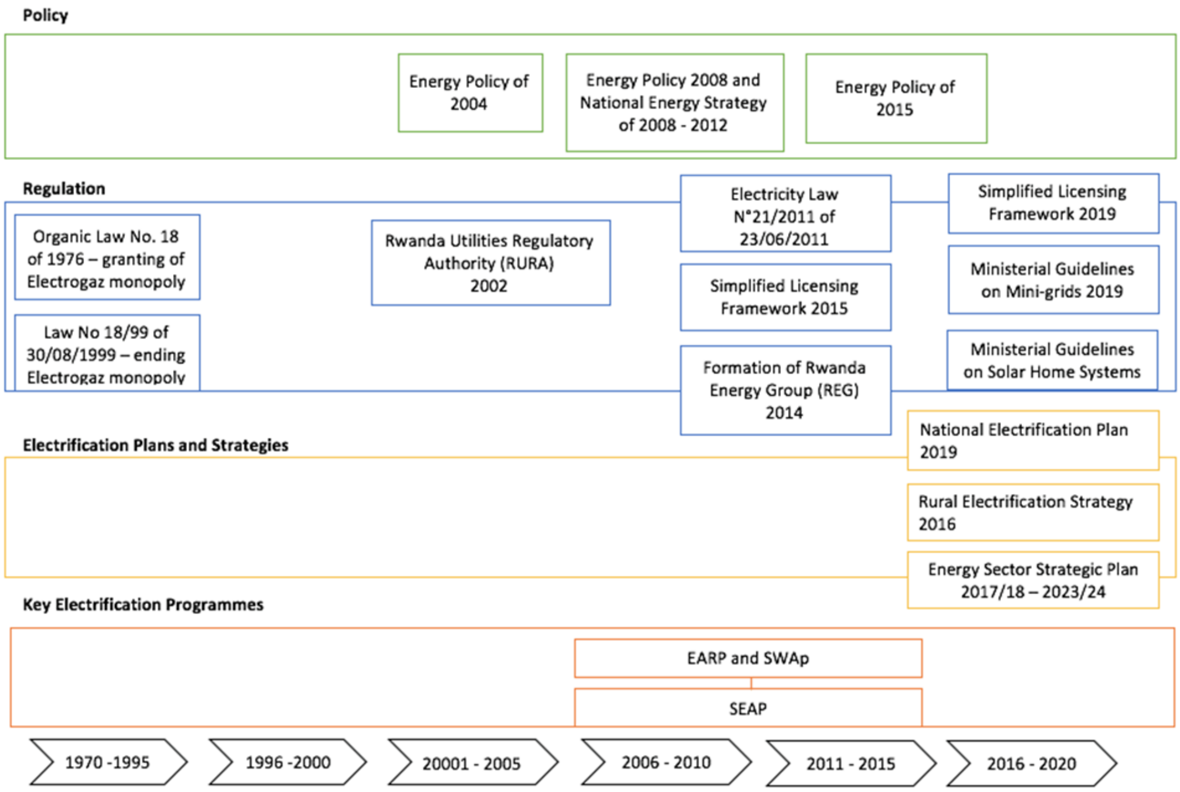


Figure 9:Rwanda policy and regulatory landscape (Author's figure)

The Rwanda Energy Policy of 2015, following the Energy Policies of 2004 and 2008, was an important milestone in Rwanda's energy policy landscape; it was the first policy to adopt a long-term outlook to energy planning, covering a broad range of issues affecting the sector. This long-term outlook is an important aspect of the IDF framework, and the pillar of *permanence* as highlighted in Section 2.2. The overarching policy objective for electricity access in the Energy Policy of 2015 is to,'enhance access to sustainable, modern energy services for all Rwandans' (MININFRA, 2015: IV - 10). The Energy Policy of 2015 highlights that enabling policy and regulatory frameworks are key to achieving the above objective and will be put in place to facilitate increased investment and private sector participation in the off-grid sector, also looking at partnerships and innovative business models. In particular the policy aims to create a conducive environment for 'off-grid energy service provision including the development of distributed, small-scale renewable energy solutions and business models '(MININFRA, 2015: 20). Key objectives of the policy, as outlined in MININFRA (2015), include:

- Harmonisation and clarity of grid and off-grid approaches;
- Piloting of new approaches and scaling up innovative partnerships to increase energy access through distributed renewable technologies;
- Simplification of licensing and increasing the attractiveness for private operators to service the off- grid electricity market;
- Scaling-up of innovative partnerships to increase rural access to appropriate off-grid solutions;
- Introduction of greater competition and flexibility in off-grid service provision;
- Development of financial support mechanisms for off-grid service provision and consumption.

From the above objectives, off-grid electrification modalities, innovative partnerships and business models are prioritised, but as will be discussed in Sections 4.3.2 and 4.2.6, within the off-grid sector, off-grid stand-alone systems and mini-grids are prioritised differently, with a greater focus on deploying solar home systems and less of a focus on mini-grids[43]. Incorporating off-grid electrification modes and models into the country's energy policy is imperative as this sets the tone for regulation and energy strategies. Making provision for off-grid models and showing the intention to incentivise private sector participation in off-grid electrification is a first step to actualizing off-grid electrification targets. This plays an important role for IDF pillar 2, *a coordinated and efficient mix of grid and off-grid technologies* but also other IDF pillars including e.g. pillar 3 on *viable business models and external finance.*

In 2013 the government indicated their intentions to separate functions of energy from water and sanitation, which saw the formation of a new wholly government owned utility company in 2014, the Rwanda Energy Group (REG), comprising two subsidiaries: Energy Utility Corporation Ltd. (EUCL) and the Energy Development Corporation Ltd. (EDCL) (World Bank, 2019). EDCL oversees extending the grid and EUCL oversees operations and maintenance and retailing (Utility R1, Power Africa, 2019).

A second key aspect of Rwanda's energy sector development was the introduction of an independent regulator in the sector. In 2002 the Rwanda Utilities Regulatory Authority (RURA) was created to independently regulate government utilities including electricity. RURA plays an important role in licensing of mini-grids and tariff approval, and the development of a regulatory framework for mini-

[43] Although there are a few mini-grid developers still actively operating in Rwanda, MININFRA has prioritised national grid extension in its universal access approach, complemented by off-grid solar home systems, with less room for mini-grid development.

grids (as will be discussed in Section 4.3.4). This further has an impact on the viability gap of mini-grid projects and regulatory certainty in the sector.

4.3.2 National Electrification Plan (NEP)

The National Electrification Plan (NEP) is an important document in Rwanda's universal electrification strategy as it provides for the least cost options for grid extension and off-grid electrification and delineates areas marked for grid and off-grid connections (see Figure 10). This is important for IDF pillar 1, *a commitment to universal access*. The plan has gone through several revisions.

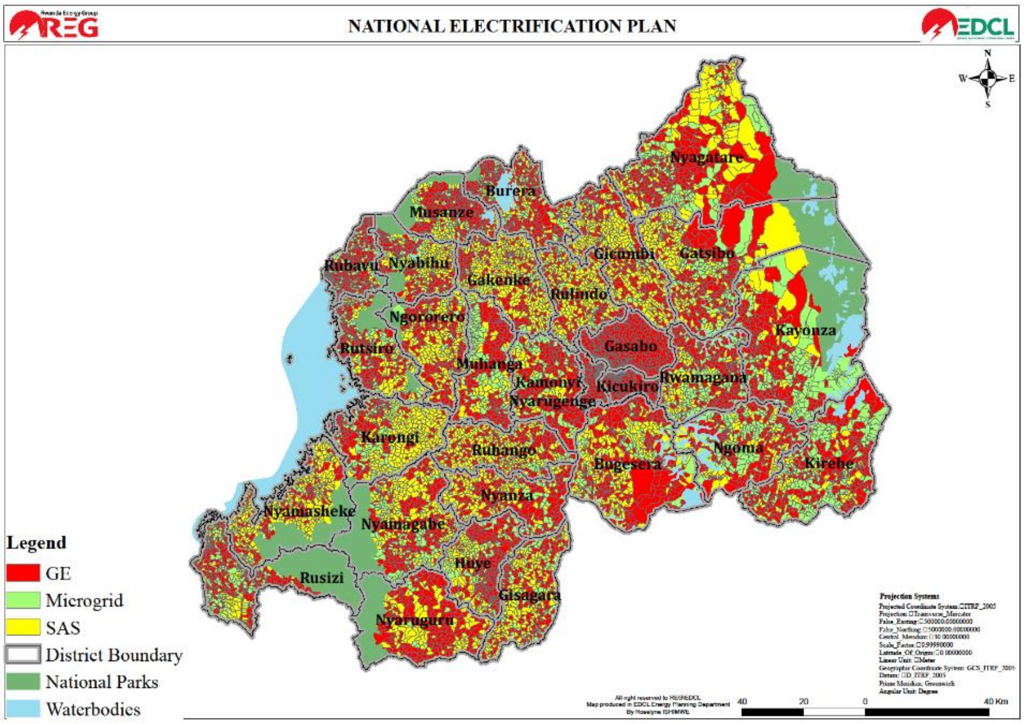


Figure 10: NEP[44] map delineating grid and off-grid sites (REG, 2019)

In 2019, the NEP was published and stated that the grid would reach 52% of the population and that off-grid connections will serve 48% of the population by 2024. Of the 48%, 10% constitutes areas reserved for micro-grids and 38% stand-alone systems. Within 38% earmarked for stand-alone systems, 7% of the households could be served through micro-grids and stand-alone systems (REG, 2019). In August 2022, EDCL released a concept note for the revision to the NEP for the period 2022 to 2024, which stated that 88.9% of all villages fell within the on-grid zone while 11% of all villages fell

[44] In Figure 10 GE refers to the areas delineated for grid electrification and SAS refers to stand-alone solar systems

in the off-grid zone (i.e., to be served by stand-alone solar systems and micro-grids). Specifically, 1.3% are zoned for mini-grids and 9.7% are earmarked for off-grid stand-alone systems. This leaves a relatively small room for mini-grid development in Rwanda. The grid and off-grid split in the NEP has subsequently been revised to 70% grid and 30% off-grid. It should however be noted that these projections in the NEP are also influenced by the institutional priorities of the country and the aim to extend the grid to most of the country by 2024. Thus, it is not necessarily an absolute gauge for the potential for mini-grids purely through a techno-economic perspective but also in terms of the priorities set by the country.

With respect to the impact of the NEP on the off-grid sector and investment, a development partner commented:

> The NEP is a good thing ultimately, it means there will be planning certainty – there is demarcated areas – of course this provides some investor certainty that the grid will not arrive for the next years - that's not a very long time when you look at return on investments for mini-grids. We believe that will be finalised [45]now, in the coming weeks (IDO R2).

Another development partner commented:

> So even the National Electrification Plan, once it's finalised will help companies to say, this is where we should focus more because in other areas the grid might arrive, customers might default (IDO R1).

From the above it can be seen that the NEP is key for planning certainty particularly around things like grid arrival, which is part of de-risking mini-grids and investment into the deployment of such systems. However as will be shown in chapter 5, while national electrification planning is important, there are still periods of regulatory uncertainty and instances where grid encroachment has been a very real challenge for mini-grid developers, and has impacted the viability of their mini-grids and the ability to continue do business within a certain area. An EnDev report further outlines the importance of streamlining mini-grid site selection in accordance with the NEP (EnDev, 2021). It also plays a role in identifying where the gaps are and where companies might need to move into the more challenging

[45] It was the expectation of the interviewees quoted that the NEP (which was being revised at the time of initial interviews in 2019) would provide more clarity on grid/off-grid demarcation. Arguably these revisions and multiple iterations, caused uncertainty for private sector companies developing mini-grids as a result of the iterations and changing demarcations for mini-grids (see interview quotes in Section 5.2.4 (pg. 118) and Section 6.3.2 (pg. 145). As electrification planning is a dynamic process, changes to key planning documents and its potential impact regulatory certainty should be considered.

areas to electrify which has a clear link to the level of *permanence* that can be achieved within an IDF framing. As will be discussed in Chapter 6, it also links the drivers and incentives for off-grid private companies venturing out into the more challenging areas.

4.3.3 Key electrification programmes and strategies

4.3.3.1 Scaling up electricity access programme (SEAP)

The Scaling Up Electricity Access Programme (SEAP) is a programme within the EARP. The SEAP II aims to improve the reliability of power supply and increase grid and off-grid access to electricity. The programme has four main expected outcomes. Results Area 1 aims to improve the reliability of electricity supply. Results Area 2 seeks to increase on-grid areas and productive uses. Results Area 3 focuses on increasing off-grid access to renewable energy, while Results Area 4 examines institutional strengthening and capacity building (AfDB, 2018).

Results Areas 2 and 3 in particular are important for the universal access targets, in accordance with the off-grid focus of the thesis and RBF programmes, which will be analysed in Chapter 6. Results Area 3 focuses on increasing off-grid access to low-income isolated rural households, mainly through solar home systems. In accordance with the NEP, RBF will facilitate selected off-grid solar home system deployments, targeting 124,800 households in the Western and Southern regions where access is less than 50%. 8.7 million Euros is in principal allocated to this area (AfDB, 2018). The bank's RBF facility will be implemented in line with national energy policies and will complement current private sector led off-grid initiatives (AfDB, 2018). This also illustrates the role of energy policy and planning in relation to key sector developments.

4.3.3.2 Rural Electrification Strategy

The Rural Electrification Strategy of 2016 plays a key role in achieving targets set in the Energy Sector Strategic Plan and National Energy Policy 2015, particularly for off-grid electrification. The Rural Electrification Strategy (2016) recognises that alternative technologies like off-grid solar systems and mini-grids are more economically efficient to provide energy access to many households in Rwanda (MININFRA, 2016). In this regard it has adopted the SEforALL Multi-tier Framework, to define access beyond grid connections. A tier 1 system refers to a basic solar home system providing a minimum level of light, phone charging and radio, where a tier 5 system provides 24/7 high power that can power commercial and industrial uses. In essence, the Rural Electrification Programme comprises four key concurrent programmes, with a focus on off-grid solar and mini-grids, as well as grid extension under the EARP (MININFRA, 2016). These programmes are elaborated below (Table 11).

Table 11: Key Programmes in EARP (MININFRA, 2016)

Programme 1	Enabling low-income households to access modern energy services through a basic solar system as a necessity. A subsidy will be given to households in Ubudehe 1 to enable them to access energy for lighting and other basic levels of service through solar home systems. This programme targets 154 000 households in Ubudehe 1, who are eligible to receive this subsidy. Approximately 2000 systems have been installed to date through donations from government institutions and private companies. Private companies are involved with the installation/ dissemination of these systems through a procurement system. 24 of the 27 off-grid solar companies operating in Rwanda have signed a cooperation agreement with EDCL to participate the tender programme.
Programme 2	A risk-mitigation facility for solar home systems targeting the private sector such that solar products will be made available on financial terms that the population can afford. This programme targets Ubudehe 2, 3 and 4 households that meet set eligibility criteria. Funds to implement this programme come from the Scaling up Renewable Energy Programme (SREP). The 24 companies who have signed the cooperation agreement to be part of programme 1 are eligible to participate in programme 2.
Programme 3	A risk mitigation facility for mini-grids - mini-grids will be developed by the private sector with Government playing a key role in identifying sites and establishing a framework through which these can become financially viable investments. The SREP fund will also be used to implement this programme. This programme targets Ubudehe 3 and 4 households.
Programme 4	Grid extension through the EARP. Government will continue to roll out the electricity network via EARP, focusing on connecting high consumption users and driving economic growth. This programme primarily targets Ubudehe 3 and 4 households and productive uses of energy.

These programmes all form part of the Government of Rwanda's approach to address universal access targets. The next section will discuss key regulations for the off-grid sector in Rwanda.

4.3.4 Key regulation for the off-grid sector in Rwanda

4.3.4.1 Simplified Licensing Framework for Rural Electrification

The Simplified Licensing Framework for Rural Electrification was introduced by the regulatory authority RURA, through regulation No 01/R/EL- EWS/ RURA/ 2015, to fast track and simplify the process of applying for licenses for small and medium power generation and distribution activities to quicken the deployment of off-grid electrification projects (RURA, 2015). The framework outlines the process of applying for a license as well as options for the sale of generation and distribution assets in the event of grid arrival. Exemptions from the regulation included:

I. 'Large isolated [46]grids that, at the time of commissioning or subsequently following expansion, have total net generating capacity that is connected to the Isolated Grid of more than one (1) MW'
II. 'Very Small Isolated Grids that, at the time of commissioning or subsequently following expansion, have total net generation capacity of less than 50 kW (< 50 kW) shall be exempted from licenses issued under this Regulation. The Developer of a Very Small (<50kW) Isolated Grid shall however notify the Authority on such activity prior to its commencement.'

In June 2019, RURA published a revised version of the Simplified Licensing Framework Regulation No 03/R/EL-EWS/RURA/2019 to address some of the shortcomings of the 2015 version as reflected in the comments of two interview respondents below. One international development partner in Rwanda commented:

> RURA has done a great job, they came out with the Simplified Licensing Framework in 2015/ 2016 and it was actually quite a good document – but it did not provide enough clarity on issues relating to grid extension, to tariffs and there was not much in the way of technical standards. The World Bank responded to those needs and a group of ESMAP consultants, worked on improving the guidelines for the past 6-8 months now. They recently had a consultation where they provided the first draft. There was more clarification on all of the matters (IDO R2).

[46] From an IRENA report the mini-grid framework applies to mini- grid projects with generating capacity of up to 1 MW; projects with 100 kW or less are eligible for simplified and streamlined licensing, and mini-grids below 50 kW are exempt from licensing requirements

Another development partner commented:

> RURA has the Simplified Licensing Framework, which is pretty good. The World Bank is working with RURA to revise this framework and they're almost finished with that. The revisions look good. They make certain things a little more specific. The one concern about the current draft is whether or not grid compensation is adequate if the grid arrives, which is critically important for investors. Provided comments to the Regulator. They want to finalise relatively soon (IDO R3).

Where the 2015 Simplified Licensing Framework exempted Very Small Isolated Grids (< 50kW) from licensing, the 2019 version requires very small, isolated grids to register their sites – apply for a registration certificate and introduced a registration procedure for these types of projects. Very Small Isolated Grids will now be required to register their projects with RURA, but do not need to apply for the licensing procedure followed Small and Medium Isolated Grids.

4.3.4.2 Ministerial Guidelines on Mini-grid Development

In June 2019 MININFRA issued Ministerial Guidelines on Mini-grid Development. The Ministerial Guidelines were created as a guiding framework for private mini-grid developers who are interested to develop the sites demarcated for off-grid mini-grids in the NEP. The purpose of the guidelines is to simplify the process of mini-grid development and create clarity for prospective mini-grid developers and investors. The overall objective is to facilitate the deployment of mini-grids as per the 300 000 connections per year highlighted in the Energy Sector Strategic Plan (ESSP), in line with the 2024 universal access target. The Ministerial Guidelines furthermore outline the procedure for both solicited and unsolicited proposals for mini-grid site development. Prior to the publication of these Ministerial guidelines there was some uncertainty about whether the government would allow both solicited and unsolicited proposals for mini-grid site development (MININFRA, 2019). In this regard, in May 2019, one development partner commented:

> Ministerial guidelines are being drafted on how governments will tender future mini-grid sites. …But the big question is, is this the only avenue for the development of mini-grids, because if you cannot have unsolicited proposals, if developers cannot go out and scope and pick their own sites and development it will basically kill the sector, and innovation in the sector and that has been a bit unclear from what has been released by the government…..I would hope that there could be parallel channels of solicited and unsolicited site mini-development (IDO R3).

This shows the private sector being able to have the freedom to scope out sites and develop sites privately alongside tendering of mini-grid sites, is something which is considered important for mini-grid development and innovation in the sector (IDO R3, Mini-grid R2). This will be explored in more detail in Chapter 6 which delves into the trade-offs between *open market freedom* and *directed development* for mini-grid sites. Another development partner commented:

> I'm not sure exactly how it's going to go. There's definitely going to be tendered sites. [.....] I think the companies would prefer to do their own feasibility studies because there are so many different technologies, so many assumptions that impacts a feasibility study. In terms of unsolicited, I think if there's money provided by the donors, say for a continuation of an RBF or a continuation of a SOGER programme – they'll allow it (IDO R2).

Therefore, clarity on things like tendered mini-grids and private developers being able to select and develop their own sites are aspects that are important to developers and impacts clarity on the types of mini-grid projects that would be possible.

4.3.5 The role and interaction between key institutional actors in Rwanda's off-grid sector

A notable feature of Rwanda's institutional environment is the coordination between institutional stakeholders who are involved in off-grid electrification (see Table 12). A unique model to Rwanda is where the utility REG partnered with off-grid solar companies to reach REG and MININFRA's off-grid electrification targets. REG signed an *Imihigo* (performance contract) with specific targets for both grid and off-grid electrification and have recognised off-grid solar companies as strategic partners for achieving their off-grid targets. In accordance with this approach, EDCL (a subsidiary of the utility REG) signed memorandums of understanding (MOU) with 24 private solar companies in Rwanda to scale-up the deployments of solar home systems in the country, improve the value chain and bring solar solutions close to households. This has contributed to the off-grid electrification achieved through off-grid solutions, primarily solar home systems [47].

Table 12: Key institutional actors for off-grid electrification in Rwanda

Key intuitional actors	***Name of entity***	***Key role and function for off-grid electrification***
Energy Ministry	MININFRA	Energy policy formulation and strategic guidance for energy sector, including off-grid sector.
Utility	REG-EDCL	Management of joint REG and MININFRA electrification targets. Management of RBF facility

[47] https://www.reg.rw/what-we-do/offgrid-solutions/solar-home-systems/

Regulator	RURA	Tariff approvals and licensing of mini-grids and issuing of Minimum Standards for off-grid solar home systems
Financing	Development Bank of Rwanda (BRD)	Providing loans to mini-grid companies
Off-grid stand-alone solar companies	Range of off-grid solar home companies	Working with the utility to reach the off-grid government electrification targets for
Private mini-grid developers	Private mini-grid developers (including MeshPower, ARC Power)	Developing private mini-grids (build, own, operating mini-grids)
International development partners	World Bank, EnDev, Enabel etc	Financing off-grid development (including RFB finance); working with the private sector to develop viable business models; advocating on behalf of the private sector
International NGOs	Energy4Impact	Working with mini-grid developers including local developers to improve demand stimulation

In addition to the *Imihigo* and MOUs, the formation of Sector and Technical working groups plays an important role in the institutional coordination. These Sector and Technical working groups allow key sector stakeholders from the public, private and international development partner sectors to be updated on key sector developments and provide comment on new policy directions and regulations. This will be further elaborated in Chapters 6 and 8, which explore how this level of coordination has enhanced off-grid electrification but also some of the complexities of making this work.

Institutional priorities have a significant influence on the electrification trajectory of a country. Rwanda's approach is guided by a grid paradigm beyond 2024 (driven by MININFRA and primarily implemented by REG), which has an impact on the technologies that will be prioritised in the short term and how these technologies would need to be integrated in the longer-term grid electrification future (ME R2). Paradoxically while some aspects of the small physical geography in Rwanda make it possible to theoretically extend the grid throughout the country, other geographical considerations make it challenging. As Rwanda is a much smaller country than Kenya, in terms of physical size and high population density, it makes it possible to extend the grid to the whole or most of the country beyond 2024 (Pérez-Arriaga et al., 2020; Ministry R1; IDO R1). However certain aspects like hilly terrain and remote dispersed populations make grid extension challenging (Bisaga, 2018; Pérez-Arriaga et al., 2020).

While Rwanda has included grid and off-grid technologies in their universal electrification targets for 2024, as highlighted in Section 4.3.2 , beyond 2024 they are prioritising the grid. Interestingly though, while the utility, REG, has a clear partnership with off-grid stand-alone solar companies to achieve joint off-grid targets, there is not same level of partnership in Rwanda between the utility and mini-grid developers. Although mini-grid companies are also part of the Technical and Sector Working Group meetings, the utility has not collaborated[48] with mini-grid developers on joint site development in the deployment of mini-grids to the extent it has with off-grid solar companies. One reason for the distinction in approach could relate to Rwanda's prioritisation of the grid beyond the 2024 target. Rwanda's aim to extend the grid throughout the country after interim 2024 targets have been achieved (or achieved in part at least) could result in the choice to prioritise the deployment of off-grid solar which are modular, fast and easily deployable and do not depend on the set-up of physical infrastructure assets that need to be built in accordance with the grid code. Thus, in one sense it may seem easier to deploy off-grid solar home systems as it does not appear to be in direct competition with grid extension. This has had notable implications for mini-grid development in Rwanda. In 2019, when initial interviews were conducted in Rwanda, the sector was still nascent with a few operators including Absolute Energy, MeshPower, Hobuka, Nestletec, RENERG, ECOS, Equatorial Power (EnDev, 2019, Mini-grid R3). Most of these mini-grids have received RBF finance as will be elaborated in Sections 5.2.1 and 6.3.1. However, in contrast to Kenya, who developed their nascent mini-grid sector through RBF and other financing models, the mini-grid sector in Rwanda has considerably slowed down, with fewer developers still operating (including MeshPower and ARC Power[49]) and some having pulled out investment in Rwanda (Mini-grid R3). As detailed through the interviewee perspectives on the Ministerial guidelines for Mini-grid development, there appears to be a move towards solicited proposals for mini-grid development and as will be detailed in sections Chapters 5, 6 and 8, the overall institutional preference for national grid electrification has had notable impacts on mini-grid development in Rwanda.

Like Kenya, the Rwandan energy sector has seen notable progress in improving energy access, within a very short space of time. Rwanda has clearly highlighted the respective contributions of grid and off-grid connections as of their electrification plan and have put specific regulations in place for off-grid

[48] Except for a more recent model where ARC power is collaborating with the government. Previously some local developers operating micro-hydro powered mini-grids also partnered with the utility.

[49]ARC Power is partnering with MECS to run an electric pressure-cooking trial on ARC power mini-grid sites which are operating in partnership with the Government of Rwanda (Modern Energy Cooking Services [MECS], 2023)

sector participation including the Simplified Licensing Framework for Rural Electrification and the recent Ministerial Guidelines on Mini-grid development, which aims to facilitate off-grid mini-grid development and further private sector development in the sector. However, there is still a lack of clarity pertaining to issues of off-grid development and regulatory certainty as key documents including the NEP and other documents are being revised and finalised. Notwithstanding the progress made, there is still significant work that needs to be done to close the electrification gap.

4.4 Conclusion

This chapter has shown the progress and challenges towards universal access in Kenya and Rwanda and the role key policies, legislation and regulation have played in the structure of the electricity sector and programmes that have been implemented to advance electrification. It also showed the role of institutional priorities in the types of technologies in the electrification mix and the relative role of mini-grids and solar home systems and how they are prioritised in the development of a country's infrastructure. Linking this back to the theoretical framing of the study, the IDF, the chapter demonstrated how the pillar of permanence, inclusivity, a combination of technologies and external resources are impacted by policies and regulations. As shown, policies and institutional vision have a bearing on which projects are prioritised in the energy mix including where mini-grids will be developed and attendant investment in the sector and how the risk of grid encroachment will be managed. These factors all have an impact on the viability gap in the sector. The policy and regulatory environment of a country are key factors that affect the achievement of SDG 7 and impacts the institutional priorities and nature of collaboration and partnerships between, public private and donor actors in a country's electrification market. This has a direct impact on the types of partnerships that can be formed.

Chapter 5 – Viability of off-grid electrification models

5.1 Introduction

Achieving universal electrification requires viable and scalable models for electrification. Chapter 4 provided an overview of the policy, regulatory and institutional context guiding electrification in Kenya and Rwanda, which is imperative for addressing the viability gap for mini-grids and stand-alone solar systems. The abovementioned contextual factors also play a key role in implementing the pillars of the IDF. The policy, regulatory and institutional contexts determine the landscape for the deployment of off-grid technologies and impacts tariffs and revenues, regulatory certainty, regulatory risk and the types of combinations of technologies in a country's electrification mix. Building on this context, Chapter 5 investigates the factors influencing the viability of off-grid business models drawing on data from the semi-structured interviews, grey and academic literature including key recent reports on the Kenyan and Rwandan off-grid sectors. Chapter 5 responds most directly to Research Question 1, namely, '*What are the key factors impacting the viability gap for off-grid stand-alone solar and mini-grid businesses in Kenya and Rwanda'?*

As highlighted in Section 2.2.4, the viability gap is increasingly important to consider when developing off-grid electrification models that work towards the goal of universal energy access, particularly when delivering energy services to areas that are geographically or socio-economically challenging to electrify. Section 5.2 begins by analysing the determinants of the viability gap for mini-grids in Kenya and Rwanda, looking at tariffs, affordability, demand, financing as well as the overarching regulatory impacts on the viability of these models. Section 5.3 focusses on the viability of off-grid standalone systems. This chapter moves away from individual country analyses but draws on key themes across the two country contexts to assess the determinants of viable and scalable models, in relation to the IDF framing; the data discussed include both Kenya and Rwandan examples.

5.2 Mini-grids

This study finds that the viability of mini-grid business models depends on a range of factors including: (i) revenues, which are impacted by tariffs and demand; (ii) affordability: and (iii) measures of cost reduction and funding to address the viability gap and the (iv) policy support and regulatory environment. These factors will be discussed in the sections below.

5.2.1 Tariffs: balancing cost reflectiveness and affordability

There is a direct link between the viability of mini-grids and the tariff structure guiding revenue collection. Section 2.2.4 defined the viability gap as the difference between costs mini-grid developers incur to provide a service and the revenues they can collect to make their businesses financially viable (Melnyk & Kelly, 2019), which is also contingent on willingness to pay. Tariffs charged for electricity sales and connection fees are an important source of revenue for mini-grid developers. For a mini-grid to be viable, costs recovered through tariffs must enable developers to recoup investments and have a margin of profit while balancing affordability. This is challenging due to low affordability and demand, amongst other factors, particularly when going into areas that are harder to electrify. Blodgett et al. (2017) highlight that by setting tariffs too low, revenues generated will not be enough to recover costs, while setting tariffs too high may stifle the growth in demand and will be unaffordable for many low-income households. As Reber et al. (2018) point out, tariff setting involves balancing the interests of three broad stakeholder categories: governments (including, utilities and regulators), mini-grid developers and customers.

As private mini-grid developers have shorter time periods in which to recoup their capital costs and make a return on investment, compared to large scale national utilities, mini-grid tariffs are higher than the grid tariff. Pérez-Arriaga et al. (2018) explain that to reduce risk, private mini-grid developers' profit timelines are defined in the short to medium term, where mini-grid developers are required to recover costs as quickly as possible. In Kenya, tariffs[50] charged by mini-grid companies range from approximately 0.4 – 1 USD/ kWh, which is significantly more than the tariff charged to Kenya Power mini-grids and main grid customers, who pay 11 US cents per kWh. In Rwanda tariffs charged after a subsidy has been applied are up to 5 times more than the grid tariff (see Table 13).

Table 13: Grid and mini-grid tariff comparison in Kenya and Rwanda

Kenya		**Rwanda**	
Grid tariff (USD/kWh)	Mini-grid tariff (USD/kWh)	Grid tariff (USD/kWh)	Mini-grid tariff (USD/kWh)
0,08 (lifeline)	0.4 - 1	0,15 (above 50kWh per month)	0,35 -0,7

[50] This is based on the 2023 tariff of 12 Kenyan Shillings per kWh (lifeline tariff) and 15.6 Kenyan Shillings above the lifeline tariff. In Rwanda the grid tariff is 189 Rwandan Francs per kWh (on an increasing block tariff). These refer to domestic customers. Mini-grid tariffs indicated are based on averages from interview data and current sector reports.

0,11 (normal)			(with a subsidy)

Mini-grid tariffs are influenced by the regulatory regime in the country of operation as shown in Sections 4.2.5 and 4.3.4. As highlighted in Section 2.5.2, Kenya applies both a uniform tariff to government owned mini-grids as well as an individualised cost-based tariff that is subject to regulatory approval for privately owned and developed mini-grids (USAID, African Union & Power Africa, 2020). With respect to the latter, proposed mini-grid tariffs are negotiated with the Regulator, EPRA, to whom mini-grid developers should submit their proposed tariffs. A respondent from the Regulator commented that once mini-grid developers have received government approval they must apply for a tariff with the Regulator (Regulator K1). This approach to tariff setting is similar to what Reber et al. (2018) describe as a lightly regulated cost reflective tariff. While there is no requirement for private mini-grid developers to charge grid parity tariffs, there appears to be a push from public sector stakeholders for mini-grid companies to charge as close to the grid tariff as possible. One mini-grid developer in Kenya commented:

> The biggest challenge we've had is the issue of tariffs, that whenever we sit in a room as operators, mini-grids regulators, energy officials, the biggest bone of contention is always the issue of the tariffs because they say as regulators they would like to see the tariffs being at the same level as KPLC[51], but KPLC is able to achieve that through cross subsidy particularly in far flung areas, so that has been the major contention (Mini-grid K1).

A development partner in Kenya implementing a mini-grid programme also referred to the tariff parity conflict:

> I would say it's a big conflict of tariff parity, the thing is where we are installing these mini-grids is also where the government mini-grids are existing, they are charging grid parity tariffs, while we are charging cost reflective tariffs, so the local people will not understand why the utility, local grids are cheaper than the private sector mini-grids. And that's a discussion, a long one with the government, on subsidising the private sector operated mini-grids because if the national utility were to charge a cost reflective tariff it would be in the same range as the private sector, but they cross subsidise because of the national grid customer base. So, they are able to charge grid parity tariffs (IDO K1).

The above statements indicate a significant challenge, as private mini-grid tariffs will be higher in the absence of a subsidy. The utility can charge the lower tariff through the cross subsidies from their large customer base and that the grid tariff is not cost reflective. Thus, without some form of a subsidy mini-grid developers would not be able to charge the grid tariff and recover the costs. The latter statement

[51] KPLC refers to the electricity utility Kenya Power and Lighting company, also known as Kenya Power

raises the issue of fairness in the tariffs charged for utility mini-grid customers and private mini-grid sites close to utility customers.

The KNES, discussed in Section 4.2.2, states that the Ministry of Energy is in favour of a uniform national tariff which would apply to both grid and off-grid customers and are thinking around ways to pass a subsidy for off-grid connections. A respondent from the Ministry of Energy in Kenya highlighted concerns about equity and fairness between grid and mini-grid customers, which echoes what Reber et al. (2018) identified as being an important consideration which impacts how tariffs are determined.

> …If you go to (company X), their rates are quite high and the argument has been if the consumers are willing to pay, why does the government have to come in? But you see now that is a debate, but fundamentally, the role of government is to make power cheaply accessible to every Kenyan, and a Kenyan should not feel they are being discriminated against by being let to pay more (ME K1).

This links back to the discussion on subsidy led and market paradigms described by Rehman et al. (2017) in Section 2.2.4, framing energy access as a social good or commodity, and that a combination or balance between these approaches is needed to accelerate access to electricity. However, to achieve greater fairness and equity in mini-grid tariffs, this would need to be met with commensurate subsidy support to enable this.

To determine tariffs, the Regulator assesses mini-grid developers' financial models, which should reflect their investments, the periods they must recoup investments and the permitting period. Other factors described by a mini-grid developer in Kenya, include the economic status and willingness and ability to pay of the communities being served by the mini-grid (Mini-grid K3). For example, the developer commented that they had applied for a tariff of 100 KES (1$) [52] per kWh for their residential rate and $1.26 for light commercial customers, but the regulator approved 68 US cents for the residential rate and 86 US cents for their light commercial rate. In this case the approved tariff was lower than the tariff applied for but still over three times the grid tariff of about 22 US cents (Mini-grid K3).

In Rwanda mini-grid tariffs are subject to the size of the mini-grid. As discussed in Section 4.3.4.1, prior to its revision in 2019, the Simplified Licensing Framework exempted mini-grids under 50kW from

[52] This was in 2018

tariff approval and mini-grid developers were free to set their own tariffs. An energy consultant in Rwanda commented:

> The Utility has taken a hands-off approach to mini-grid developers (below 50 kW). RURA is now introducing standards (EC R1).

This regulatory approach (or provision) reduces the regulatory burden on smaller mini-grids which would enable mini-grids to be developed more quickly[53]. As Table 14 below shows, all the mini-grid[54] projects listed are 50kW or less, which shows many mini-grid developers have built sites under the 50KW threshold and that the simplified licensing framework served as an incentive to construct sites under this threshold. At the same time this could also be due to the low demand among newly connected mini-grid customers in Rwanda and that 50kW could easily serve the needs of the households and communities being served (see EnDev, 2019). However, in a subsequent revision to the Simplified Licensing Framework in 2019, small isolated mini-grids less than 50kW are required to register their projects with RURA and follow a special licensing procedure that applies to small isolated mini-grids (RURA, 2019).

Table 14: Number of mini-grid sites supported by EnDev RBF finance and households connected (EnDev, 2019)

Company	Technology	Location	Size	No. of households connected	Grant support
Neseltec	Solar	Kirehe district	30 kW	183	EEP
ECOS	Hydro	Muhanga district	11 kW	303	EnDev
RENERG	Solar	Nyamasheke district	30 kW	121	USADF
MeshPower	Solar	Multiple in Bugesera and Ngoma districts	1 kW each, 57 sites	2,046	EEP & EnDev
MeshPower	Solar	Bugesera district	4kW AC/DC	78	None
Absolute Energy	Solar	Gatsibo district	50 kW	505	EnDev

Similarly, Kenya has revised its regulatory framework for mini-grids and developed the Mini-grid Regulations of 2021 (discussed in Section 4.2.5), which details the process for licensing tariff approval, and grid arrival. In addition, licensing provisions under the new Energy Act of 2019 requires all projects

[53] Provided that there are not other challenges (financial or otherwise) in getting mini-grids off the ground.

[54] Currently as of October 2023, fewer mini-grids are still operational in Rwanda. These include MeshPower and ARC power. Some mini-grid developers have pulled out of Rwanda/no-longer operate sites.

below 3MW to apply for a licenses. However, in the new regulations the time needed for an initial response to licensing has been reduced to 15 days.

Interviewees in Rwanda expected that there may be a push for a grid parity tariff in the revisions of the New Electrification Plan and the Simplified Licensing Framework. A development partner in Rwanda commented:

> Regarding the tariff we are currently using a cost reflective tariff for mini-grids which is important. This is still supported in the simplified license and the tariff issue is regulated by RURA. However, it's also a policy decision, because it's not at grid parity. […] . For now, its cost reflective, but there is always a threat here that a policy decision can be taken to revert to a grid parity tariff, which will basically destroy the market – there will be no viability – there would be no business case (IDO R2).

The above statement shows that changes to tariff regulations and the requirement to charge grid tariffs is a significant risk for mini-grid developers and can negatively impact financial viability if there is no subsidy in place to account for the difference between a cost reflective and grid parity tariff. It also links to the idea that it is not enough to simply have policies and regulations in place, but that these regulations need to be very clear and consistently applied.

From the interview data, it appears that mini-grid developers in Rwanda were operating in a regulatory lacuna while the NEP and Simplified Licensing Framework were being revised. This caused uncertainty for private mini-grid developers such that if the new regulations were to change favourable regulatory conditions, then developing mini-grids would become increasingly difficult. A comment by a development partner (NGO) in Rwanda reflects this degree of regulatory uncertainty:

> At the moment the regulatory situation is a bit unclear, but I think it's under 50kW, you can set your own tariff, to be cost reflective, but this is changing – in this new plan of electrification of the country the Regulator is very concerned about the tariff and they want the tariff to be as near to grid parity as possible. So that's another challenge for mini-grids. If the regulator says we have to have grid tariff parity, then mini-grids would become very, very difficult without very heavy subsidies (IDO R5).

The development partner had anticipated the change (previously exempting mini-grids under 50kWs) although the new regulations still aim to facilitate mini-grid development through less stringent application processes. However, periods of uncertainty where there are changes to the policy and regulatory environment can cause trepidation in the sector. Looking at it from a regulator's perspective, to protect mini-grid customers there needs to be certain minimum checks and balances in place to keep a proper record of all the projects that are being developed and putting measures in place to register projects. This relates back to Section 2.5 where regulations need to balance the interests of multiple stakeholders in the sector (Bhattacharyya & Palit, 2016; Pérez-Arriaga, 2016).

The interview data furthermore show that affordability and low domestic demand serve as greater drivers for bringing down the tariff in Rwanda, in contrast to Kenya where more interviewees mentioned the government's push for grid parity tariffs as a reason for needing to reduce the tariff. A mini-grid developer in Rwanda commented that they would not have a problem with a grid parity tariff if there was a subsidy in place to enable it:

> And I'm okay with grid parity as long as the subsidy is there to enable it because you're not going to get developers coming in, (and) there is no subsidy available, there is no incentive available, if you build a grid you need to charge a grid price – it does not make sense. I do like the idea of charging as low as possible so that we can encourage demand. There was this CrossBoundary[55] experiment where the low tariffs saw an increase in demand – especially pronounced in low energy consumers – they almost doubled their consumption (Mini-grid R1).

The above view could be driven largely by the low purchasing power of the households these mini-grids are serving, as cost reflective tariffs simply will not be affordable to these households. Similarly, a development partner (NGO) in Rwanda commented:

> Also, just in terms of general conversations with regulators and developers, they seem very concerned, and should be concerned about keeping the tariff as low as possible, but they also must remember that the developer itself cannot have very high tariffs, because these areas just will not be able to afford it. They must have the lower tariff, because if they start charging a huge amount, no one is going to pay, and they just will not sell electricity (IDO R5).

Thus, a regulatory and political push for grid parity tariffs would not be the only reason why mini-grid developers may charge lower tariffs. As illustrated in the quote above, ability and willingness to pay in many instances could naturally drive the tariffs lower, especially in geographic regions and across socio-economic categories where people can afford to pay very little. This is reflective of the experience of mini-grid developers in Rwanda, but also applies to Kenya, especially when looking at some of the KOSAP counties where affordability becomes an overarching consideration (see Section 4.2.3).

[55]The CrossBoundary Mini-grid Innovation Lab trials appliance financing and tariff reduction strategies, amongst other, and forms part of CrossBoundary Energy Access (CBEA) - a blended finance facility investing project finance into mini-grid portfolios in Sub-Saharan Africa (ruralelec.org)

The above discussion also relates to the framing of energy access as a social good (see Section 2.2.4), while at the same time requiring models that are financially sustainable to enable the delivery of key energy access services. The section above also indicates varying institutional priorities within the broader mandate of universal energy access – while both public and private sector entities are working towards the goal of universal access, and contribute through their respective efforts, the interviewees strongly showed the public sector's mandate to keep tariffs affordable, while the overarching consideration for private sector actors mini-grid developers is to develop a sustainable revenue model.

The above framing of energy access as a social good furthermore links strongly to three of the IDF pillars, namely *inclusivity, permanence and external financial resources*. An important aspect of inclusivity in an off-grid electrification model is affordability, to enable access to energy access technologies, but this needs to be balanced with financial viability to foster greater permanence, by enabling private mini-grid developers to have sufficient revenue and funding to be able to provide a long-term service. Financing for developers and revenue is closely tied to the pillar of external financial resources and the types of funding for mini-grid projects. Furthermore, as highlighted in the theoretical framing of the IDF, one of the contributions of the study is demonstrating the linkages between the pillars of the IDF (see Section 2.2 and 9.3). From the above discussion there is a strong link between the level of *inclusivity* that can be achieved, which is linked to affordability. However, to have a degree of *permanence* it needs to be underpinned by financial sustainability. There needs to be a financial incentive for service providers to deliver energy access affordably and inclusively, to benefit both the companies and end-users. This is in turn influenced by the prevailing regulatory regime and factors like being able to charge cost reflective tariffs and the certainty and consistency with which regulatory tariffs and licensing provisions are applied. Building on the discussion above, the next section will specifically examine financing, targeted subsidies to address the viability gap and cost reduction strategies.

5.2.2 Financing, subsidies and cost reduction

One of the challenges for mini-grid finance is de-risking the sector and bringing in as much private investment as possible, which is in line with a shift to more private sector involvement in off-grid electrification worldwide. Due to the nascent nature of the industry, mini-grids are considered an emerging asset class that require considerable de-risking to bring in capital, because of the inherent risk and variability in site, demand, revenue profiles (Waissbein et al., 2018). However, through demonstrating the business case for mini-grids, the sector is starting to show promise, and financing mini-grid portfolios will become possible. A mini-grid developer in Kenya commented:

> The entire sector is about trying to create a new asset class of these microgrid portfolios- and de-risk them, to draw in as much private investment as possible – simultaneously convincing the public sector that we are doing the same work as national utilities - and would like subsidy parity - if that happens you would see microgrids explode (Mini-grid K2).

This also links back to the discussion in Section 2.4.2. which discussed emerging funding strategies for scaling the mini-grid section including blended finance (as a form of aggregation) where mini-grid sites are bundled to make the investment more attractive. This goes beyond the funding of single sites to creating portfolios of viable sites.

Possible funding avenues for mini-grids include grants, debt and equity. Mini-grids in Kenya and Rwanda are mainly financed through private equity and grants, with commercial debt being more challenging to obtain. A mini-grid company in Kenya commented on the technical assistance grants they received from the United States Trade and Development Agency (USTDA):

> So far… the funding that we got was from the USTDA, that was basically for feasibility, and now in developing these sites we did not have anybody to fund the project, so we have developed those sites… from our balance sheet (Mini-grid K3).

An industry association for mini-grid developers in Kenya, East Africa and Nigeria, commented that commercial debt finance is lacking in the sector. They argue that commercial debt is what is really needed to scale mini-grids. This echoes the findings in the literature review, Section 2.4.3, which also showed that commercial debt is more difficult to obtain. The industry association commented:

> You can build the amount of sites that your equity investors have the capital for you to build and, you can get some grants, technical assistance and local bit of support here and there…but without having debt you cannot really grow (Mini-grid association 1).

This concurs with the view of a mini-grid developer who commented that as a start-up they cannot continue to use their equity to build grids at scale (i.e., thousands of connections). From the above we can see that there is a ceiling to the level of scale mini-grids can achieve through private equity and grants.

Likewise, commercial debt is hard to secure in Rwanda. The mini-grid sector in Rwanda is nascent, with a few developers operating in the sector and with limited proven business models. Due to the limited proven business models and the perception of risk, mini-grid developers in Rwanda are not able to obtain commercial finance from local banks. Banks in Rwanda would ordinarily fund sectors that are more established with shorter term financing terms and have stringent requirements for collateral and high interest rates, which makes commercial debt finance difficult to obtain as well as expensive. In 2018 local banks in Rwanda did not extend any credit to mini-grid companies. Banks would require substantial risk guarantees before extending lines of credit (EnDev, 2019). Climate Investment Funds (2022) indicates that local currency credit for mini-grid developers in Rwanda remains a challenge, which necessitates de-risking and partnership with the local development finance institutions in Rwanda (i.e., the Rwandan Development Bank).

A development partner in Rwanda commented on the risk for developing mini-grids in Rwanda and how that has impacted the type of finance leveraged and the amount of subsidy required to address the viability gap:

> I think mini-grids are just too risky, I think generally, but especially in Rwanda. Commercial debt is not going to happen. 70% CAPEX[56] grant – 30% equity is generally what you see. The donors don't want to go over 70% generally because they want the developer to have some 'skin in the game', but they can go higher if needed---even concessional debt --- longer term debt is difficult right (IDO R3).

A microgrid developer in Rwanda concurred that grant finance is still needed in the sector to develop mini-grids, particularly when serving communities beyond the low-hanging fruit, where affordability is low and there is an absence of anchor loads:

> In terms of where the funding comes from, the vast majority of our grids have been co-financed with grants and I see that happening for some time going forward, especially the communities that we serve – most of the more commercial money that's come in for mini-grids targets larger grids or grids where you do have anchor loads. We still haven't seen commercial debt funding, or development debt funding at grids aimed at subsistence communities (Mini-grid R1).

The above two statements demonstrate that grant finance still plays a significant role in getting mini-grid projects off the ground. It is further evident that the mix of customers (domestic versus anchor loads) affect the viability of the sites, and in the absence of anchor loads it is sometime challenges to derive a reliable stream of revenue. This could be contrasted with interview data from Kenya where some larger mini-grid companies were able to secure commercial debt, for example for mini-grid

[56] CAPEX costs refer to the upfront costs required to construct the mini-grid, whereas OPEX costs refer to the costs required to operate and maintain the mini-grid (See section 2.2.4)

projects connecting large tea estates, as they were commissioned by the owners of the estates to develop the mini-grid (Mini-grid K2). Setting up businesses beyond the low-hanging fruit will have implications for viability. Without anchor loads, or an economic centre with existing or potential business activity and commensurate subsidies to address the viability gap, developing viable models in these contexts will be challenging

The developer in Rwanda went on to highlight that commercial funding rates and terms are not conducive for a nascent mini-grid sector and that concessionary debt [57] would be a better option.

> I'd say let's just start with getting development funding - you're trying to ask for really long-term debt in a really young industry, no one is going to give you 15, 20-year debt for an industry that's only been around 5 years in any kind of meaningful way and relies so much on government policy and there's all these regulatory risks (Mini-grid R1).

One of the ways the Government of Rwanda is addressing the lack of debt finance, particularly concessionary debt, is through the Renewable Energy Fund (REF) facility administered through BRD and funded by the World Bank. The REF, which will be elaborated on in Section 6.3.3 has a new window for direct lending to mini-grids at concessionary rates (i.e. lower interest rates and longer terms). The REF facility is designed to provide bridge financing for companies supported through EnDev's RBF facility, to finance the pre-commissioning, as EnDev finance will only be disbursed upon commissioning and a certain number of household connection targets are met.

From the above, the types of financing, be it equity, debt or grants can have an impact on mini-grid developers' ability to bring in finance and achieve greater scale. As emphasised, commercial debt was especially challenging to obtain in the sector, with interviewees expressing the need for debt financing facilities, particularly targeted for mini-grid developers. It furthermore emphasised the idea that concessional debt would be a better way for mini-grid developers to have a point of entry with more favourable terms and low or zero interest rates. Linked to the above financing section, the next section will look more specifically at subsidies in the form of grants to reduce the viability gap.

5.2.4.1 Subsidies and the viability gap

The need for subsidies to address the viability gap has emerged as an important theme. Respondents in both Kenya and Rwanda concur that mini-grids require subsidies to reduce the viability gap - as with

[57] This is usually provided at lower interest rates, longer repayment periods and favorable terms. This would be provided through development banks rather than commercial banks

grid electrification and rural electrification (Mini-grid K1, Mini-grid K2, Mini-grid K3, ME K1, Mini-grid R1, IDO R2, IDO R3). Viability gap funding in Kenya and Rwanda is primarily provided through upfront grants and RBF facilities funded by international development partners such as GIZ and FCDO. As highlighted in Section 2.4, a subsidy can be in the form of a grant but can take different forms. A mini-grid developer in Kenya commented:

> Rural electrification has never been done without a subsidy, it never really makes sense as a business model unless you have a massive urban base which we don't' (Mini-grid K2).

In Rwanda a 65% to 70% CAPEX subsidy is required to make the mini-grid projects viable (EnDev 2019, IDO R2). The interview data supports this. A microgrid developer in Rwanda commented on how challenging it is to demonstrate a viable business model and the need for grants and subsidies:

> I think that is a very difficult market to demonstrate good viability and [mini-grids in Rwanda] will rely on grants and subsidies going forward. We operate our grid sustainably in that we are gross profitable, but very few of them will pay themselves back and so subsidies are still required for a lot of these communities – the majority I would say (Mini-grid R1).

This illustrates the essential role of subsidies making mini-grids work, particularly when serving low-income customers.

A respondent from the Ministry of Energy in Kenya stressed the role of the private sector and noted that the private sector needs to be incentivised to come in and develop mini-grid projects. This is particularly important in the outlying more dispersed areas that are more difficult to electrify. This links back to what Lepicard et al. (2017) noted about the concentration of off-grid providers within certain geographic, easier to reach areas, and that incentives are needed to go beyond that to reach the more difficult areas (see Section 2.2.3). The Ministry of Energy also recognises the importance of fiscal incentives and subsidies but is also cautious of the impact of these subsidies on market distortion. Continuing in the same line of thought the respondent argued:

> …we are careful about subsidies because subsidies can also lead to a distortion because it gives signals that are not correct, 'cause in terms of market - when you subsidise, the moment subsidies are withdrawn, everything may collapse, so that subsidy has to been well targeted, and must also have sunset clauses that say it is going up to this and then you reduce up till a certain level, until progressively you withdraw it (ME K1).

A mini-grid developer in Kenya further stressed the need for ongoing subsidies in hard-to-electrify areas:

> On the other hand it's also very important to give subsidies, especially on sites like the one we are going to develop for GIZ, most of these sites are in Northern Kenya… looking at payment abilities and the economics generally for those people up there, subsidies are very important.

> Subsidies will also have great impact in the lives of the people, and it will also have great impact in terms of the number of connections we are going to make (Mini-grid K3).

From the two comments above, it is clear that subsidies are particularly needed in the more remote rural areas and in areas where the ability to pay is low, and where national electricity authorities to-date have been unable to electrify populations for similar reasons. This supports the findings of Blodgett al. (2017) who explored factors impacting the profitability of Vulcan's portfolio of mini-grid sites in Kenya. They found that combining an increased demand with a reduction in CAPEX could catalyse mini-grid growth and enable communities to be electrified, where costs are high and ability to pay is low. Important to note, however, is that while subsidies are important, they on their own do not make mini-grids scalable, especially if the size of the subsidy is too small (Blodgett et al., 2017).

Reflecting back on Section 4.2.2 which discussed Kenya's electrification strategy, an annual off-grid subsidy of $19,427,500 will be needed to achieve universal access (KNES, 2019). However, from government and the utility's perspective, implementing such a subsidy becomes a challenge. A respondent from the utility was of the view that it would be difficult for them to subsidise or cross – subsidise private sector mini-grid developers from public funding:

> They [private sector mini-grid developers] have tried to push for that, but it is not possible – how can one company (pay) another company and most of the time these companies are foreign. So how do we take money generated within the economy and pay somebody else to take it away. It does not really make sense (Utility K2).

A respondent from the Regulator also noted that cross-subsidisation for mini-grids would be challenging:

> Now that the private sector is coming in, sometimes getting that cross subsidy may be very difficult. The private sector will not have that kind of overall billing like Kenya Power and Lighting have. And that is why we are coming up with mini-grids that will have their own tariffs and the tariffs may actually be higher, but if you look at it, what the consumers were paying for their energy needs before the mini-grid arrives, and you do that comparative analysis, you find that the consumer is left better[58] off with the mini-grid (Regulator K1).

Whereas national utilities have larger scope for cross-subsidisation of grid connected customers across their customer categories or geographies (urban and rural customer base), private mini-grids do not benefit from the same level of cross-subsidy, with much smaller customer bases compared to national

[58] From this quote it can be surmised that the mini-grid could offer a higher tier of service (or potentially cleaner or safer alternative) compared to the energy sources mini-grid customers may have previously had access to, even though this is at a higher cost than the grid tariff.

utilities. However as mentioned, in Kenya a uniform national grid tariff is applied to public mini-grids that are jointly developed and managed by Kenya Power and REA. In essence public mini-grids are cross-subsidised from grid customers as they are also customers of the utility, Kenya Power.

As the above quote implies, administering a cross-subsidy between the public and private sector can be administratively cumbersome, and it is not necessarily within the ambit or scope of the public sector to do this. One example of trying to cross-subsidise mini-grids at a country level, was seen in the county government of Turkana, where the county government indicated an in-principle commitment to cross-subsidise some mini-grid projects in their county in an effort to reduce the tariffs charged in sites where mini-grids were being piloted (IDO K1). These mini-grids are developed through PPPs, with international development partners, but have been 'handed over' to the county government. Therefore, these privately built mini-grids become public mini-grids. One development partner explained the impact the subsidy would have on lowering the tariff.

> To the customers it is an advantage because if the private company was to invest 100% of their money and charge a cost reflective tariff, mostly it would be one dollar per kWh. In the range of $1.5 to 2$, but what we have seen with the subsidies, the tariffs are coming down, if you give 50% subsidy, the tariffs I've seen been proposed for the three companies we've awarded is between $0,7 and $0.9 dollars per kWh. So, it's a good thing to the consumers also if I were to pay $1.20 and being charged $0,8, its better now, it's cheaper and I can consume much more, and can do more activities (IDO K1).

The above sections illustrate that public mini-grids or mini-grids developed through PPPs in Kenya, will benefit from cross-subsidies, where the utility will be the retailer of electricity and mini-grid customers would belong to the utility. However private mini-grids are yet to benefit from this level of cross-subsidy, and at present mostly depend on external subsidies from international development organisations in the form of grant finance. The section that follows will discuss CAPEX and OPEX subsidies.

CAPEX and OPEX subsidies and cost reduction

There are different options for subsidies that can address the viability gap, including CAPEX or OPEX subsidies, each with relative advantages as described in Section 2.4.3 (Melnyk & Kelly, 2019; BloombergNEF & SEforAll, 2020). A mini-grid developer in Rwanda concurred with Williams et al. (2015) who noted that CAPEX subsidies are often preferred to OPEX subsidies as they reduce the initial investment and align with the cost- structure of mini-grids, which require substantial investment in electrification distribution and generation equipment. The developer commented:

> I'm personally okay with a CAPEX subsidy, because it keeps things simple. I think an ongoing tariff subsidy is an interesting idea, but I think that creates extra overhead…. But a CAPEX subsidy generally keeps it simpler. I am okay with that because we are trying to demonstrate we are trying to run things sustainably – at the very least gross profitably – which means if you get the right CAPEX subsidy the project can make sense (Mini-grid R1).

Thus, an OPEX subsidy can be administratively complex and has the risk that the subsidy will not be honoured for the lifetime of the mini-grid or agreed subsidy period. This concurs with Pérez-Arriaga et al. (2018) who highlighted that laws and regulations are often not in place to ensure that the subsidy will be paid in the long term. In the absence of regulatory certainty, a discontinuation of the subsidy over time negatively impacts the profitability of these models. In this regard a development partner in Rwanda commented:

> If you have a tariff subsidy, that can go on in perpetuity, there is just a danger that one day the regulator will say we are not paying that anymore and then you're in trouble. For me it's much better to have a grant fund (CAPEX subsidy) (IDO R5).

A mini-grid developer in Kenya commented that a CAPEX subsidy of about half their CAPEX per connection would dramatically reduce the payback needed. The subsidy makes the project viable and enables them to bring in private equity. The respondent was however also in favour of a tariff subsidy:

> I'd say the other subsidy structure that we are a fan of would be a tariff subsidy. We can build a project, be very transparent about our costs to build and operate it, figure out how many kWh we expect to get over the lifetime of the system, and receive outside funding to allow us to charge the same rate as the national utility (Mini-grid K2).

The above section has highlighted the importance of CAPEX and OPEX subsidies for improving the viability of mini-grid sites. It has further showed through the interview data perspectives the relative advantages of CAPEX and OPEX subsidies. However as argued by Blodgett et al. (2017), subsidies alone will not be enough to create a viable and scalable model for mini-grids and should be coupled with cost reduction strategies to lower the costs of mini-grid development. These include accurate system sizing and demand side management; equipment prices; scale and the regulatory framework. Other measures include increasing the density of connections; adopting lower technical standards; reducing overhead and transaction costs by clustering projects; using GIS or satellite imagery to improve site selection (Blodgett et al., 2017; Agenbroad et al., 2018).

While the previously subsections focused on the need for subsidies to close the viability gap, this section shows that subsidies should be considered together with cost reduction mechanisms to reduce the viability gap, by lowering the volume of subsidy required by strategically managing costs where relevant.

5.2.3 Demand stimulation and productive uses

Demand stimulation and productive uses of energy are key aspects of developing viable mini-grid business models (Crossboundary, 2022, Mini-grid R1, IDO R2, EI 9, Mini-grid K2, Mini-grid K1, IDO R3). In Rwanda, domestic consumption for mini-grids is generally very low, 1kWh – 2 kWh per month (10kWh as the highest average monthly consumption) with few large anchor customers (EnDev, 2019). The low demand results in low revenues from household sales of electricity, which adversely impacts the ability to recover costs and ultimately the viability of the business models. This requires more anchor loads[59](commercial and industrial) and to stimulate productive uses of energy (EnDev, 2019; Crossboundary, 2022). Regarding productive loads and increasing the viability of the sites a mini-grid developer in Rwanda commented:

> Household revenues we've discovered are very, very low in these areas - $1.5 to $2 per month and that consumption would be even less if we were selling at grid cost electricity, we'd be making $0,5 per month for these households for energy they consume, and so productive uses and businesses are crucial. The problem is in these villages we serve there aren't really many anchor loads – there isn't that much existing latent demand because we deliberately chase some of the harder places to demonstrate mini-grids. So, introducing productive loads and driving increased demand is critical to our business model right now (Mini-grid R1).

The above highlights that making a mini-grid viable with customers with very little purchasing power and low demand can prove very challenging. While it makes more economic sense for developers to target sites with greater anchor loads and more affluent customers, realising universal electrification necessitates workable models for low-income communities beyond the *low-hanging fruit* of electrification, as disused in Section 1.1. This links back to the balance that needs to be struck between the financial viability of off-grid mini-grid developers and reaching the objectives of SDG 7, especially in the more challenging areas where affordability is very low. This directly impacts the level of inclusivity that can be achieved as emphasised in the theoretical framing of the IDF. The above example is also particularly relevant in the context of the study as it provides the perspective of a mini-

[59] Anchor loads refer to a type of load that would provide the mini-grid with a more constant and reliable source of revenue, which is usually a commercial or industrial customer, who consume substantially more that domestic households and who are able to pay mini-grid developers on a regular basis with greater certainty.

grid developer who serves households where low affordability and low demand is a real challenge, which shows some of the complexities of building a mini-grid in these environments.

Although low demand was emphasised more in the Rwandan interviews than in the Kenyan, challenges with demand stimulation and low demand are also a consideration in sites in Kenya (Blodget et al., 2017). For example, Blodgett et al. (2017), who studied Vulcan's portfolio of mini-grids in Kenya and found that one of the sites in needed to be decommissioned due to low energy demand.

A development partner in Rwanda also stressed the importance of productive loads for successful mini-grid deployment:

> It's very important for the cases we see. We've been working with Energy4Impact to support productive uses and that has greatly improved the viability of the site. It goes hand in hand. On one side it improves viability, on the other hand it improves rural economic development, so it's a win-win situation (IDO R2).

The development partner also added:

> If I could redesign our programme, I would definitely have a budget for productive use. If you just connect households you have a limited amount of load for the evening and in the daytime, nothing is being utilised, so that's the logic from a technical perspective. Then if you connect more and more households, you need a bigger system - a larger battery, costs increase for relatively small demand. You'll be surprised how much a milling factory or just a small milling operation or welding and a couple of other things can really improve the revenues and sustainability of the business model (IDO R2).

The above is supported by a recent Crossboundary study that found that grain milling can increase the profitability of mini-grids by 11% and refrigeration by 6% (Crossboundary, 2021). Furthermore, studies including Power For All (2019) and Crossboundary (2021), find that 'high asset utilisation' and demand profiles that match the cost structures of mini-grids can improve the viability of sites, and productive uses are a key aspect to this. For example, productive uses can increase the daytime loads, which matches with the solar generation profile that is higher in the day (midday) and this can help to reduce the costs of the mini-grid systems (Power For All, 2019; Crossboundary, 2021).

Another development partner (NGO) commented on the high CAPEX and the importance of anchor loads:

> So, in terms of the demand stimulation, one of the issues facing all mini-grids really is the anchor load. You know you need an anchor load in a mini-grid. At the moment the capital cost is still so high that you need a lot of demand to stimulate that. We work with mini-grids to

stimulate demand on the mini-grids... In Rwanda it's challenging to find a high demand user (IDO R5).

However, as another development partner pointed out, stimulating demand and encouraging productive use is also challenging and requires money and partnerships with organisations that specifically focus on demand stimulation:

> Developers have had some success in stimulating demand, but that takes money. You need grants to do that part because the money just isn't there. Energy4Impact provides some funding for productive use. […] Developers can put in their own money, but then it's probably somewhat difficult for them to make their money back – unless they are thinking long enough term or thinking in terms of when they really scale to more mini-grids, maybe it makes more sense.[…]. So, it's a difficult problem. It requires some grant funding or willingness on the part of the developer to put in some equity (IDO R3).

This further illustrates how partnerships for demand stimulation can be used to improve the viability of mini-grid sites, which further ties in with the importance of partnerships in general and how they can be used to address the viability gap (which will be elaborated in Chapter 6).

The development partner NGO in Rwanda commented that an impact of the NEP is that high load users would generally be connected to the grid or earmarked for grid connection, leaving low load users for off-grid development. In Rwanda most of the tea or coffee plantations which could typically serve as high load users are already connected to the grid. While it would make economic sense for higher loads to be connected to the grid and generate more revenue for the utility, the scarcity of readily available high load users that can serve as anchor loads makes it challenging for private mini-grid developers. Another development partner in Rwanda commented:

> Mini-grids are challenging here because population density is quite high, a small country, which means nothing is that far from the grid, so the risk of grid arriving makes it harder here than other countries. […..] Mini-grid developers need to do something to catalyze more productive use. Obviously, you look for places where that might already exist but since the grid is not that far, any significant productive use means the utility says we should just extend the grid there. If there is anything of moderate size, that will be the next target because they're running out of places to extend the grid that's not just villages and nothing else (IDO R3).

In contrast with Rwanda, Kenya has more high load users. One mini-grid developer in Kenya commented:

> In Kenya, we have so far been contracted out by private tea estates, that have thousands of workers living on their estates, who have not had power - (owners of the tea estates) have decided to spend money on the electrification of these customers (Mini-grid K2).

Another mini-grid developer in Kenya commented on the mix of mini-grid sites they have, from more commercial sites to sites where more demand stimulation would be required. Their site selection was also impacted by the impact investor financing the development of their sites and the balance between commercial return and impact expected.

> …some sites were commercial, areas where productive use was high, and it would make business sense to get some good revenue coming in from sale of power. Then there were sites that would also need further support in terms of demand stimulation, so you go in there and establish the power system and connect people, but beyond that, you provide some financing to be able to buy appliances (Mini-grid K1).

From the above, it is evident that demand is a key consideration for the viability of off-grid sites. A focus on proactively stimulating demand and supporting productive uses, through for example appliance financing, can significantly improve the business case of mini-grid sites. In addition, productive uses are key to increasing the utilisation of the mini-grid, which will in turn drive down costs as mini-grids that are underutilised increase the costs and reduce the viability of the systems. As further mentioned, partnerships with organisations that are actively engaged in supporting productive uses are important for facilitating or funding these activities.

The above sections identified tariffs and affordability; financing subsidies; cost reduction; demand stimulation and productive uses in relation to developing viable and scalable mini-grid models. This shows that subsidies and grants need to work in tandem with cost reduction strategies to optimally lower the costs of developing these systems and address the viability gap. Cost reduction helps to reduce the amount of subsidy needed. The section that follows will turn to regulatory considerations around grid arrival, planning and uncertainty.

5.2.4 Grid arrival, planning and uncertainty

The overarching regulatory impacts of tariffs and licensing on mini-grid viability have been illustrated in Sections 5.2.1 and 5.2.2. Although tariffs link closely to regulation, they also link to the financing discussion above. This section will focus on grid arrival, planning and uncertainty. In addition, grid arrival and compensation are key regulatory risks affecting mini-grid developers in Kenya and Rwanda, to varying degrees. One mini-grid company in Kenya mentioned:

> …because the private sector wants to bring in capital into this - then they need to be assured that, particularly in the far- flung areas, when the grid arrives there would be a way integrating so that they are able to recoup their investments (Mini-grid K1).

A respondent from the Ministry of Energy in Kenya commented:

> Because the challenge would be what would happen if the grid arrives, Kisii is an area within which the grid is within reach, these are now the real issues that are being discussed, and the question has been, what happens when the grid comes…. (ME K1).

A development partner in Kenya commented on the uncertainty grid arrival creates in the absence of clear agreements:

> Yes, that is one of the things we wanted the regulations to address - because that's a big question and a big fear, 'what will happen when the grid arrives' is always their question (IDO K1).

A development partner In Rwanda highlighted that the risk of grid arrival is imminent and poses a real risk, due to Rwanda's geography and the government's plans to electrify the entire country with the national grid beyond 2024.

> I think there is still some trepidation by the private sector for grid extension because there aren't a lot of assurances that they'll get their return. In a country like Tanzania it does not really matter because the grid will not extend everywhere for the next 20 years, but here you are in a small country and grid extension poses a real threat. So, if you're investing a certain amount of money and expecting a 15-to-20-year equity return on investment and you're just going to get the depreciated value of your assets five years later when the return is usually 7 to 10 years or more – then you are going to be losing money. I think it does worry the private sector, but I'm not sure if one understands the implications either (IDO R2).

Interviewees in Rwanda concurred that grid encroachment was a tangible and imminent risk for mini-grid developers. A mini-grid developer in Rwanda explained the tangible impact of grid encroachment on their sites. As the developer explained, revenues in some of their sites started to decline after the grid was extended near to their sites.

> That is largely, almost every single time due to the grid arriving and because the grid is 90% subsidised and it offers full power, people choose to go to the grid and it's a better option for sure. The beauty is that they (our systems) are small, and we can just recover the assets and move them over, but that's not trivial and it's not free, we still must invest in a new site (Mini-grid R1).

In the above example households had the option to switch to the main grid as it provided a more comprehensive service and was cheaper than the mini- grid. This also links to the idea of the spectrum of energy services that off-grid technologies can provide and that while mini-grids have the potential to offer close to a grid level of service, there are various factors that influence the level of service that mini-grids can provide (looking at the Multi-tier framework). Because their systems are more modular, they could more readily be deployed on other sites. In that way small, modular mini-grid set-ups create the necessary flexibility to re-locate the mini-grids if necessary. In this way modularity creates a buffer again regulatory uncertainty. Although this is not without cost for redeploying assets elsewhere and potential revenue loss on existing sites.

Regulatory uncertainty about grid arrival increases the risk for mini-grid development, and has a negative impact on IDF pillars, especially *permanence*, *external resources*, and a *combination of electrification modes* (Bhattacharyya & Palit, 2016). Uncertainty around grid arrival in Rwanda is addressed through the NEP which delineates grid and off-grid sites. Interviewees in Rwanda largely concurred that the development of a national electrification plan was a positive development for the sector. At the time when the NEP was still being developed in Rwanda in 2019, a development partner in Rwanda commented:

> The Government is working on a National Electrification Plan, which is a map that will delineate the country into on-grid and off-grid areas. That's not available yet. That's been a significant delay for mini-grid developers. The map has gone through multiple iterations. There is no final map yet and so it means the utility cannot give authorization for mini-grids to be developed on any site until they know that it's off-grid. Many developers have been waiting for this confirmation letter from the utility (IDO R3).

A mini-grid developer in Kenya commented:

> …if the grid gets to where you have your system, it was forcing so many developers, from my previous experience the main grid [arrived at] the two sites where I worked, we did not have an option, the only option we had was just to decommission that system, we had to remove the entire system and try to deploy it somewhere else – and we've invested heavily (Mini-grid K3).

In Kenya options for grid arrival have been discussed and incorporated in the draft Mini-grid Regulations of 2021 (see Section 4.2.5). Regarding the options in the event of grid arrival, a respondent from the Ministry of Energy in Kenya also commented on some of these options:

> …and several options have been explored – the developer can sell that whole facility to the off-taker, and the off-taker therefore can continue. That is one option. The other option will be they can be allowed to become independent power producers so that now have a PPA with the off-taker and in that case the negotiation will be at what tariffs…. (ME K1).

The above would, however, imply a shift in the value chain roles with developers becoming electricity generators instead of customer facing, as electricity retailers. Whether this would be attractive to mini-grid developers may vary from developer to developer. Developers will not have the incentives to be involved in demand stimulation for the sites if they are simply going to be generators of electricity. The idea of shifting roles and functions in the value chain is further explored in Chapter 7. Furthermore, the exact compensation mechanisms still need to be fleshed out.

In Rwanda, options for grid arrival are also explored in revised versions of the Simplified Licensing Framework, which details scenarios of grid arrival and how developers will be compensated for their assets in the event of grid arrival. However, there is not exact clarity[60] yet on what shape these will take for grid arrival options (EnDev, 2019).

With respect to possible compensation approaches, a development partner in Rwanda commented:

> What the developers would want in an ideal world would be compensated based on a set amount of their equity investment over x years. So, once they've recovered that, they can sell the depreciated asset (IDO R2).

The development partner further commented on the lack of clarity on the practicalities for grid arrival:

> If they are selling to the utility, then the utility must sell at grid parity. So maybe that model could work after X amount of years. But' I'm not even sure that could cover operational costs, so I don't see that model working unless the tariff is subsidised. None of this has been resolved or discussed on this practical level with stakeholders. I think a lot of the developers have not thought deeply about it (IDO R2).

A mini-grid developer in Rwanda argued regarding compensation and grid arrival that:

> Compensation for the assets, a grid buy-out, isn't super attractive unless you also have kind of compensatory mechanism for lost revenues. RURA will make us charge tariffs which are cost reflective, but as low as possible based on a 15-year project lifetime. If the national grid arrives in 5 years and if what we get is like three-quarters of the distribution costs and they don't need to buy the generation – we would have made a big loss because the tariffs we are charging were predicated on having a 15 year project life cycle – it's very tail heavy as well - demand starts off very low and we're trying to grow it over time so if we only get the first 5

[60] While the Simplified Licensing Framework provides scenarios and makes provision for compensation for mini-grid assets in the event of grid arrival, the specifics of compensation will vary according to the dynamics of each site e.g. age of assets, and whether this includes distribution and generation assets where applicable. According to Article 32 of the Simplified Licensing Framework, the regulatory authority RURA, will make provision for the purchase price for 'isolated-grid' or mini-grid assets.

years of this and then that's the least profitable 5 years, then that does not make sense (Mini-grid R1).

From the above it can be seen that regulatory certainty on grid arrival and planning and the adequacy of compensation, should the grid arrive, are key considerations impacting the viability of mini-grids in Kenya and Rwanda. Yet, it is those periods of regulatory uncertainty that can delay the deployment of mini-grids and stifle investment needed to achieve viability and scale in the sector.

The sections above show that a combination of regulatory, affordability and financing considerations impact the viability gap of mini-grid models in Kenya and Rwanda (see Figure 11 below). These are essential considerations in long-term energy planning i.e., enabling policies and regulations for de-risking the sector and long-term planning to create security for subsidies and to strengthen and give confidence to the private sector and investors. Regulatory, affordability and financing considerations are thus essential to the pillars of the IDF, namely *permanence* in terms of long-term planning and investment, and *external resources* as well as how long-term planning and security through favourable regulatory conditions can enable subsidy support and investment into the sector. These are all interlinked as tariffs are part of the financing model of the mini-grid developers but also within the regulatory domain and subject to regulatory approval. As highlighted in Section 5.2.1, tariffs and affordability play a key role in the level of permanence and inclusivity that can be achieved, which is also linked to the type of financing and affordability of finance that mini-grid developers can access. Thus, the IDF pillars of *permanence, inclusivity* and *external finance* are critically interlinked and impacted by affordability, the regulatory environment as well as demand stimulation, cost reduction and financing. Affordability impacts financial inclusion especially when serving low-income households. Improving end-user affordability and lowering the tariffs could drive increased electricity consumption at lower costs with people being able to afford more at costs.

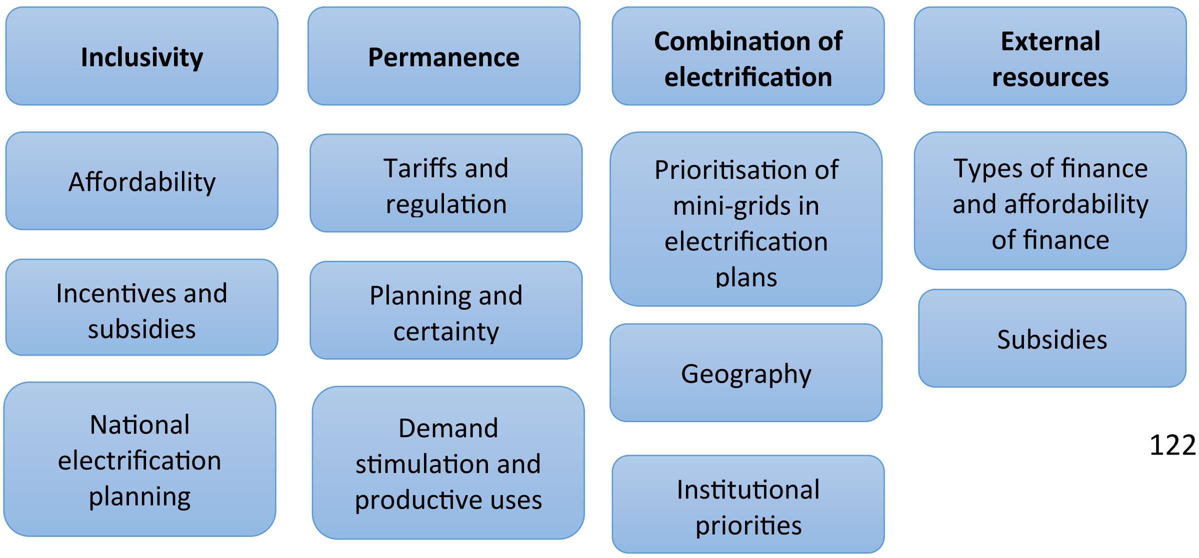


Figure 11: Viability gap determinants and IDF for mini-grids (Author's figure)

With both regulation and affordability having a significant impact on the viability gap of mini-grids, particularly in low-income settings, subsidies and specific financing mechanisms are needed to reduce the viability gap. *The permanence* of mini-grid operations depends on regulatory certainty; sudden changes to regulation and regulatory uncertainty increases risk and reduces investor confidence in projects and in the sector at large. Permanence also depends on the financing ecosystem and external finance that's leveraged for mini-grid projects. The regulatory environment impacts the *combinations of electrification modes* and how models can effectively co-exist. The above sections also identified that partnerships could be a strategic way to reduce the viability gap. For example, mini-grid developers could partner with organisations that specialise in demand stimulation (Section 5.2.3), or with the main utility in terms of certain aspects of the value chain as per the model to be used in the KOSAP project.

Partnerships for off-grid development through the lens of the IDF will be discussed in Chapter 7. Furthermore, financing partnerships with international development organisations and local development banks could help to address some of the bottlenecks in financing these projects. These types of partnerships will be further elaborated in Chapter 6.

5.3 Off- grid stand-alone systems

Following on from Section 5.2's discussion of the factors influencing the viability gap for off-grid mini-grids, this section will discuss key factors influencing the viability of off-grid stand-alone solar systems [61].

5.3.1 Affordability and sales

Household affordability is a key consideration affecting the viability of any off-grid solar company business model. Several respondents in Rwanda mentioned affordability as one of the key challenges in the market affecting the sales of off-grid standalone systems (IDO R2, IDO R3, EC R1, IDO R1, EnDev, 2019). One development partner commented:

> The important context is affordability. Rwanda is a poor country (IDO R3).

[61] Off-grid standalone solar systems refer to solar home systems, pico-solar systems, solar lanterns and lamps. It could serve domestic and some (more limited) productive uses.

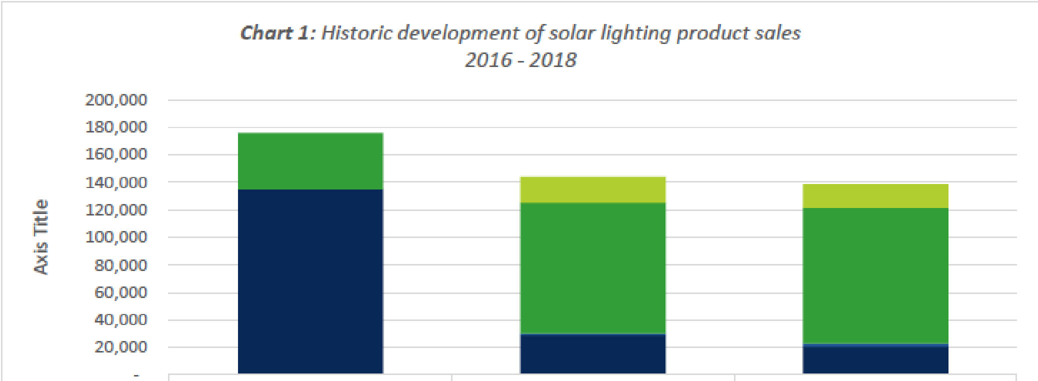
According to a recent Endev report, affordability was highlighted by off-grid solar companies as a significant challenge affecting the energy sector as well as the achievement of energy access targets. This relates to targeting more challenging areas where affordability is low and incomes are varied (EnDev, 2019). Another development partner in Rwanda said:

> We've now reached a point in the Rwandan market where the issue of affordability has become quite visible. When we talked to the companies last year for the review, which is what we always do for the programme and the off-grid sector status report, one of the key things they mention is affordability (IDO R2).

To illustrate the impact that affordability has had on the market, one can consider the flattening and declining sales of off-grid solar systems. Although the off-grid stand-alone market in Rwanda has developed significantly in the last few years and is recognised as an important part of Rwanda's national electrification plan, the market for off-grid stand-alone solar products is currently quite challenging. One development partner explained that in 2013 and 2014 the off-grid solar sector was still relatively nascent with only a few companies operating in the market and sales were low (IDO R1). In 2017, however, there was a notable spike in sales (EnDev, 2019; Power Africa, 2019) which in part could be attributed to development partner support in market building. While solar home systems sales more than doubled between 2016 and 2017, from 41, 019 to 94 791, sales flattened in 2018 with a marginal increase of 1.5% between 2017 and 2018 (see Figure 12). At the same time solar lamp sales have decreased significantly from 134, 897 in 2016; to 28 894 in 2017 and 20,419 in 2018 (EnDev, 2019). Higher tier systems started to increase and then flattening and lower tier systems[62] started to decrease (IDO R1). The development partner commented:

> …and sales of solar home systems have been flat or decreasing for a while, partly because of the affordability issue, maybe even mostly, but there's many factors that go into this (IDO R1).

[62] This refers to lower tier stand-alone systems like solar lamps and lanterns.



	2016	2017	2018
SHS tenders		18,996	17,379
SHS sales	41,019	94,741	98,046
Lamp tenders		1,511	2,859
Lamp sales	134,897	28,894	20,419

Figure 12: Sale of stand-alone solar products (EnDev 2019)

In addition to sales flattening, the Rwandan market has also seen an increase in customer non-payment rates. Notwithstanding credit risk assessments and attempts at making repossession policies more flexible, solar stand-alone system companies reported increases in non-payment rates in 2018, which to an extent were driven by serving households with low and less stable incomes, who are often perceived as higher credit risks. Additional drivers included an uncertainty and expectation about grid arrival; an inadequate understanding of the credit purchase requirements; a lack of understanding of the lifespan of the systems and how frequently maintenance would be required (EnDev, 2019). A development partner commented:

> But it now seems like they are reaching the point here the low-hanging fruit are gone and now they must reach out to customers with either lower or less stable incomes and that is impacting the sales dynamics but also the default rates. So, companies have claimed that the default rates over the last year have increased. So, based on this some companies would tell you that they don't consider Rwanda to be a 100% commercial market, (but) a supported market (IDO R1).

A respondent from a solar home system company in Rwanda also highlighted the variability of income as a factor that could contribute to an increase in default rates:

> Even though there is a level of credit checking, people will have varied income: seasonal, temporary contracts. The situation could [change] quite drastically from month to month. Even if they can afford a Mobisol or Bboxx system, that can change. They are left in a situation where they want to continue using the system, because its beneficial and better than kerosene or candles. Then you are left with a customer who is paying well and then suddenly they are unable to pay. Then the default rates go through the roof (OGS R1).

Another development partner commented:

> …and repossessions are becoming more of a common thing. The companies try to avoid it, but they have policies that if you have not paid for 60 or 90 days, then they come and repossess a system, but it's bad for the company. It's better for the company to avoid that and get the customer to start paying again. They try as much as possible to avoid it (IDO R3).

The above indicates a notable challenge for delivering universal access, with repossessions becoming more prevalent in the Rwandan off-grid stand-alone solar market. It undermines some of the initial gains of improved access by taking back some of the systems, due to changes in income or circumstances leading to household non-payment. This relates to the discussion on market-led versus subsidy-led paradigms and energy services, where under market conditions businesses would need to make business decisions on issues like non-payment as this negatively impacts revenues, but it also raises the question of 'equity and fairness' in energy access as some households would have contributed towards paying off these systems. Linking this back to the IDF framework, repossessions have a bearing on the IDF pillars of *inclusivity* and *permanence*; a key aspect of inclusivity[63] means serving households who cannot afford the systems, and repossessions immediately negates any degree of permanence. Furthermore, solar home systems are also seen as *transitory* solutions, providing an entry level of access. In terms of the IDF pillar looking at the *combination of different off-grid technologies* and grid and off-grid electrification modes, planning is needed to be able to transition households that were using stand-alone systems to mini-grids and grid connections. Similar to the discussion on mini-grids the IDF pillar, *inclusivity* is impacted by affordability and ability to pay, with a notable viability gap for off-grid solar companies serving households in these low-income brackets. This also links to the type of finance that off-grid companies can leverage (to be elaborated in Section 5.3.2) as well as subsidies. As will be discussed, one of the ways in which the government of Rwanda is addressing the affordability gap is through the tiered Pro-poor Ubudehe subsidy (see Section 6.4).

The cheapest solar home systems in Rwanda retail at about $4 per month, whereas the maximum[64] energy expenditure for rural households without access to electricity, estimated through household surveys on current energy expenditure (see Figure 13), is about $1 per month (EnDev 2019). This

[63] While inclusivity as envisioned in the expanded framing of the IDF which this thesis proposes, encompasses more than just affordability, financial inclusivity is a key aspect which needs to be considered when applying an IDF framing and seeking ways to deliver energy access to those who are socio-economically or geographically marginalised.

[64] This is an estimate drawn from the Integrated Household Living Conditions Survey (a national survey conducted in Rwanda every four years) which the EnDev (2019) report has cited.

indicates an affordability gap of about $3 per month when looking at the least expensive systems on the market. One development partner commented that several household surveys have been done on energy expenditure (including candles, kerosene, batteries) which is used as a proxy for willingness to pay. Every four years the government conducts a large survey of about 15 000 households, the latest being Integrated Household Living Conditions Survey (EICV) 6, conducted in 2020. These surveys are useful for providing an indication of ability to pay. Although it is not directly a measure of willingness to pay, it does provide a sense of what households may be willing to spend on off-grid solar products.

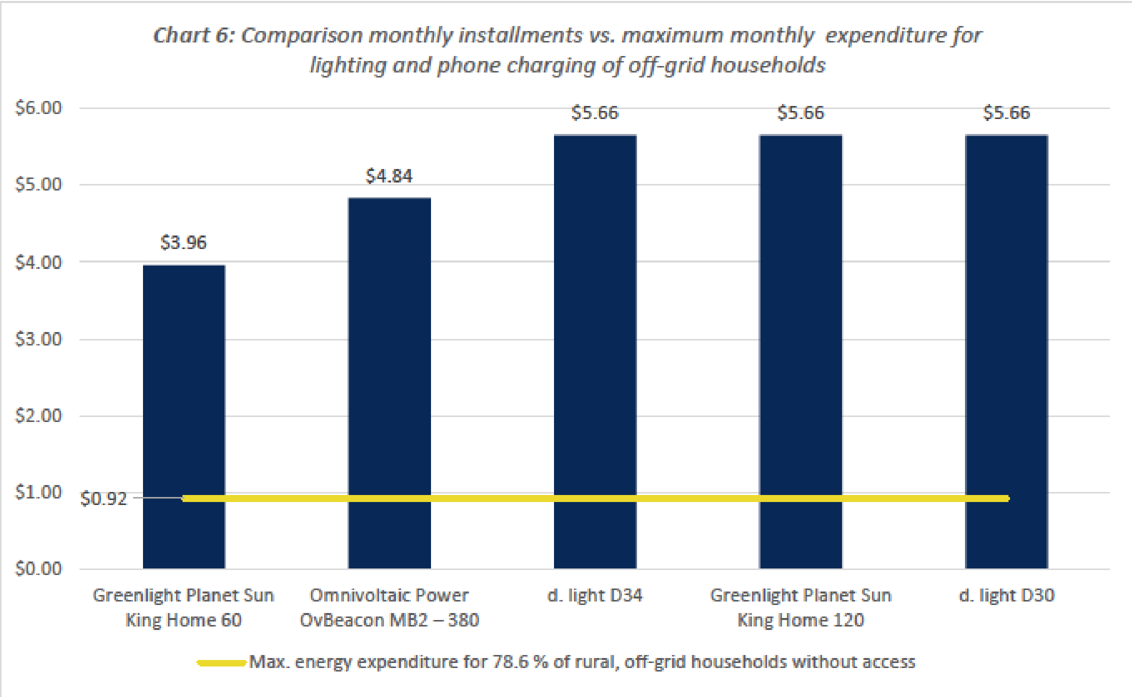


Figure 13: Prices of off-grid solar products in Rwanda (EnDev, 2019)

In contrast to Rwanda, an off-grid solar home company in Kenya mentioned that their non-payment rates have been relatively low:

> So basically 93% is our repayment – which means - for every dollar we put up we collect 93 cents from the customer, and 7% is what we lose being in the financing business – but I think we do much better than the others – some of the other businesses haven't put out their figure publicly, but we're by far the best on credit performance in the PAYG business (OGS R1).

Berahab (2020) highlights that PAYG business models and attendant smart monitoring technologies have lowered default rates in Kenya. They found that remote monitoring reduced default rates by 82%, with BBOXX Kenya's default rates reducing from 11% to 2%. Late monthly payments have also decreased by 45%. However, this is not necessarily representative of OGS solar companies in Kenya and was for 2018.

As described in Section 2.2.3, Kenya has one of the most thriving and dynamic markets for off-grid stand-alone products in East Africa, like pico-solar and solar home systems. This is attributed to the proliferation of mobile money which introduced greater affordability into these programmes as well as the market development work of organisations like Lighting Africa, and the initial favourable VAT policy (as discussed in Section 4.2.5). The early success of off-grid deployment in Kenya created a 'snowball effect' as with the growth of innovative payment platforms and increased uptake of products, more companies started to turn their attention to Kenya and increased investment in off-grid solar products. Sales volumes of pico-solar systems exceeded 600 000 while sales of solar home systems were above 120 000 for the period July to December 2018 (Power Africa, 2019a). The solar home system market in Kenya has attracted several companies including Azuri, BBOXX, Barefoot Power, Greenlight Planet, Mkopa, Mobisol and others. Furthermore, the market has seen a growth in the sale of appliances, with 69,361 appliances sold from July to December 2018 (Power Africa, 2019a.), which can be attributed to in-house appliance financing that is often done with the sale of solar home systems. Notably in the first quarter of 2020, the Kenyan market also experienced a decline in sales of off-grid solar systems. This was more pronounced in cash sales than in PAYG solar systems, possibly due to people having less disposable income than usual due to the financial strains of COVID- 19, but to an extent the PAYG model also helped to make these systems more affordable through incremental purchases (IDO R1).

However, in Kenya sales are concentrated in the bigger cities, e.g., Nairobi and Western counties. While some companies have started to expand their footprint into other counties, other counties remain unserved, with companies finding it difficult to expand into the Northern and Eastern counties, as these regions are more geographically dispersed and form part of the geographically underserved or marginalised counties. While a concentration and unequal distribution of sales is noted as a problem in markets with higher penetration, in more complex markets, other challenges persist including, small off-grid populations, low population density, unconducive environments high import tariffs, and changing regulations on VAT exemption (Lepicard et al., 2017). Similarly, in Rwanda the *low-hanging fruit* have been picked and sales are proving more challenging in the harder to electrify areas. The concentration of sales in some geographic areas, with a lack of sales in others, draws attention to one of the disadvantages of a purely market-based approach where companies can pick the most profitable customer bases. While it makes business sense to target customers who can afford the energy service, it points to the failure of the energy market to serve all households with the electricity service. So, while some customers will not be able to be served on a purely financially viable basis, provision needs to be made to bridge the affordability gap for these customers.

Power Africa (2019a) also points out that the affordability gap in the more challenging underserved counties (i.e., the counties targeted by the KOSAP project), is considerable as the maximum expenditure on energy per month in the underserved counties range from $1.46 to $7.67 per month as off-grid solar products cost $5 per month. This means that households in certain counties cannot afford these systems. This is where the KOSAP project aims to fill this gap, through the envisaged 1.96[65] million new solar home systems that will be deployed in underserved counties, with a subsidy to the off-grid companies, as highlighted in Section 4.2.3.

5.3.2 Financing and the viability gap in stand-alone systems

Access to finance is a key aspect of off-grid solar companies required for both capital investment and working capital needs. In Rwanda off-grid stand-alone solar companies are primarily funded through international debt, which is supplemented by grants and equity. According to EnDev (2019) international debt made up 96% of the funding sources of the off-grid solar companies they supports, while grants comprised 3% and equity 1%. Local debt, however, was very challenging for companies to obtain (EnDev, 2019). According to a Shell Foundation & Catalyst Off-grid Advisors (2018) report, to achieve universal access in Rwanda, there is a need for more funding in the form of grants, equity and debt and first and second generation[66] deployments of off-grid stand-alone systems. Their analysis shows that there is potential for four first generation companies to serve 1.2 million households and would require $9 million in grant funding, $111 million in equity and $124 million in debt. In addition, there is an opportunity for two second and third generation companies to serve a further 400 households requiring $5 million in grant funding, $50 million in equity and $40 million in debt. In

[65] This amount was originally envisioned in the KNES published in 2018 as part of the original 2022 universal access target. Solar home systems are currently being financed and sold through the RBF and debt financing windows under KOSAP

[66] The Shell Foundation & Catalyst Off-grid Advisors (2018) defines 1st generation deployments as the initial international or multi-national companies that have entered the off-grid solar market, achieved significant penetration and deployments at scale and were successful in raising significant amounts of capital. 2nd generation deployments refer to newer entrants to the market who could gain a share in the market and require additional funding to achieve scale.

contrast with the mini-grid sector where we see a larger percentage of grants and equity, debt finance was the greatest source of funds for off-grid solar companies (Shell Foundation & Catalyst Off-grid Advisors, 2018). Debt finance for solar home system companies has shortened tenures - usually about 3 years to match the cash flow requirements over the financing life of a business - in contrast to longer term debt required by mini-grid companies (IDO R3).

A development partner commented that for some companies obtaining working capital, particularly local currency credit, is challenging. As most of the sales are done through a PAYG model, it results in delayed income and requires working capital to tie companies through the periods when they await payments from their customers. Local Rwandan companies find it more difficult to obtain local currency credit than international or multi-national companies, who are often able to get credit lines extended through their headquarters through international lending. Most of the companies in the Rwandan market have not reached the cash flow break-even point. The cost of finance is also a key consideration affecting model viability. The development partner commented:

> So financing is still a major issue, having this working capital to bridge the installment period, and here in Rwanda, you will see most banks do not give out local currency loans to solar companies. There are only two companies to date that have succeeded in getting a loan and the issue is basically that the interest rates are quite high, banks perceive the sector still to be too risky, require a lot of collateral and they also highly discount the collateral, because what you have with the solar companies usually the solar systems are 'receivables', which makes it very expensive for companies here to get local debt (IDO R1).

One of the ways the Government of Rwanda is addressing the affordability gap is through a new tiered subsidy according to different Ubudehe[67] categories (see Section 4.3.3). While previous subsidy programmes implemented by EnDev were primarily targeted at market development, this subsidy is specifically focused on addressing the affordability gap, enabling solar home system companies to reduce the prices of their products when selling systems to households under specific socio-economic segments (to be elaborated in Section 6.4).

One of the challenges in the design and potential implementation of this subsidy programme is a fair allocation according to the Ubudehe categories; those classified under Ubudehe 2 or 3 are based on

[67] Ubudehe is a socio- economic classification system in Rwanda comprising 6 categories including household income, consumption, household assets, tenure etc. Ubudehe 1 are generally considered less well off than Ubedehe 2 and 3 etc.

certain classification criteria may be less well off than someone classified as Ubudehe 1. Regarding this a development partner commented:

> It's really hard to target and pick the right subsidy levels, which is something we're still thinking about and struggling to figure out because of this spread in all three. You're going to leave some people out and over subsidize others. It's impossible to avoid (IDO R3).

Another more long-term challenge is the sustainability of the subsidy and continued funding beyond the pilot roll-out. A development partner highlighted that government and utility custodianship beyond the pilot would be a key aspect of the long-term sustainability of the programme, both in terms of the capacity to implement the subsidy as well as financing the programme from the national budget. The aim is to transfer this programme into a sector-wide government programme that will initially be financed through development finance as the national budget will not be sufficient to achieve universal electrification. The development partner said:

> So, the idea was to make into this bigger programme where we can actually hand over the programme, say you guys can take over this now, we can pull out eventually and it will still work (IDO R1).

This also highlights the importance of embedding a subsidy programme within a country's national electrification programme to enable 'ownership' or custodianship beyond a single donor programme which is subject to change. This speaks to the need for more continuity in these programmes.

5.3.3 Quality standards for stand-alone systems

For off-grid solar companies, regulation of quality standards could impact the viability of their business models. In Rwanda, while policies for off-grid solar companies have generally been favorable, recent developments suggest a possible move away from *light touch* regulation to a *heavier touch* regulatory approach. In August 2018, the Government of Rwanda issued Ministerial Guidelines for Minimum Standards on Solar Home Systems. These new guidelines specify which solar systems can be sold in the market, with respect to both the size and quality of systems. Development partners have expressed that these standards were somewhat unexpected, with resulting increased prices being undesired as it would make solar products unaffordable, in a market where affordability is already a significant challenge. A key concern of development partners and the solar companies they represent, was that most of the smaller and more affordable systems on the market would be excluded. This could widen the affordability gap. Ongoing discussions between sector players and the government are trying to address these concerns. A development partner commented:

> Companies that sell smaller home systems and development partners are pushing to adjust these requirements to allow the more affordable systems. So that's the discussion that's still ongoing now and this is one of the things the Government hopes to finalise in the next month or so (IDO R3).

This also brings across the idea of development of standards and regulation for off-grid stand-alone solar being in a state of flux and subject to a certain degree of influence from off-grid stakeholders. Part of the rationale for these standards is setting minimum standards of service, so that households who purchase or receive these systems could be counted as electrified. These specifications incorporate Lighting Global Standards with additional technical minimum standards including three lights, one hundred and twenty lumens for at least four hours per day as well as minimum requirements for radio and mobile phone charging. This would have a benefit of ensuring a minimum quality of service. However, regulation on product quality needs to be balanced with affordability (MININFRA, 2022). A further rationale expressed by a development partner is that there has been a concern from the government about obtaining spare parts for these off-grid solar systems, but this is not something which can be resolved immediately as systems are manufactured for sales internationally.

The impact of these standards will be influenced by the types of systems been sold and will not necessarily adversely impact all companies in the market, particularly the companies selling the larger systems. The development partner commented:

> I think it depends who you are talking to and what systems they have…. Some people will tell you, whatever happens the companies will adjust. Others say that if the standards are adopted the way they are now, yes some companies may adapt, but it will delay the market for some time (IDO R1).

In Kenya, Lighting Africa has done a considerable amount of work in improving the share of quality products in the market. In 2008 Lighting Africa initiated their flagship programme in Kenya when the market was still in its infancy and solar lantern penetration was only about 2%. Between 2009 and 2013 the market for stand-alone systems had grown by over 200%. The share of quality products improved rapidly; 4.3 million quality verified products were sold between 2009 and 2013, in line with Lighting Africa standards. More than 40% of the off-grid market consists of products that have met Lighting Africa's lighting global standards. The off-grid market in Kenya is a very competitive market with several SMEs occupying a space in the market. The VAT on off-grid solar products has also played a significant role in creating this favourable market but these exemptions, although currently reintroduced, have been subject to various changes with passing of legislation, which has caused uncertainty in the sector during the times when these changes were happening. The Kenyan government has VAT exemption on quality assured products (see discussion in Section 4.2.5).

Lighting Africa has developed a series of quality standards and testing methods for pico-solar lanterns and plug and play solar kits of up to 100W, to protect consumers from poor quality products and improve customer confidence. Quality assurance work is now primarily conducted through Lighting Africa's affiliated programme, Lighting Global. The Kenyan government is in the process of adopting harmonised standards in line with Lighting Global standards.

Kenya's light touch approach to solar off-grid product regulation could be regarded as one of the key reasons the sector was able to develop so rapidly, in conjunction with the market building efforts of organisations like Lighting Africa. However, as seen from Section 4.2.5 and in the sections above there was sector oversight, e.g., the requirement for registered technicians/ installers to be able to install off-grid solar home systems and changing stance on VAT, it's not so straight forward to classify it as a *light touch* or *heavy touch* approach. Generally, Kenya's sector was seen to have favourable off-grid polices but heavy touch and light touch approaches are not necessarily as straight forward and subject to changes in regulatory regimes.

Through Kenya's approach to regulating off-grid solar stand-alone solar products there is a balance being struck between promoting and incentivizing quality products without restricting specific sizes of systems. One off-grid solar company in Kenya argued the complexities of ensuring quality and affordability in relation to standard settings:

> So, quality of product is an issue and I think between Lighting Africa and GOGLA, and a couple of institutions, they are looking to certify products and say you should certify your products and then designate it as the right quality and things like that, but you can never get away from the fact that there is always going to be a cheaper alternative that is flooding the market. That's where things like marketing, branding etc. go a long way in giving the customer assurance that these guys are here to stay (OGS K1).

The respondent expressed full support for standard setting in the industry and stated that:

> There absolutely should be a standard, but you'll never be in a market where only a product certified is going to sell. You'll have the standard certified products and you'll have the other ones (OGS K1).

The challenges identified above also highlight the dynamics of a free market where customers are at liberty to purchase cheaper products that have not necessarily been certified and that serve shorter term and immediate needs.

From the above sections it is evident that affordability, financing and quality standards for off-grid solar products all have an impact on the viability gap for off-grid stand-alone systems. Similar to the discussion on mini-grids in Section 5.2.1 affordability, remains a key consideration for the viability of off-grid solar models and is an important consideration when looking at reaching customers with low affordability levels and ability to pay. In Rwanda affordability was a key challenge which interviewees emphasised; to make business models work, affordability needs to be addressed. The need to focus on affordability is enmeshed with the theoretical framing of the study and IDF principle of *inclusivity.* As demonstrated in the interview, companies in both Kenya and Rwanda have exhausted the *low-hanging fruit* and serving the more geographic and socially economically *hard to electrify* areas has proved more challenging. Thus, for off-grid electrification models to foster greater inclusivity, attention needs to be directed to the areas in which these companies are operating, and the types of subsidy support needed to address the affordability gap and in so doing addressing parts of the viability gap. Figure 14 shows the key factors impacting the viability gap of stand-alone solar models in relation to the core IDF sub-pillars in Kenya and Rwanda.

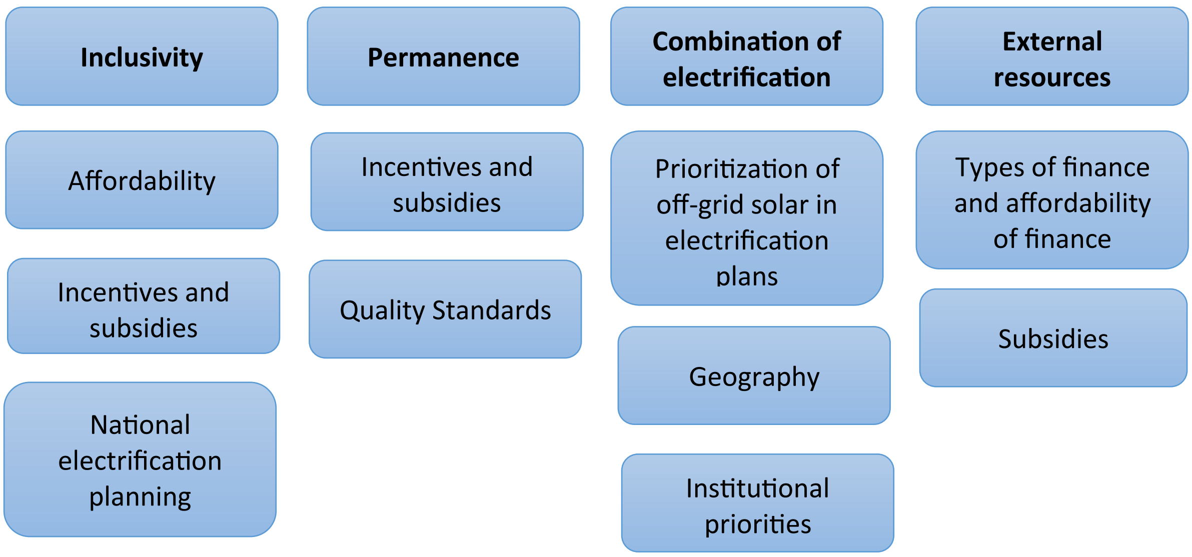


Figure 14: Determinants of viability and the IDF for stand-alone solar (Author's figure)

From a regulatory perspective, standards also play an important role in the quality and durability of products that have entered the market, which also links to the tiers of service in the ESMAP Multi-tier framework. As demonstrated through the case of Rwanda the new regulations on solar standards impacted on affordability by imposing a minimum level of service off-grid stand-alone solar systems needed to offer. These factors identified impact the viability of off-grid models and the four pillars of the IDF.

5.4 Conclusion

This chapter has identified and analysed the drivers of the viability gap in the case studies of Kenya and Rwanda. It was found that in the case study sites the viability gap is impacted by several interlinked factors including the regulatory environment, affordability, and financing. These factors all contribute to the complexity of building viable and scalable business models beyond the low-hanging fruit. The above factors broadly apply to both mini-grids and off-grid solar systems, yet impact these technologies in different ways, with tariff regulation, regulatory risk and grid arrival and demand stimulation being more applicable for mini-grid and sales and affordability, and standard regulation more applicable for off-grid solar. Affordability and national electrification planning affect both mini-grids and stand-alone system models. Furthermore, the chapter has identified direct and more subtle ways in which pressures are exerted through different mechanisms (e.g., regulation) or policy decisions.

For private mini-grid development, tariffs are an important consideration as they directly impact the revenues of the mini-grid developers. While the regulatory regime in both Kenya and Rwanda have allowed for developers to set their own tariffs subject to approval by the regulator in Kenya and more recently in Rwanda, there is a subtle push (drive) for grid parity. However, beyond a push for grid parity, when serving low-income settlements, the affordability gap resulted in some developers having to keep tariffs as low as possible. As a result, lower tariffs lead to a larger viability gap in the absence of subsidies or anchor loads. For solar home systems in Kenya, the costs of the systems are not regulated per se and off-grid solar companies are able to set the prices for off-grid products without direct regulatory oversight. However certain policy decisions, including the VAT on solar systems and components, impact the price and affordability of off-grid products (see Section 4.2.5). In Rwanda, however, the new standards for solar products has had an impact on the prices and affordability of systems that met the minimum quality standard criteria. This contributes to the literature on the linkages between the affordability gap, tariffs, and regulatory design (see Sections 2.5.2, 2.5.3 and

2.6), and the findings of Lepicard et al. (2017) on off-grid providers exhausting the low hanging fruit and needing to serve more challenging markets and customer segments.

Table 15 demonstrates that private sector off-grid providers need to navigate many challenges, some of which are within their 'sphere of control' and others outside of their control. Other aspects would fall more within the 'sphere of influence' where the private sector is able to exercise a certain degree of influence over certain aspects, but not entirely. Mini-grid tariffs fall in the sphere of control of private mini-grid developers and regulators; mini-grid developers set tariffs based on regulatory approval. Cost reduction is mostly in the sphere of control of private developers but also depends on import duties and the wider value chain of products that affect the prices of mini-grid components. For stand-alone systems, solar product VAT is determined by import duties within the sphere of control of policy makers and legislative authorities.

Table 15: Determinants of the viability gap (source: Author's table)

Determinant of viability gap	**Domain**	**Sphere of Control**
Mini-grid tariffs	Regulatory, policy and affordability (market)	Private mini-grid developer and regulator
Uncertainty about grid arrival	Regulatory, policy	Regulator
Demand	Affordability (market)	End-users, developers
Cost reduction	Policy, finance	Mini-grid developers, policy makers
Solar product VAT	Policy and regulatory	Policy makers and external funders (international development partners)
Minimum standards solar home systems	Policy, finance	Government, policy makers
Subsidy for off-grid solar	Policy, finance	Donors, Financiers, Governments

The chapter has also identified key areas where PPPs and financing partnerships could be effective for dealing with the viability gap. This includes partnerships for demand stimulation (i.e., private mini-grid developers partnering with Energy4Impact Mercy Corp) (see Section 5.2.2). It further includes partnerships for building or maintaining grids and financing partnerships with international development organisations working with mini-grid developers (5.2.3). Building on the findings of this chapter, Chapter 6 will specifically focus on the financing partnerships and broader financing ecosystem, with a focus on development partners supporting private sector mini-grids and off-grid solar business models through RBF programmes.

Chapter 6 Financing the viability gap – an Integrated Distribution Framework perspective on results-based finance and the financing partnership ecosystem.

6.1 Introduction

Chapter 5 identified the drivers of the viability gap for off-grid electrification models in Kenya and Rwanda and found that tariffs, affordability, and regulatory concerns around grid arrival were key challenges for private mini-grid models. For off-grid stand-alone solar models the viability gap was largely caused by low affordability and ability to pay, especially beyond the *low-hanging fruit*[68]. Chapter 5 illustrated the challenges private sector off-grid companies face in building viable business models, particularly in areas where demand and affordability are low, and households dispersed. This underpins the urgency for innovative financing models and partnerships specifically targeting the more challenging, hard to electrify areas to address the viability gap and improve the scalability of electrification models.

Chapters 6 and 7 turn to solutions to the viability gap and models that can advance SDG 7, and respectively explore emerging financing models and partnerships needed to close the viability gap. A situational analysis was done through preliminary interviews with country stakeholders and a review of key sector reports, which found that RBF and PPPs are key approaches used both in Kenya and Rwanda to address the viability gap and achieve scale in the sector. To this end Chapter 6 specifically explores the role of RBF as a tool to reduce the viability gap and scale mini-grids and stand-alone solar systems, through the lens of the IDF.

Section 6.2 firstly discusses the financing landscape for addressing the viability gap (building on the discussion in Sections 2.4, 5.2.2, 5.3.2) and then analyses specific RBF programmes for mini-grids and stand-alone systems in Kenya and Rwanda. It then discusses these programmes through the lens of IDF, in Sections 6.3 and 6.4 respectively.

[68] Particularly emphasised it the Rwanda interviews

6.2 The financing landscape for reducing the viability gap

As demonstrated in the literature review, viability gap finance is increasingly important for closing the viability gap for mini-grids and stand-alone systems (see Sections 2.2.4 and 2.4). TEA (2022) argues that to close the viability gap and scale quickly, subsidies are invariably needed, most commonly though RBF. Section 2.4.1 introduced the financing landscape for developing mini-grids and stand-alone solar systems. Section 2.4.2 highlighted that grants blended with equity is the most commonly used funding mechanism for mini-grids (BloombergNEF & SEforAll, 2020). Section 2.4.2 identified RBF as an increasingly dominant approach adopted by many countries in Sub-Saharan Africa. However, the interview data support the literature, in that RBF models for mini-grids are not a panacea for closing the viability gap (Johnstone & Garside, 2019; Nagpal & Pérez-Arriaga, 2021) and represent one of several funding tools needed to deploy mini-grids and stand-alone solar systems and present significant challenges.

Respondents largely concurred that RBF models need to be augmented by other approaches to close the viability gap (e.g., EI4, EI5, IDO R2, EI7). For example, one development partner in Rwanda, who manages an RBF programme for mini-grids highlighted that companies are increasingly focusing on productive uses to improve viability:

> Some companies are developing business models that focus on productive uses to increase the load and their incomes. RBF alone will not be enough to stimulate the sector, or our programme alone will not be enough yet, but maybe in the next five or six years if there is continued funding then companies will be able to scale and I think it will just be a few companies that will be able to scale (IDO R2).

This also demonstrates the importance of continuity of funding as the IDF is premised on permanence and long-term sustainability, but RBF programmes are limited in duration.

From the interview data, RBF is one of several funding mechanisms needed to reduce the viability gap. This is evidenced by a quote from an interviewee (mini-grid expert) at an international development organisation, who emphasised four key considerations that impact the viability of an electrification model. These include favourable debt terms, patient equity, a workable tariff that balances regulatory requirements, affordability and an RBF subsidy that is sufficient to cover the viability gap. Regarding the first two points, the interviewee commented that companies would need to have favourable debt terms and patient equity.

> As a developer, it's really hard. Because you have essentially four pieces that all have to fit together perfectly, you need to have the right terms on your debt. So, if you need patient equity, you have to find the right equity investor partners who are willing to be with you for the next 10 or 15 years and not expect to double their money, because that's just not how this works (EI 4).

This relates to the findings on financing for mini-grids as highlighted in Section 2.4.2 and Section 5.2.2 which discussed the combination of debt, equity and grants needed to fund mini-grid business models and fund the viability gap. The respondent further explained:

> The RBF program needs to provide a sufficient amount of grant that, can cover the viability gap and the tariff, and so there are two pressures on the tariff. One is, of course, if there's a regulatory cap, or if, if the regulations mandate a particular type of tariff, and that's certainly one pressure on the tariff, but the other one is the ability and willingness to pay at the end customer. So, it's these are the four pieces that have to work together to get the project to be viable (EI 4).

Regarding the sufficiency of RBF grants, as demonstrated through the examples of the EnDev programmes in Kenya and Rwanda, which provide up to 50% and 70% of the CAPEX respectively, these subsidies fill part of the viability gap, but mini-grid developers still need to go out and raise the finance needed to finance the remainder of the CAPEX investment. Particularly in the case of Kenya, a development partner commented that tariffs would still need to be cost reflective, and while the RBF grant had the effect of bringing down the tariff, it would still be significantly higher than the grid tariff. The above comment reaffirms the findings in Section 5.2.1 on how regulatory pressures and affordability need to be balanced to achieve viable models in the context of hard to electrify areas. Affordability and ability to pay (particularly emphasised by the Rwandan interviewees) could serve as a greater driver to lower the tariff. Interviewees further emphasised how RBF is only one piece in the equation of making mini-grid models viable.

> These are the four pieces that have to work together to get the project to be viable. RBF is just one slice of that and unfortunately -- typically, the grant per connection is typically set at a fixed amount at the beginning of finished goods program. But all these other things are in flux. It would be ideal, although much more complicated, if the RBF program had some flexibility. If the developer comes to you with a project that is technically sound, and is financially viable, because it's got the tariff, the debt and the equity, if it receives a poor connection subsidy, the RBF program should be able to come in and provide that RBF. It's like the RBF comes in as the last piece (EI 4).

The above statement raises an important point about the need for greater flexibility in the design of RBF programmes, and that the value of the subsidy is pre-determined and capped at a certain amount.

One of the challenges a development partner managing the EnDev RBF in Rwanda mentioned is that of needing to raise equity as a part of the criteria since the grant only covers 70% of the CAPEX of the project. This, coupled with regulatory complexity, as shown in the instance of the EnDev RBF programme in Rwanda, complicates the disbursement processes for RBF.

> Currently we have a few more projects in the pipeline. Some of the challenges that developers are facing now is 1) raising their equity, especially for local developers – that's a component of the access to finance 2) is the delay with the NEP - we were ready to sign a few projects (EI 6).
>
> We haven't had a project that's ready to be financed, because they haven't had their permissions – they haven't raised the equity. So, I think there are still some challenges ahead, especially as the project reaches our credit team who may be more stringent – than their investment officers working for the REF (EI 6).

Within the idea of a funding pipeline or continuum, combinations of finance including equity (and debt) are needed to finance mini-grids. The above quotes also demonstrate how interwoven other sources of finance are, as developers need to secure other finance in the form of debt or equity to make it work. This needs to be combined with an RBF grant that can sufficiently cover the viability gap.

6.3 RBF programmes for mini-grids in Kenya and Rwanda

6.3.1 Introduction to EnDev RBF programmes in Kenya and Rwanda

One of the early pilots for demonstrating the business case for mini-grids in Kenya was the GIZ Promotion of Solar Hybrid mini-grids (Pro-solar). As part of the Pro-Solar pilot in Talek county (70km from the grid), GIZ managed an RBF facility that provided grants to develop mini-grids under a private sector model (IDO K1). This was funded by the (then) United Kingdom Department for International Development (DfID)[69] to subsidise the CAPEX of mini-grids. Pro-solar was launched in 2013 for a five-year period up until 2018, to accelerate energy access through solar hybrid mini-grids, and with private sector participation. The pilot project showcased the technology, provided a training facility, and demonstrated private and public sector collaboration to develop mini-grids (IDO K1).

[69] Now Foreign, Commonwealth and Development Office (FCDO)

The RBF programme was embedded in GIZ ProSolar project, which provided technical assistance and de-risking for solar hybrid mini-grids (Figure 15). This included:

- Technical assistance to financial institutions and mini-grid developers;
- Assistance costs of pre-feasibility studies, government clearances, memorandums of understanding;
- Stakeholder engagement with government entities (EnDev, 2021)

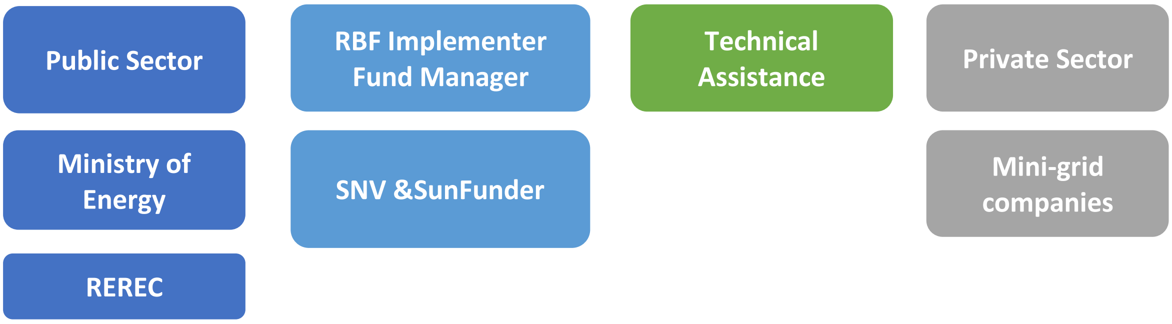


Figure 15: Implementing partners for EnDev IDF Kenya (Author's figure)

This was structured as a maximum of 50% of the CAPEX through an RBF structure. Developers were given an incentive finance contract with letters of credit to enable them to apply for finance. This enabled private mini-grid developers to invest 50% of the CAPEX (and secure the balance of the remaining 50%) and had the effect of bringing down the tariff charged to customers (IDO K1). Lowering the tariff directly links to the pillar of *inclusivity* in the IDF framing as energy services need to be financially inclusive and affordable to reach unelectrified end-users with energy services that are affordable (see Section 5.2.1).

As per the RBF design, 30% of the total incentive was for the power plant and distribution system commissioning and 70% for connections made per household and maintained for a period of at least three months. There was also an incentive for the energy produced (per kWh) for the first two mini-grids developed. In the calls for proposals, four companies were selected to develop fourteen sites of 464kWp in Marsabit and Turkana[70], which would translate to 1400 connections. As of June 2019, two sites were commissioned after two years of signing the RBF contract, eight were under construction and three were under permitting and procurement (EnDev, 2019). As Marsabit and Turkana, were two of the underseved counties in the KOSAP project, the GIZ Pro-solar project also experienced the

[70] These are two underserved counties that the KOSAP project also targets.

challenge of competing with the KOSAP project in terms of the sites that were allocated for mini-grid development, with GIZ needing to look for alternative sites as KOSAP was the flagship programme in Kenya that was embedded within the KNES. This relates to the IDF pillar of permanence, which is impacted by institutional priorities and how off-grid technologies are embedded within a national electrification plan and incorporated into the vision of a country's electrification plan.

Similar to the RBF facility for mini-grids in Kenya, EnDev GIZ manages an RBF facility for mini-grids in Rwanda which entered into a second phase in 2022. To develop Rwanda's nascent mini-grid sector, EnDev introduced RBF programmes for mini-grids, to support international and local companies developing mini-grids in the sector. This involved a partnership with Energy4Impact (now Mercy Corp), BRD and the government of Rwanda (see Figure 16).

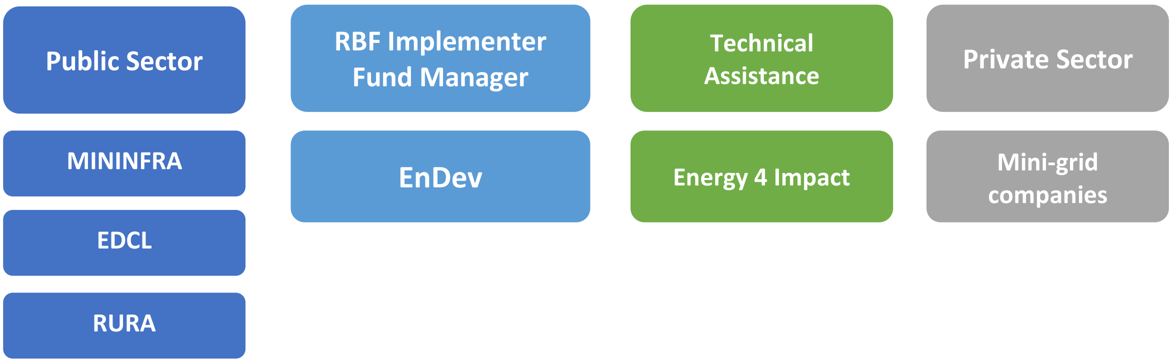


Figure 16: Implementing partners for EnDev IDF Rwanda (Author's figure)

The first aspect of EnDev's RBF finance in Rwanda involved technical assistance to improve regulatory conditions. Energy4Impact[71] assisted local companies with demand stimulation and modeling of tariffs. As discussed in Section 5.2.3, EnDev worked with Energy4Impact Mercy Corp to support productive uses which significantly improved the viability of sites, while having a positive impact on rural economic development (IDO R2).

This illustrates that demand assessments and partnerships to improve the readiness to apply for RBF programmes is an important aspect of making the RBF projects viable. This requires partnering with organisations that are best placed to provide this specific assistance. Assisting companies with demand assessments to assess the demand of their sites and factoring this more accurately into their

[71] Now Mercy Corps Energy4Impact. Energy4Impact no longer has a country presence in Rwanda and does not provide this assistance

applications for RBF finance can improve the quality of proposals, and therefore, the likelihood of obtaining funding. It furthermore aligns with the necessity for productive uses and how it can improve site economics and the viability of mini-grid models, as demonstrated in Section 5.2.3. It also reaffirms the idea that subsidies are not enough to make models viable, and additional measures should be implemented to improve the viability of sites through e.g., productive uses.

The actual RBF facility only came in the second stage after groundwork had been done. This shows that technical assistance is part of setting the scene for RBF. The facility provided grants ranging between 65% to 70% of the CAPEX. An interviewee explained the how the subsidy support is calculated as follows:

> They have to access the debt, and during the financial analysis we determine a subsidy amount and it's up to 70% of the CAPEX and to date it's been 65% to 70% of the CAPEX for the projects we've supported, because of the lack of viability and lack of demand to keep the tariff at a reasonable level (IDO R1).

According to an EnDev report, subsidies tended to be closer to 70%[72] due to several market barriers including the nascent stage of market development, insufficient proven business models, low demand on sites, high operational costs and lack of affordable access to pre-financing for working capital (EnDev, 2022).

From the above, a 70% CAPEX subsidy is needed to make a viable business case for the mini-grids in Rwanda, supported under EnDev's RBF subsidy for mini-grids. This is notably higher than EnDev's RBF in Kenya, where the subsidy was capped at 50%. This could be because of the larger viability gap in Rwanda, as Rwanda's affordability[73] and ability to pay is relatively lower than Kenya's (Power Africa, 2019b). In Rwanda several interviewees emphasised that Rwanda is a low-income country and affordability remains a key challenge (EC R1, IDO R3, IDO R1, Industry Association R1). The above further shows additional technical service support and partnerships with organisations like Energy4Impact to address the viability gap. The above sections have established the need for a

[72] From report and interview data in 2019 and 2023 (EnDev, 2019, IDO R1, IDO R6)
[73] For Rwandan families energy expenditure is very low. The cheapest solar home systems are RWF3,500/month ($3.87/month), which poses a significant barrier for off-grid stand-alone solar companies (Power Africa, 2020)

CAPEX[74] subsidy to address the viability gap and improve the viability of mini-grid projects in Kenya and Rwanda, which has also been highlighted in Section 2.4. The sections that follow will delve deeper into the challenges and advantages of RBF models, and how IDF principles can be used to improve the long-term sustainability and design of off-grid electrification financing approaches like RBF that are designed to reduce the viability gap.

6.3.2 Challenges and advantages of RBF financing models

To achieve universal access to electricity, in alignment with the IDF principles of *inclusiveness* and *permanence*, financing models and subsidies need to be designed to facilitate permanence and inclusivity. The EnDev RBF programmes in Kenya and Rwanda, discussed in Section 6.3.1, highlighted aspects of the programme design, regarding the maximum grant value allowed (as a percentage of the CAPEX) and stakeholders involved in RBF programmes. To this end careful attention is needed on the present design of RBF programmes, looking at advantages but also challenges with the inherent design. These aspects will be discussed below in relation to the abovementioned programmes but could apply more broadly to other RBF programmes on the continent.

In the context of Kenya, a development partner, working on an RBF programme, mentioned some of the advantages of private sector mini-grid development under Pro-solar through the RBF subsidies compared to the PPP model also piloted under GIZ Pro-solar, one being that private mini-grid developers must prioritise customer service and work hard to stimulate demand and collect revenue as their continued existence or sustainability depends on it.

> The advantage is that they own the mini-grid and they own the market in that area and they work very hard to develop the market for electricity within that village because as it is they have invested their money, 50% of the project and they have to recover it. So,… they are very careful, especially on customer service, customer care. They have to provide quality electricity, reliable electricity, engage the customers, to make sure they consume, the more they consume, the more they have returns and the more they make profit (IDO K1).

From the above, developers are investing at least half of the CAPEX, and having 'skin in the game' requires them to make a return on their investors. This also shows the need to move beyond

[74] Longer term project outcome and impact data on the EnDev RBF programmes would be needed to be able to say if these projects were successful, including beyond initial connections funded. The reports cited provided information on the number of mini-grids developed through the funding and number of connections. Notwithstanding, a CAPEX subsidy of between 50% -70% was a salient feature of the EnDev RBF programmes used in both Kenya an Rwanda. From the interview quotes with EnDev programme mangers a CAPEX subsidy was a prerequisite for making the project they assessed viable when doing their assessments.

connection only. They would therefore need to invest in revenue boosting activities including demand stimulation, as this has a direct impact on income and profits. Another advantage mentioned by the development partner, is innovation and the quality of the mini-grids.

> The other advantage of this set up is also the innovation, the technical innovation and the quality of the mini-grids. Because these private companies get permits for 20 years, they also implement quality mini-grids, I mean they get quality components…..they also actually employ advanced technologies. I mean for a model where the private sector is investing and have to hand over their sets after 7 years, they will not think of the long-term investment of advanced technologies (IDO K1).

Considering the above quotations, a private model funded through RBF would inherently have more incentive for demand stimulation, customer service and innovation as the mini-grid developers would adopt a longer-term view of their mini-grid assets, compared to a PPP or programme requiring developers to sell their assets back to the utility after a certain period. While private mini-grid developers may build sites, with the objective of operating these sites for the long-term, private models are not necessarily inherently more quality and customer oriented. In contrast to the above, providing a slightly more nuanced perspective on RBF, one interviewee commented that RBF is more focused on connections and as such the long-term maintenance or quality of connections is not necessarily prioritised.

> The question is what is the best use of money as far as subsidy is concerned? Are we looking at the quality of the connection or are we just encouraging developers to quickly deploy projects, because they know they will get X amount per connection and after getting X amount their sites are not well maintained etc (MG IL1).

The above statement makes an important point about the longer-term quality of electricity connections and what is being incentivised beyond the connection. As verified connections is a key disbursement criterion for RBF programmes, the emphasis on connections, while important, is only the first step in delivering a long-term sustainable delivery model. This also relates back to the incentive for energy produced (for the first two mini-grids) under the GIZ Pro-solar programme.

With respect to the long-term sustainability of a model, an interviewee pointed to ways in which longer term sustainability of mini-grid projects and provision for operations and maintenance (O&M) costs should be built into the financial models mini-grid developers should provide when applying for RBF finance.

> Ideally, before the mini-grid project is approved by the RBF program, you've seen their financial model, and you've seen their technical design. Built into the cost of electricity should

> be the replacement and O&M costs, so that the tariff that they're charging their customers, plus the initial RBF, which typically only covers the first three to four years of operation need to be sufficient to cover all of the costs (EI 4).

However, the interviewee mentioned that this is often not the case, and the O&M and replacement costs are often not included in the RBF subsidy assessment, and the RBF grants are usually not enough to cover this. Therefore, to improve the longer-term sustainability of a mini-grid, these factors should be considered in iterations (or variations) of RBF subsidies. This, however, depends on the total amount each developer is eligible for and how maintenance is incentivised as part of disbursement tranches. Furthermore, tariff reduction should be considered in tandem with subsidies. To this end a respondent from a mini-grid innovation lab commented on cost reduction mechanisms that they are currently exploring:

> We are trying to test if tariff reduction can be a more efficient way of deploying subsidies. The reason why this could be the case 1. Tariff reduction is based on consumption, so developers are actually motivated to help customers to consume more, which most likely means productive use, which most likely means economic activities. 2. Developers are actually incentivized to ensure the quality – it's not just about connections, but quality as well – if your site is down most of the time, you will not get the subsidy (EI 5).

The interviewee went on to highlight additional challenges around equity and access to RBF programmes for local developers. Some local developers in Africa are at the stage of building a pipeline of projects and getting to the number of connections that can be claimed for in an RBF programme. The interviewee further argued that local African developers do not always have access to the same funding sources and lines of credit international developers have access to.

> (Another) issue is not having as much access to finance at that stage, compared to access to international markets, which is what most of the biggest mini-grid developers [have access to] – you find that most of them are not African owned or founded. The point is there might be a need for more financing downstream and that is where potential subsidies, guarantees or interest buy downs, could be pointed instead of things like RBF (EI 5).

This links to equity and fairness in the *inclusiveness* pillar of the IDF, not only with respect to the market segments served but also equity in the presence of the companies – smaller and larger, local and international. One interviewee mentioned the importance of supporting local companies to participate in the market and the technical assistance needed to achieve this:

> So technical assistance will be needed for smaller companies to also build their business models and reach scale you need basically all players on board to achieve universal access and you cannot do it with just a few companies that are currently around, you need more companies and you need to have an opportunity to build capacity and scale with the local companies, that means differently structured financial mechanisms, technical assistance etc. and that's then when a next challenge is (EI 3).

A further consideration highlighted by an international development partner with experience in manging RBF programmes is how the regulatory environment impacts the roll-out of RBF programmes. This links back to the discussions in Sections 4.3.4 and 4.2.5 on the role of regulation for the successful roll-out of mini-grids and Sections 5.2.1 and 5.2.4 which identified tariffs, grid arrival and encroachment as important considerations that contribute to the viability gap. It also links to the interlinkages in the IDF framework on *permanence* of operators and the ability to bring in *external finance*.

> There is one important difference (between mini-grids and stand-alone solar systems) and that has to do with the regulatory framework that makes it more challenging for mini-grids than off-grid stand-alone solar companies to become very successful. For mini-grids you need concessions, tariffs – you are dependent on the national government (and sometimes also local governments) – that makes it quite challenging also for RBF schemes to be rolled out – and what we say it does not make sense to launch an RBF if you don't have a solid regulatory framework in place for mini-grids (EI 3).

It is evident from the above that mini-grid development is closely linked to the prevailing regulatory environment and by extension, programmes that provide funding for mini-grid developers are also dependent on regulatory stability and clarity to successfully roll out an RBF programme. Section 5.2.4 highlighted the importance of regulatory clarity and showed the impact of regulatory uncertainty, grid encroachment and electrification planning.

In line with the above, closely linked to the impact of regulation, a development partner working on the EnDev programme in Rwanda commented on the impact of national electrification planning on the roll-out/ progress of the second phase of their programme.

> We launched the second phase of the mini-grid programme last year February (2022) - we had some challenges with the NEP. The government was updating the NEP – we had to wait until the new NEP was published. We started again the application assessment last year and before signing the contact, we do the site visits to see if there is no national grid already there (EI 6).
>
> Unfortunately one of the sites was already reached by the national grid – so we had to go back to our national utility to have some discussion and then they informed us that there is some site visit by the national utility to validate the off-grid side – so now the new validation was completed – we are waiting for the national utility to share the updates with us and also the companies – because the companies cannot continue to work on the confirmation before they receive the confirmation of the approval from them (EI 6).

This comment exemplifies how the RBF programmes in Rwanda are closely interlinked with national electrification planning. As illustrated, changes to the NEP, the key electrification guiding document in Rwanda (see Section 4.3.2), has a key impact on the roll out and approval of RBF and requires confirmations from national electrification entities to reduce the risk of grid encroachment (identified in Chapter 5). Clarity on grid arrival would give development partners confidence that money disbursed for projects developed in certain area, would not be a waste or duplication of resources. In this instance, while waiting for updates to the NEP, the potential site for a mini-grid project funded through RBF was adversely affected. This relates to the IDF pillar of a combination of electrification modes and having clear coordination to circumvent potential challenges with regulatory risks. Interestingly, in line with Rwanda's more integrated approach to electrification planning, there is consultation between international development partners and the national utility (and other relevant electrification agencies) as a key part of the approach, even with respect to disbursing development finance.

Another challenge related to procurement delays. There were also some initial procurement delays caused by the selection of a fund manager, bureaucracy, division of tasks and the novelty of RBF at the time, and experience in managing the facility (EnDev, 2019). This is furthermore consistent with findings from a recent report from the Shell Foundation and AMDA which stated that early lessons from DFID (now FCDO) funded RBF programmes showed that it takes approximately three years from when a subsidy programme is first announced to when a project is deployed (Shell Foundation & AMDA, 2019). Consequently, many of the smaller companies are not able to sustain their operations while they wait for RBF finance to be disbursed, and many mini-grid developers spend more than two years raising funds to build two to three sites, which is not a scalable model.

This illustrates that mini-grid development involving procurement can be delayed, be it a publicly tendered mini-grid procurement or a procurement process facilitated by international development partners. Therefore, a key role in the governance of decentralised energy electrification programmes is around improving efficiencies in the institutional processes between a range of actors and developing ways to streamline different decision-making processes. In addition, the way RBF programmes are structured can cause delays, as mini-grid developers will only be paid out once certain milestones are met for developing the sites and connecting new customers. Therefore, if developers, especially smaller or new developers, are developing sites and need to raise finance privately first, this could cause significant delays.

Moreover, having to charge cost reflective tariffs was another challenge private sector developers needed to navigate. Even though the CAPEX subsidy had the effect of reducing the tariff, private developers would still need to charge a cost reflective tariff which is higher than Kenya Power's grid tariff or public mini-grids tariff. As one development partner noted:

> The model also comes with challenges because they have to charge cost reflective tariffs - it's more expensive than the public mini-grids or public private mini-grids. The areas we are also targeting, the off-grid areas, it's where the majority of poor people in Kenya also live and also the ability to pay for these people is a bit low and they also have to compromise on that (IDO K1).

The above illustrates a distinction from the KOSAP mini-grid model (to be discussed in Chapter 7) as the KOSAP mini-grids will be charging the grid tariff, while private mini-grids using an RBF subsidy will still be charging higher tariffs than the grid, even though the subsidy helps to bring down the tariff.

Further challenges relate to the RBF approach itself, the one being that RBF funding windows are time bound and limited in duration and not a continual stream of funding.

> We could have the same financing, but what we could pursue as development partners, GIZ, DFID, World Bank, AFD is a more structured and sustainable way of financing mini-grids, because what I have for example, I'm implementing RBF financing, but its only limited to 2019. What happens after that, will there be mini-grids developed without the RBF financing, that's the question we need to ask ourselves? (IDO K1).
>
> I don't know how we could consolidate this financing in one pipeline. It could be replenished over time, because we have AFD also running the same facility – RBF, financed also by DFID and European Union. There is a proposal by AMDA, to have all the mini-grid finances channeled through one stream, maybe through AMDA. Private sector could continually apply for subsidies and it should be structured and specified to what extent so that it can… sustainable before the market matures because as it is, it is not yet mature (IDO K1).

It is evident that there is a need to structure RBF facilities in a more sustainable way, as the funding needs extend beyond the initial development of the mini-grid projects. While the per connection grant (up to a pre-defined percentage of CAPEX) is important, it does not cover operation and maintenance costs for the life of the mini-grid. This could lead to challenges later down the line if the growth in mini-grid demand does not materialise as initially projected. In January 2021, Sustainable Energy for All announced the UEF, which is a multi-donor RBF facility providing incentive payments for energy solutions across several countries. The facility aims to be a USD 500 million facility by 2023 and has opened for projects in Benin, Sierra Leone and Madagascar (SEforAll, 2023). This is a step towards a 'Pan African' facility that would be open to several countries, creating a dedicated facility to mini-grid developers and additional financing avenues beyond specific country RBF programmes. The aim of such a Pan African facility with a revolving fund is to address some of the long-term sustainability issues found with RBF programmes to date.

6.3.3 The pipeline of funding – challenges and opportunities

Within the discussion of RBF finance, it's important to keep in mind that RBF is simply one of the many financing tools needed to finance mini-grids and address the viability gap. This requires pre-financing in the form of either equity, debt or other avenues of grant finance and post-financing to ensure the necessary funds to build a sustainable mini-grid operation (IDO K1, IDO R2, EI 4). To assist mini-grid developers in accessing additional finance, EnDev in Rwanda works closely with BRD, who administer the REF (funded through a 50-million-dollar World Bank part grant, part loan) under its fourth window. The REF facility is designed to provide bridge financing for companies supported through EnDev's RBF facility, to finance the pre-commissioning, as EnDev finance will only be disbursed upon commissioning and a certain number of household connection targets being met. The total amount per applicant cannot exceed USD 500 000. This is one of the ways the Government of Rwanda is addressing the lack of debt finance, particularly concessionary debt.

There have, however, been challenges with this fund as the mini-grid developers at the time, were not successful in accessing the funding. At the time of the initial interviews in 2019 however, no projects[75] were able to access finance through the REF but there is a pipeline of projects (EnDev, 2019). As highlighted in Section 5.2.2 this fund has been restructured to address the challenges experienced in the first iteration. There have been more disbursements for solar home systems, but no mini-grid projects were successful as of 2022. With respect to the initial interviews, prior to the changes, most respondents concurred that at the time (2019) the fund was not very successful.

> The fund has not been very successful yet. It was officially launched at the end of 2017. It took it some time to operate, it's obviously a new area for BRD. It typically focusses on large infrastructure developments including energy. With the mini-grid window we work with them quite closely—in theory they should meet the need, they haven't signed a loan yet and part of that is the projects here need subsidies (IDO R1).

Another development partner commented:

> They obviously do quite a risk assessment and the developer has to pass both BRD and World Bank to get the financing and I think some of the projects have been struggling to meet some of the requirements of the Bank, even then it's a bit difficult, there's so much inherent risk in mini-grids (IDO R2).

[75] This refers to all companies who have applied to the programme. Some of these companies form part of the interviewed companies.

A mini-grid developer in Rwanda commented:

> I was in a meeting with all the mini-grid developers in Rwanda and there's this $50 million REF fund that nobody can get access to (Mini-grid R1).

Following the restructuring, according to Climate Investment Funds (2022) more solar home system companies have been successful in attracting finance through Window 4, which involved direct financing for solar home system companies.

The above also shows that the effectiveness of RBF approaches is contingent on the broader financing ecosystem and that if there are gaps in the broader eco-system, RBF programmes may not realise their maximum impact in the energy sector. This is supported by the findings of an EnDev (2019) report that finds that funding mechanisms beyond RBF are needed to transform off-grid markets.

The above examples of RBF financing partnerships for mini-grids demonstrate that a range of stakeholders is needed to build the financing eco-system to advance SDG 7. These include public sector partners (e.g., the utility, ministry of energy, the regulator), financing partnerships for other avenues of financing for pre- and post-subsidy support, fund managers, technical assistance, and partnerships for demand stimulation. The value of forming partnerships for financing private sector mini-grids was demonstrated through the technical assistance as part of the pre-RBF support and challenges with continuity in the funding. Furthermore, as discussed, RBF programmes have limited windows and developers need to find funding in addition to and outside of this. As an energy expert explained:

> There's a slight iteration on the RBF model where a developer is allocated, let's say $500 per connection. But they're able to receive some of that immediately, maybe on signing the contract with the government. And then maybe they receive a second tranche, once they've built the mini-grid, and its commissioned, and then the third tranche of that RBF is paid out on a per customer basis (EI 4).

This would address some of the pre-financing challenges that developers experience and enable mini-grid developers to obtain financing to start their projects and be eligible to receive RBF disbursements, because they had the funding to be able to reach certain key pre-defined disbursement milestones. This iteration of the traditional RBF allows for an initial upfront payment built into the RBF itself, which also reduces the burden of needing to secure a loan upfront (or equity investment).

On the point of RBF programmes being able to incentivise mini-grid companies to go beyond the low-hanging fruit, the interviewee described how mini-grid companies could be incentivised by offering a higher subsidy per connection over and above the normal subsidy per connection that they would receive.

> One way that you can, again, alter an RBF program is to try to offer a higher incentive. So basically, that's your standard RBF - $500 per connection, right. But if you go into areas, X,Y and Z, which we know to be very low income and very difficult, maybe there's some security concerns and if you want to build mini-grids in that area, you're eligible for $700. So, you can use the same RBF concept, to incentivise developers to go into areas that are particularly difficult to ordinarily make a strong case for mini-grids to work (EI 4).

This is an important consideration particularly for going beyond the value they would have received in any case, as both viability and the regions being targeted should be considered. The above sections highlighted important considerations for the roll-out of mini-grids in Kenya and Rwanda, which also can be applicable to various other RBF programmes emerging on the continent. The next section will discuss important considerations for RBF programmes for solar home systems in Kenya and Rwanda.

6.4 RBF Finance for solar home systems in Kenya and Rwanda

KOSAP has a dedicated RBF finance component for off-grid solar systems[76]. The primary aim of this component is to incentivise off-grid solar companies operating in Kenya to expand their geographic reach into the 14 underserved counties to address the low penetration of off-grid solar systems in these counties. The incentives are a solar RBF facility and a debt financing facility. A respondent from the Ministry of Energy in Kenya commented:

> KOSAP [will] be trying the results-based financing, that is sort of an experiment we are trying, because the landscapes where we have taken this are very dry, arid lands, where populations very dispersed- so there will be real challenges, and that’s why we are saying, if we succeed, then that gives us a good model to use (Ministry K1).

The solar RBF is a US$12 million fund that will provide finance to solar home system companies in Kenyan Shillings. The facility aims to address the low penetration of off-grid solar products in the 14 underserved counties, by encouraging companies to expand into these areas and compensating them for the opportunity costs associated with providing services in these challenging environments. These counties are particularly challenging to serve because of widespread poverty, as well as remote and dispersed populations, resulting in low affordability and high costs of infrastructure provision. Through

[76] Although the treatment of solar home systems and mini-grids is different under the KOSAP programme.

the initial RBF financing, it is envisaged that companies would be able to raise further finance including debt to be able to scale (Ministry of Energy, 2023).

The debt facility managing US 30 million, involves on-lending to local banks to provide local currency credit to solar companies. The facility aims to provide support to sustainable energy access and quality tier 1 and tier 2 Lighting Global approved solar home systems in the 14 underserved territories, addressing the working capital constraints faced by many off-grid solar companies in the market. The facility will be made available to Kenyan registered companies with a 2-year track record in the distribution, financing and servicing of solar home systems. The facility also aims to encourage the growth of early-stage local companies (Ministry of Energy, 2023).

The Government of Rwanda also made available public finance to off-grid solar companies, through development finance including a World Bank loan to finance the new tiered subsidy, through the REF. This new subsidy primarily addresses the affordably gap in Rwanda for off-grid solar systems (see Section 5.3.2) and is targeted at different Ubudehe[77] socio-economic categories. The subsidy will be made available specifically for off-grid companies that sell stand-alone systems in Rwanda, administered through a results-based financing facility. The subsidy programme has been designed by Power Africa with EnDev and the World Bank. While previous subsidy programmes implemented by EnDev were primarily targeted at market development, this subsidy is specifically focused on addressing the affordability gap, enabling solar home system companies to reduce the prices of their products when selling systems to households under specific socio-economic segments (OGS R1). The concept for the subsidy was prepared by the Ministry, the utility (REG/EDCL) and development partners and approved by the Sector Working Group. The subsidy was piloted in Nov 2019 by EnDev in partnership with EDCL and co-financing from Power Africa with a focus on four districts in the South of Rwanda. The subsidy came into effect in October 2020 and is funded by the World Bank, the Swedish Development Cooperation Agency and Enabel (MININFRA, 2020). Six companies were involved in the pilot, to facilitate competition and consumer choice.

As a result of the Pro-Poor RBF, more than 22 000 low-income households were provided with energy access, 71% of which were classified as Ubudehe 1, the category of households who are least able to

[77] Ubudehe is a socio- economic classification system in Rwanda comprising 6 categories including household income, consumption, household assets, tenure etc. Ubudehe 1 are generally considered less well off than Ubedehe 2 and 3 etc.

afford access to clean energy alternatives. In addition, PAYG companies experienced higher ulilisation rates and lower default rates (which was mentioned in Section 5.3.1 as a notable challenge in the Rwandan off-grid solar market). By October 2021 more than 28 000 new connections had been achieved from the time the new RBF Pro-poor funding window was made available. It is further envisaged that 5.2 million new connections will be made under the REF window 5 (EnDev, 2022). The observation on the decreased default rates in monthly payments of customers shows how improving affordability at a household level can improve the ability of customers to honour monthly repayments to energy companies. As noted in Section 5.3, the requirement of companies having to have sell products meeting certain minimum standards, also increased the prices of off-grid solar systems, with many households being unable to afford the $4 per month some of these systems were being priced at. This shows the need for such RBF subsidies to close the viability gap.

In line with the strong coordination between the utility and private sector stand-alone solar companies, highlighted in Section 4.2.6, the utility has a role in identifying households that are eligible for the subsidy according to the tiered Ubudehe classification. As Figure 17 below illustrates, EDCL, has a hands-on role in the management of the RBF subsidy. They also have a role in the verification and quality control of the RBF that private sector off-grid companies submit to the REF.

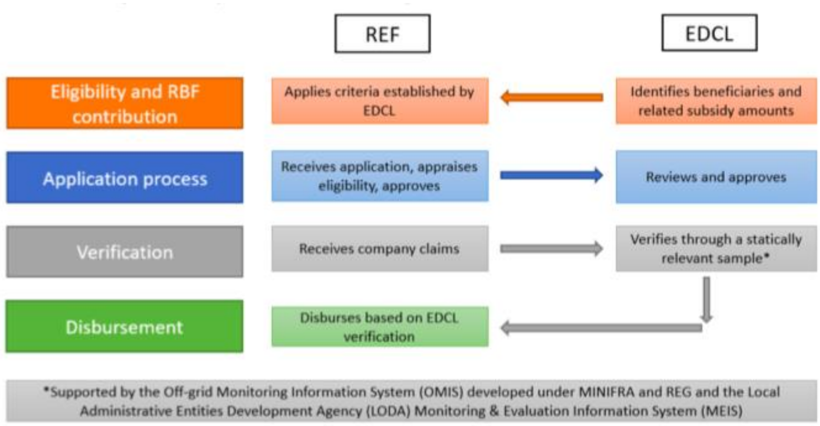


Figure 17: Implementation of the REF RBF Window (World Bank, 2020)

Under the subsidy, households classified as Ubudehe 1 will receive a 90% subsidy, Ubudehe 2 a 70% subsidy and Ubudehe 3 a 45% subsidy. These subsidies are particularly needed for Ubudehe 1 and 2, as the market price of these systems are unaffordable to the majority of these households and companies cannot make a sustainable business case selling to these households without a subsidy or additional financial support, be it donor funding or other sources. One off-grid company in Rwanda mentioned that they are not allowed to provide credit to households classified as Ubudehe 1 (sell systems on PAYG basis) due to a high credit risk of not being able to afford and thus not being able to pay for the systems over time (OGS R2). Another respondent highlighted that this causes Ubudehe 1 households to be effectively excluded if systems are sold on a purely commercial value basis.

> So, if you want to electrify in a sustainable way through quality services then unfortunately its's not going to be that cheap, that means that obviously Ubudehe 1 households are largely precluded from accessing those (OGS R1).

One of the challenges in the design and implementation of this subsidy programme is a fair allocation according to the Ubudehe categories, since someone who is classified under Ubudehe 2 or 3 based on certain criteria may be less well off than someone classified as Ubudehe 1. With respect to this a development partner commented:

> It's really hard to target and pick the right subsidy levels, which is something we're actually still thinking about, and struggling to figure out because of this spread in all three. You're going to leave some people out and over subsidise others. It's impossible to avoid (IDO R1).

This links more broadly with the challenges of implementing subsidies also highlighted in Section 2.2.4.

Another long-term consideration is the sustainability of the subsidy and continued funding beyond the pilot roll-out. A development partner explained that government and utility custodianship beyond the pilot would be a key aspect of the long-term sustainability of the programme; both in terms of the capacity to implement the subsidy as well as financing the programme from the national budget. The development partner explained that initially they had developed the concept and tried to get the buy-in from the utility and the government. EnDev's idea was to roll out the subsidy programme, adjust where needed and on-board government and utility staff to implement and take over the programme. Ideally such a programme needs to be embedded within a government electrification programme, initially financed through development finance, but also funded in part through the national budget as the government takes ownership of the programme. The development partner said:

> So, the idea was to make into this bigger programme where we can actually hand over the programme, [to] say you guys can take over this now, we can pull out eventually and it will still work (OGS R1).

The development partner further commented:

> There is a recognition that the government would have to play a role. Because if they don't it's from the start something that would be hard to maintain and there is only so much that you can get from donor funding and only for so long you can secure it, - so for it to be a sustainable stream of funding you would to be somehow managed by the government and

> come from the government, even if there will be contributions from DFIs, or whoever would be willing to sort of buy into this, and I think there is generally that appreciation (OGS R1).

At the same time, another interesting perspective is that there will be a need for continued business model and financing innovation. While the newly launched subsidy would be a huge boost for the sector, in the absence thereof the private sector would find a way to innovate. The development partner explained:

> At the end of the day, I think it would be achievable whatever goal Rwanda has set but it would just take much longer and my guess is that if this subsidy wasn't going to go ahead, there would be other innovative financing mechanisms that companies would look for or the government would be looking to design (OGS R1).

This illustrates that these subsidies give a much-needed boost to the sector, but the sector would need to continue to innovate, so that there is not a complete dependency on particular subsidies. This includes innovation in business models on how to bridge the affordability gap and leverage reduced prices of solar components and how these solar products are procured. This also includes ways to reduce operational costs and find innovative ways to serve customers in challenging markets and geographic locations. However, this would make a much harder business case and would take more time, because it will be a longer and more organic process without the funding. Furthermore, continued innovation in the business models to reduce costs and improve distribution would be essential even with the subsidy in place, to be able to sustain operations when the subsidy window closes, and companies would need to start to look to other types of financing.

6.4.1 Designing financial incentives for off-grid solar to benefit all ecosystem actors

To design incentives for off-grid solar companies to be part of larger national electrification programmes it is important to consider what factors might influence the private sector to expand or scale operations into other regions. As discussed in Section 6.4 the KOSAP project in Kenya offers incentives for off-grid private sector companies in Kenya to sell off-grid solar products within the underserved counties, through an RBF and debt facility for solar home systems. However, venturing into the more challenging areas is more complex than just having an initial incentive in place through RBF finance. A development partner commented on the motivations for off-grid businesses to go into the more challenging areas through subsidies with reference to experiences with RBF in Tanzania, and how this may be applied to the Kenyan context of incentives under KOSAP.

> The reasons for companies to engage in those markets should also be business reasons, they should (at) the end have trust that those markets would have the potential for them to create

> a sustainable business. Otherwise they will also never do it, because again they were heavily investing to set up the office structure, hiring staff, distribution chains, everything, so the companies that actually engage there with RBF incentives were actually the ones that also trusted that eventually in a couple of years' time that would become a sustainable business. Some of them managed to achieve that, and others not (EI 3).

Similarly, an energy expert in Rwanda commented on whether companies would consider expanding their footprint with reference to KOSAP:

> I mean, definitely, because at the end of the day it's business, it's just about making those strategic decisions about where your business can perform best, and that's why we've seen in Kenya, the Western counties attracting a lot of interest now, the coastal areas where you've got wealthier segments of the population but you still have significant proportion of unelectrified population where you know people are able to afford and I think this is why those counties and those regions that are included in KOSAP (OGSR1 2).

The above shows that off-grid companies' decisions to expand into the more challenging areas, would primarily be guided by what makes business sense. While incentives like the RBF subsidies might make a case for them to consider expanding, there are numerous other factors (financial and non-financial) that would need to be considered as well. This includes the ability for companies to sustain their operations beyond the initial subsidy/ grant payment and how their overall operations would be affected. It also relates to what a strategic decision would make sense.

It also illustrates that within the KOSAP territories there are differences in what people may be able to afford, and within the unelectrified counties you have households with a higher ability to pay. This might also mean that within the underserved counties in the KOSAP project, some companies might still target the more well-off counties first before going into the other counties.

A respondent in Rwanda commented on the Kenya's KOSAP programme, and why such approaches are needed:

> I think this is why those regions that are included in KOSAP, why the government is specifically targeting those is because companies are hesitant to go there knowing that they are going to struggle on their own. It's huge you know to expand, open a new shop, expand operations in a new region is already difficult enough, to do so in a rural area where you have no guarantee you are going to sell or are going to sell very little where you have nomadic populations and that does not align with your business because you cannot offer people a very mobile solution, unless it's a solar lantern (OGRS1).

Another international development partner, similarly commented:

> At the end of the day, you want the sustained presence of those companies that even after RBF financing those companies maintain operations, their after sales service as well, but also that further impact is being generated by the project (EI 3).

The above demonstrates that when off-grid companies expand into the more difficult areas, beyond the low-hanging fruit, they would need to consider many factors and these can differ according to the maturity of the off-grid solar company and their risk appetite. Ordinarily it could take years before companies start expanding their reach into the harder-to-electrify regions on their own, and therefore there is a need for government intervention through programmes with targeted incentives like KOSAP in Kenya to help achieve the country's electrification targets. Yet, even with incentives in place, there is no guarantee they will sustain their operations. This makes it very complex because there is the need to balance the financial sustainability and interests of the off-grid companies with the goal of universal access and going into the areas not gone into before will prove challenging. It's also important to bear in mind that ensuring financial sustainability and reaching universal access are not mutually exclusive, as you need to continue to serve your existing customers sustainably and not compromise your operations in the areas you are currently serving. So, it may be a trade-off of being able to service existing customers well versus running the potential risk funding new expansions at the expense of existing operations. This also links back to the idea of scaling up operations and doing it too quickly or prematurely.

6.5 Discussion on emerging themes through an IDF lens

6.5.1 Inclusiveness

Within the IDF pillar 1, *a commitment to universal access and leave no-one behind* it is important to consider how i*nclusiveness* is built into the design of financing mechanisms like RBF. The above sections explored how RBF can be used as a tool to facilitate inclusiveness by incentivising mini-grid developers and off-grid stand-alone solar companies to develop projects beyond the low-hanging fruit in areas that are more geographically difficult to reach and with low affordability. The KOSAP RBF for solar home systems in Kenya and the Ubudhehe Pro-Poor RBF subsidy in Rwanda target parts of Kenya and Rwanda that have not received grid access and are socio-economically challenging to electrify. For example, as discussed above, the EnDev RBF programme in Rwanda, which was implemented before the Ubudehe subsidy, was primarily aimed at market creation for off-grid solar as opposed to addressing the affordability gap, by subsidising the cost of the solar systems. The extent to which RBF programmes can facilitate inclusion is linked to the design of a particular subsidy programme. Not all RBF programmes are necessarily designed to support inclusivity objectives but as Phillips, Attia, and Plutshack (2020) argue they can be used to nudge the private sector into areas where they ordinarily would not go without the incentive. This further relates to whether RBF programmes are tied to specific geographic locations or if the RBF is just open without restrictions on the specific locations.

Another aspect of inclusiveness relates to how accessible RBF and other financial incentives are for local developers and whether they have access to the same funding opportunities as international developers do. International developers often have access to lines of credit that local developers don't ordinarily have. This links to the need to strengthen the whole local financing ecosystem, including local debt facilities. While raising finance, especially debt finance, can be challenging for local and international developers alike, the interview data strongly suggest the need for dimensions of equity and inclusiveness to be considered and enabled for developing off-grid energy projects, using the IDF framing as a guideline. This also relates to the pillar of *permanence* because for long term sustainability, it's important for local energy provision to be supported.

Open market 'freedom' vs directed development

A sub-theme related to inclusiveness is the trade-off between open market freedom and directed development. The RBF model for financing mini-grids offers more 'freedom' in the value chain than tender-based PPP approaches, and a greater incentive to invest in demand stimulation and customer engagement as mini-grid developers will not only be service providers for operation and maintenance but have a more vested interest in the longer-term overview of the mini-grid.

The RBF approach to incentivising mini-grid development offers more freedom in the value chain for selecting sites and applying for funding to develop mini-grids, while developers would still be responsible for constructing and retailing electricity to the end-users. As opposed to the KOSAP model where mini-grid developers partner with the utility and rural electrification agency to develop sites, in an RBF model, mini-grid developers partner with international development partners who are typically the funders and/or managers of the RBF programmes. This typically includes technical assistance support for preparing the applications for funding and organisations like Energy4Impact for demand stimulation. In this way the RBF finance partnership provides ecosystem and value chain support, rather than direct involvement in the value chain.

6.5.2 Permanence

Another key sub-pillar of IDF pillar 1 is *permanence.* From the interview data presented above and discussions of RBF incentives for stand-alone solar systems, the degree of permanence that can be achieved is also determined by the ability of off-grid companies to sustain their operations and grow their businesses beyond the initial subsidy period. While RBF programmes may be more catalytic, they do not guarantee sustained operations beyond the subsidy period and the ability of these companies to continue to engage in these off-grid markets like the underserved counties in Kenya or the regions where the Ubudehe subsidy is being applied. This requires a financing ecosystem to support the different stages and financing needs of off-grid companies as they grow, in addition to continued business model innovation (and internal ways to reduce costs).

Another aspect of *permanence* is embeddedness within the long-term electrification vision and national electrification planning strategies of a country. As emphasised in the interviewee data, the regulatory environment and national electrification programmes can influence the suitability of RBF programmes and the practical implementation thereof. As shown in the case of Rwanda, revisions to the NEP resulted in RBF finance being delayed until there was clarity on the NEP and the demarcation of grid and off-grid areas. This shows how regulation and the long-term electrification plans can influence the suitability of finance.

Speed and scale

Achieving scalable models for off-grid electrification is one of the objectives of RBF programmes for mini-grids. However, in the above examples RBF programmes for mini-grids have supported relatively smaller numbers of connections compared to the envisaged number of mini-grids to be developed under KOSAP, which model which uses a competitive tender approach for the mini-grid component. However, with the RBF programmes it allows individual private sector developers to apply for the subsidy and receive support for their projects at different times, without having to wait for a large batch of sites to be procured before the mini-grids can be developed. So, in this sense RBF approaches provide part of the incentives and support needed to scale the sector at a relatively greater speed, provided that mini-grid developers can obtain pre-financing to get the mini-grid projects started and post-subsidy finance to support the growth in demand of the mini-grid. However, the scale and speed that RBF programmes can achieve is highly dependent on the processes involved in approving applications, disbursing funds to eligible companies and the time lags between awarding the subsidy and disbursing the funds. Therefore, RBF mechanisms are not inherently more scalable, or always faster than larger scale mini-grid tenders, but offer the opportunity to scale the sector, keeping in mind that adjustments need to be made to certain aspects of the design of the RBF programmes. Thus, the supportive ecosystem of finance discussed above is also integral to the speed at which RBF financed mini-grids can be developed as financing delays in obtaining the match funding before the subsidy can be obtained.

6.5.3 Combination of delivery modes

As seen in the above cases of Kenya and Rwanda, RBF programmes support different energy technologies, and can be compatible with the approach of having multiple technologies (delivery modes) within a region to support the goals of universal access to electricity.

As shown in the discussion above about the impact of grid encroachment on the roll-out and disbursement of RBF finance, a combination of delivery modes grid and off-grid, can impact off-grid finance and the implementation of projects. While grid and off-grid technologies are needed to close the energy access gap and extend energy services to unserved or underserved regions, and is a key part of the IDF framing, technologies can 'compete' with each other, and they can often be a duplication of resources if the eventuality of grid arrival does not have clear guidelines. In contrast with Kenya, Rwanda has clear plans (as highlighted in the National Electrification Strategy) to implement an extensive roll out of the grid, beyond 2024 and this consequently does not leave much room for mini-grid development with the risk of grid encroachment being imminent and is something RBF programmes and other financing programmes need to contend with.

6.5.4 External resources

The IDF sub-pillar of *external resources* is another key aspect of the IDF, and links directly to IDF pillar 3, *financially viable business models*. To achieve the goal of universal access a broad suite of financing instruments is needed to finance off-grid projects and scale the sector, and RBF has increasingly been used as an approach to address the viability gap for mini-grids as well as off-grid stand-alone solar. Catalytic finance like RBF programmes has been mostly funded by international development partners and donors like the World Bank, GIZ and FCDO, to catalyse markets for mini-grids and off-grid solar as seen in the RBF programmes in Kenya and Rwanda, with an increased focus on addressing the affordability gap as well. As discussed in Section 6.3.3, a pipeline and ecosystem of funding is needed to support the achievement of universal access, and RBF serves as one of the funding instruments to support this. However as noted, to develop projects the private sector needs pre-RBF finance as RBF disbursements are only made upon certain achieved milestones, and post-RBF finance to serve the different growth financing stages of projects. For off-grid solar companies, especially the smaller ones, working capital is a key consideration, and RBF finance does not address the gap. Similarly, mini-grids developers would need to fund the upfront CAPEX through grants or equity, or a combination thereof and RBF finance approval can only be used as a tool to secure finance to construct the mini-grids. As indicated above the need for pre-finance sometimes leads to substantial delays in the speed at which finance is being deployed in the sector. Another important consideration when bringing in external resources is the continuity of funding as RBF finance has specific windows after which the subsidy windows and thus a key consideration for RBF within the IDF is evolving RBF into longer term financing options.

Lastly, as noted in the discussion on inclusivity, an important consideration is developing and supporting a local financing ecosystem to enable local companies to access finance. As highlighted in the interview data, while RBF programmes are open to both local and international companies; local companies with less of a track record often need additional investment readiness support to assist their applications for finance, and larger international companies may have a competitive advantage accessing this type of finance. However as seen in the design of the KOSAP programme, the RBF windows are open to Kenyan registered businesses, which to an extent facilitates a degree of localisation.

6.6 Conclusion

This chapter has demonstrated the complexities of RBF models as a vehicle to address the viability gap and how the framing of the IDF can improve the *permanence* and *inclusivity* of RBF as a financing model as well as how *combinations of electrification modes* (i.e., the coexistence of grid and off-grid infrastructure) can impact the roll-out and success of RBF programmes and finally within the IDF pillar of external finance, how the enabling financing ecosystem is needed beyond RFB. Indeed, as the interview data and supporting literature have demonstrated, RBF is one piece in the financing model, but is not a panacea for addressing the viability gap or inclusivity and achieving universal energy access.

As highlighted, there are many trade-offs and factors that would need to be considered when the private sector forms part of larger scale national electrification projects. This is particularly important to consider when serving unelectrified (and under-electrified households) sustainably in the most geographically remote areas, where affordability is a key consideration and ability to pay is low. Aligning incentives between different actors is a key part of building a successful partnership for off-grid electrification. However, as this chapter shows, even when there are targeted incentives like RBF in place there are a variety of challenges, and the chapter thus identifies the salience of partnerships within RBF models and wider the wider financing ecosystem of which RBF forms a part. For example, in Section 6.3.1, it showed the respective public, private sector and donor actors involved in managing the EnDev RBF programmes for mini-grids in Kenya and Rwanda and in Section 6.4 the Pro Poor RBF for stand-alone solar systems in Rwanda where the utility, EDCL works with the development bank, BRD to administer the RBF subsidies. As mentioned in Section 6.1, RBF finance along with partnerships for the tendering of mini-grid sites are the two main approaches to address the viability gap and achieve greater scale for deploying mini-grids. Chapter 7 will thus focus on PPPs for mini-grids as another key approach used in the off-grid sector.

Chapter 7 – An Integrated Distribution Framework perspective on Public Private Partnerships for mini-grids: A case study of the Kenya Off-grid Solar Access Project

7.1 Introduction

Chapter 6 explored RBF models as an approach to close the viability gap and achieve scalable models for energy access. It also showed the intricacies of using RBF as a mechanism to address the viability gap for mini-grids and stand-alone systems in Kenya and Rwanda through the EnDev RBF programmes and Pro-poor subsidy in Rwanda, and how IDF principles could improve the long-term sustainability and design of RBF models. Building on the insights from Chapter 6, this chapter turns to PPPs through national electrification programmes like KOSAP. It explores emerging partnership models and incentive-based[78] programmes for mini-grids with a focus on serving populations that are geographically and socio-economically challenging to reach.

This chapter analyses another approach for developing viable mini-grid models, predominantly observed in Kenya. This will be done through a case study of KOSAP to analyse the dynamics of PPPs for mini-grid development. A case study of these programmes has been selected to showcase how the viability gap is addressed through specific national electrification projects. Through initial interviews, KOSAP was mentioned by several interviewees due to its relevance for the off-grid sector in Kenya and in particular the role it has on the mini-grid sector. In contrast to Kenya, Rwanda did not have a large-scale PPP like KOSAP for mini-grids[79]. As such, the focus of this chapter is therefore on the lessons gleaned from the KOSAP project in Kenya, and how lessons from KOSAP could apply to Rwanda and other regions in Sub-Saharan Africa that may be implementing similar projects. Although the mini-grid component of the KOSAP project has not started with construction yet[80], organisations and actors in the Kenyan electricity sector have indicated the anticipated impact in the sector once the KOSAP mini-grid component is fully underway. They have also indicated the impact on private mini-grid

[78] Incentive based programmes refer to either large scale national programmes with donor funding to scale or develop off-grid projects. This can include PPPs, tender based programmes or RBF programmes, which offer incentives like grants and/subsidies for off-grid projects.

[79] With the exception of the new partnership between ARC Power and the Government of Rwanda which aims to electrify 40 000 households through grid tied mini-grids.

[80] The Kenyan Government has taken steps to enable the start of the construction of sites. In August 2023, Kenya Power has issued a tender for the development of mini-grids under KOSAP in 8 of the 14 counties

development, as a result of KOSAP sites being 'ring- fenced'[81] for mini-grid development under a PPP model through the selected private sector providers and public sector partners.

This chapter specifically focuses on mini-grids per se. While stand-alone solar systems are also a part of the KOSAP project, this was shown through the RBF and (debt financing facility) for solar home systems discussed in Section 6.4. Section 7.2 will analyse the model used under KOSAP and the impact on the value chain.

7.2 Analysis of the KOSAP PPP model

As discussed in Chapter 4, KOSAP, initiated by the Ministry of Energy and the World Bank, is currently Kenya's flagship programme for achieving off-grid electrification targets. KOSAP, which largely builds on the model used in the GIZ Pro-solar PPP pilot in Talek county, aims to promote the uptake of off-grid solar in 14 identified underserved counties among households, enterprises and community facilities. The significance of KOSAP is that it specifically targets geographically dispersed and distant counties in Kenya, which to date remain largely unelectrified, and areas where a viable business case for mini-grids, would be difficult for the private sector to service on their own due low ability to pay, insufficient demand and few anchor loads or productive uses (Power Africa, 2020). Power Africa (2020) highlights that only 23% of households in the KOSAP Service Territory are electrified, compared to the 70% national electrification rate at the time (2020). From an IDF *inclusivity* perspective, the extent of under- electrification in those counties illustrates why the Kenyan government chose to focus the KOSAP project in the 14 underserved counties. This furthermore makes KOSAP an important project to analyse from an IDF perspective. As discussed previously in Sections 2.1 and 2.6, a key aspect of the IDF framework is *inclusiveness*. This necessitates electrifying all parts of a country, including the most geographically and socio-economically challenging. As such the KOSAP project targets previously marginalised parts of the country that have not received grid service. As envisioned in the design of the KOSAP project, selected private sector providers (mini-grid developers) in partnership with the utility Kenya Power will be responsible for electrifying the households within identified sites (lots) under KOSAP, that are determined by the public sector partners (refer back to Figure 8).

[81] For the context of this study, 'ring-fenced' refers to mini-grid sites under KOSAP being set aside exclusively for development using this model.

The model initially proposed for KOSAP, in its conception in 2017, was a small power producer (SPP) model, where generation and distribution assets would be owned separately. In this model mini-grids would generate and sell power to the utility. The proposed model separates the functions of the generation company and the distribution company (ESMAP, 2017). In a recent update, in August 2023, Kenya Power issued the tender for the mini-grids to be developed within the 8 lots in the selected underserved counties. The selected service providers (i.e., mini-grid developers/contractors) under KOSAP would be responsible for designing, supplying, and commissioning PV mini-grids and the distribution network in the 8 pre-determined lots in the underserved counties (Kenya Power, 2023). The selected providers are not involved in the retailing of electricity, as the utility, Kenya Power, would serve the customer facing retailing function and retail to the customers at the grid tariff.

This model where developers are only involved in certain parts of the value chain, for example, construction, commissioning and O&M has an impact on the level of *permanence* that can be achieved in operating the mini-grid. On the one hand a model where mini-grid developers are not involved for the long term (i.e., for the full duration of a 20-year permit/license they would ordinarily get) means that they are less incentivised to operate for the long term and invest in productive uses and other demand stimulating activities, as they simply have an O&M contract. In that way this model does not necessarily enable the long-term presence of private sector operators. Having a partnership with the public sector could facilitate permanence, if adequate provision is made for funding the maintenance, replacement and expansion costs of the mini-grid. This could also reduce the risk private developers are exposed to in terms of funding sources drying up or serving customers who they cannot serve both viably and affordably. These risks, along with others, may lead to private developers discontinuing to operate in a particular area but having a partnership with the public sector could enable more continuity if the necessary provision is made.

As illustrated in Figure 18 below, each successful private sector bidder will sign an O&M contract for the generation and distribution assets (ESMAP, 2017; Kenya Power, 2023). This offers private developers consistent remuneration over the 7 year period. Being compensated through an O&M contract could reduce some of the challenges private off-grid companies have in making their models viable and being dependent on revenue from retailing to customers, thereby addressing the aspects of the viability gap. This could mitigate irregular revenue collection and the risk it poses to private mini-grid developers when developing projects serving customers with limited income and ability to pay (BloombergNEF & SEforAll, 2020). This also helps with the *viability gap* through dedicated revenue to the developers and the *affordability gap* as the mini-grid customer will be charged the grid tariff that is subsidised.

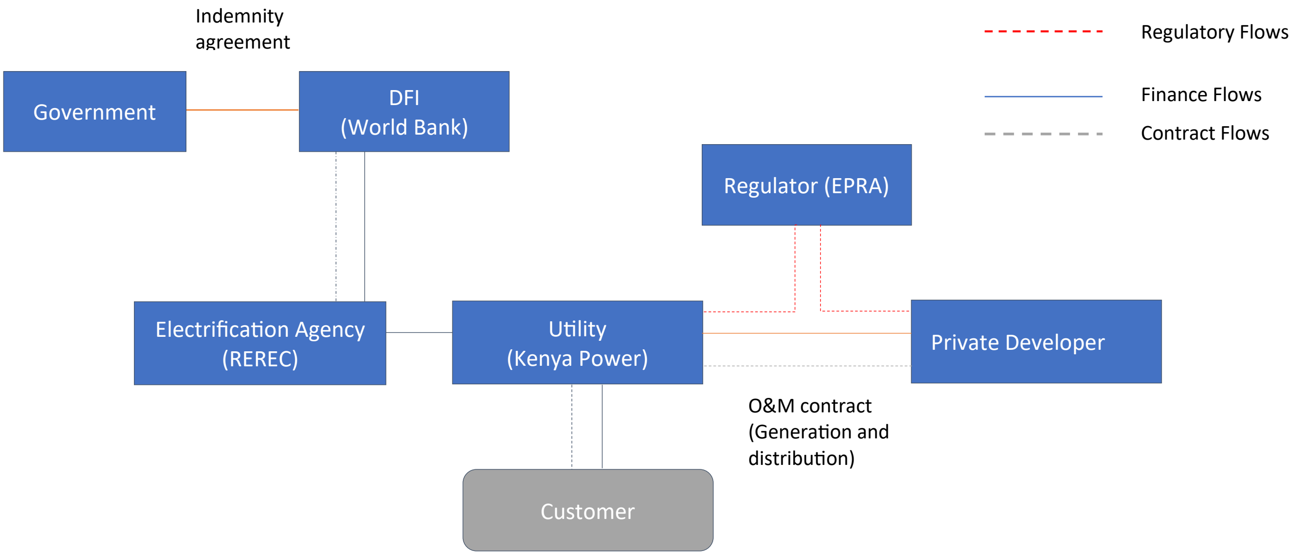


Figure 18: Schematic of KOSAP PPP model - finance, contract and regulatory flows (Author's figure)

On the one hand this could be advantageous as the private developers are not exposed to the risk of low demand and low ability to pay, since the utility will do the retailing and will cross-subsidise the mini-grid customers as they do the grid customers. From another perspective, however, retailing electricity and growing the customer base through demand stimulation is something which is important to private mini-grid developers and a key strength of the private sector. Although not in the original design of the programme to have the private sector responsible for demand stimulation, demand stimulation by the private sector can be a useful value add for such a model, as it leverages aspects where private sector mini-grid developers could add value. However, stimulating demand requires money (either funded by mini-grid developers themselves or through external funding like grants for mini-grid development), as discussed in Section 5.2.3 and additional partnerships for demand stimulation may be needed in this respect. The Regulator (EPRA) will play a role in the oversight of quality standards for mini-grids which are being developed in accordance with mini-grid regulations and the KNES.

A mini-grid developer in Rwanda commented on how they perceived a model like KOSAP in the Rwandan context:

> I think it can make sense, but you have to be careful where the incentives lie. Let's say we built some grids, handed them over to REG and they paid us like a flat fee per connection to

> manage them, but REG did all of the revenue collection, we would have zero incentive to do our demand growth activities, so there would need to be a revenue share for us to continue to invest in those activities and investing in those activities, like I said is a win-win for everyone – having a revenue share makes sense (Mini-grid, R1).

The above draws attention to the alignment of incentives. This suggests that with private sector involvement it really comes down to whether incentives are adequately aligned. It furthermore links to a study conducted by Carbonara & Pellegrino (2020) who explored risk and reward sharing mechanisms within PPPs and how this could be used to incentivise innovation in PPPs. In the above case a revenue share model between the utility and the mini-grid developer could serve to incentivise the private sector to stimulate demand, which is an important part of growing the mini-grid, and which would also boost revenues which can be shared between the utility and the private sector developer. In this way incentives for mini-grid development can also be paired well for demand stimulation. Carbonara & Pellegrino (2020) further argued that bundling construction and operation can improve both efficiencies of the project, which will have a financial benefit for investors. Conversely, separating construction for operations will lead to less innovation and less quality. Similarly, Farquharson, Torres de Mästle & Yescombe (2011) contend that well managed PPPs, optimally allocate risks between public and private actors. This enables efficient resource allocation over an asset's lifecycle, with private sector partners having an incentive to consider the long- term aspects of asset maintenance. It is therefore critical to consider how incentives are designed within PPPs as long-term sustainability is a key aspect of the IDF pillar of *permanence* and this translates to the more granular level of respective the long-term sustainability of mini-grids by allowing O&M to be adequately accounted for in the design of the PPP.

7.2.1 Impact of KOSAP on the mini-grid sector – shifting roles in the value chain?

The potential impact of KOSAP on the Kenyan off-grid sector is complex with respect to benefits and challenges. On the one hand KOSAP pilots a model that holds promise for scale[82], with more certainty for private developers through the design and supply and O&M contracts to develop and operate mini-grids in the more challenging and harder to electrify areas (Power Africa, 2019; Ministry of Energy K1; Ministry of Energy K2). This is the view held by a range of stakeholders, including the Ministry of Energy as custodians of the project and key institutional donor funders like the World Bank. However, some of the private developers and organisations working closely with them, felt that KOSAP would

[82]Scale to be achieved through the bundling of sites for the development of 137 mini-grids

effectively exclude private developers from participating in the sector with the freedom to select and develop sites and retail to the customers. Off-grid sector reports also show these dual perspectives of the potential impact of KOSAP on the mini-grid sector. One report echoes some of the concerns of private mini-grid developers (and the association), stating that KOSAP might dampen innovation[83] in the Kenyan off-grid mini-grid sector and limit other types of funding like equity investment for mini-grids (ESMAP, 2017). Power Africa (2019) is more optimistic that KOSAP, as part of a key recent developments in Kenya's mini-grid sector, is likely to 'revive the Kenyan mini-grid market' again, following a period of regulatory uncertainty and consequently reduced mini-grid development.

A development partner commented on KOSAP:

> Well, I think it's great that governments like the government of Kenya and others are increasingly prioritising off-grid energy as part of the solution and are also willing to invest in it because, mind you, the World Bank is providing a loan there, right… In the end it's the government of Kenya who invests in this and decides that to actually achieve universal energy access in Kenya in those underserved counties we need off-grid solutions, we need solar home solutions, we need mini-grids, that's a major breakthrough actually (EI 3).

A respondent from a mini-grid developer's organisations expressed this dual sentiment:

> It's actually a very good programme, it's fascinating for a number of reasons, but primarily it's encouraging for the sector because it is a loan to the Kenyan Government --- this is the first time that any Sub-Saharan African government in the world has asked for a loan, saying we think we can recoup our costs from these off-grid investments (Mini-grid association 1).

At the same time however, an interviewee from the association described KOSAP as a 'loss' for the sector, because the role of the private sector would be limited to building the sites and then operating and maintaining them, without having the autonomy[84] to select the sites and retail to the customers (Mini-grid association 1).

One of the concerns expressed by mini-grid developers and development partners (in line with the interview quotes above) is the inability for private mini-grid developers to choose their own sites, and the view that that there will be very few viable sites left outside KOSAP, beyond sites already

[83] While the ESMAP report has not explicitly explained the reasoning for arguing KOSAP may dampen innovation in the sector, it could be assumed that innovation is usually coupled with 'open market freedom' and not structured PPPs with pre-defined site selection or uniform tariff requirements etc. The mention of limiting other types of funding or equity in the sector may be due to the perception that KOSAP might be 'crowding out' other types of funding or off-grid programmes within the KOSAP territories.

[84] Outside of the KOSAP territories private developers are allowed to build, own and operate sites under pure private models or other variations.

developed and selected by the private sector outside of KOSAP model. A mini-grid developer and development partner commented:

> The challenge with that is the KOSAP has picked all the commercial centres. It's all good if some of the sites are left for the private sector operators…. Because if it was open, and they just picked it randomly and then left some commercial sites for the private sector developers, then it would have been a fair process (Mini-grid K2).
>
> KOSAP has taken the best sites for mini-grids, so the space for private sector is really reduced. The towns which have been left are quite small – so private sector going into the off-grid areas – there is no motivation anymore – also when you consider that the neighbouring utility will be charging grid parity tariffs and you want to reflect cost reflective tariffs that will also be a challenge (IDO K1).

It can therefore be surmised that KOSAP has created 'competition' in Kenya's off-grid sector for viable sites. From the perspective of enabling a larger scale deployment of mini-grids through the KOSAP project PPP model, the immediate 'ringfencing of mini-grid sites' as sites that can only be developed through KOSAP, limits the sites the private sector can choose from. This also implies that private mini-grids that can be developed under a shorter timeframe, will not be able to serve an energy access gap, which leaves unelectrified households and communities with fewer options e.g. solar home systems or paraffin, LPG, biomass etc. With fewer sites open to the private sector, this dampens the motivation to develop sites, and could stifle further private investment into mini-grid projects. The above quote also importantly draws attention to the potential impact not only on the KOSAP sites itself but on neighbouring sites, and the differential tariff between KOSAP mini-grids and those developed privately.

Another apparent concern by some private mini-grid developers and organisations working with them is that private developers would not be the retailers of electricity under the KOSAP model. This view is also evident in a comment by a development partner working with mini-grid developers in Kenya and a mini-grid developer in Kenya.

> The shortcoming I see with this KOSAP model is the omission of private sector retailing of electricity. The way it is structured – the revenue collection will be by the national utility. What we were campaigning for in the Pro-solar, was private sector participation in the retailing of electricity. But now how it is structured we might (have) a retailing monopoly at the end of the day because all customers will belong to Kenya Power (IDO K1).
>
> We thought that as much as the idea is good, because they really want to focus on parts of Kenya that has been left out for many years, our thinking was that this should have just been open to private sector players, who would be able to go there and bring new technologies to bear and would enhance customer service (Mini-grid K1).

The above statements link back to the discussion of the value private sector mini-grid developers could add in demand stimulation and customer engagement, as a key part of the private sector mini-grid model depends on demand stimulation and growing the mini-grid. So arguably KOSAP will not benefit from private sector retailing – one of the key areas where the private sector could offer value along the value chain. This could mean that mini-grid customers will not benefit from the quality of customer service the private sector could offer. Therefore, as discussed above, looking into a revenue share model might offer additional benefits of private sector demand stimulation and customer engagement which assists the utility in this aspect, while the private sector is incentivised to do so. However, it is important that the Government of Kenya have taken pro-active steps to move into the areas beyond the 'low-hanging fruit' through KOSAP, to reach parts of the country with a regional electrification rate almost three times lower than the national average. The private sector would ordinarily prioritise sites with the greatest potential for building a viable model. This 'cherry picking' does not further the IDF principles, particularly *inclusivity,* with a provider responsible for electrifying all households within a specific territory. Thus, if it were entirely up to the private sector to move into the more challenging areas without commensurate subsidies and other support to strengthen their business case, arguably, large pockets of the country would remain unelectrified.

The model proposed for KOSAP may be signaling to the market that private mini-grid developers are not 'needed' in the way that they have been thus far. i.e., by identifying potentially viable sites on their own, bringing in their own finance, retailing to their customers and only applying to the regulator for licensing and tariff approval. This, however, seems to be the opposite of what the Ministry has intended with KOSAP, as this project was conceived for the purpose of incentivising the private sector to partner with the utility and REREC to develop sites in more challenging areas. The Ministry emphasised the importance of incentives for the more challenging areas, and the role that the private sector would play in this regard. So, while the private sector is needed, it may be that this will be on terms defined in the project. This could furthermore signal shifting roles for the private sector mini-grid development in Kenya and beyond, as the KOSAP project might set the tone for large scale procurement of sites, with other East African countries already adopting the tender approach (i.e., Ethiopia, Rwanda and others). Key sector organisations like AMDA represent the interests of their growing membership of mini-grid developers in East Africa and across the continent. As discussed in Section 4.2.6, AMDA serves as an intermediary between the private sector and other key stakeholders like the utilities and Ministries of Energy and serves as a collective voice for their membership to increase the 'bargaining power' and 'say' developer have on key sector developments like KOSAP.

While the KOSAP project covers a large part of unelectrified households in Northern and Coastal Kenya, outside of KOSAP, there will be sites left that have not been developed. These remaining sites will be more challenging as they are the more difficult sites to develop a business case for in these underserved counties. Generally developing mini-grid sites and creating a viable model is challenging as this depends on the density of connections, affordability and ability to pay, revenues, demand stimulation efforts, and tariff regulations (see Section 5.2). Prior to KOSAP 'ringfencing' sites for development, private sector developers had a larger 'pool' of potentially viable sites to select from. As this pool is now considerably reduced, this arguably makes developing further mini-grids more challenging. Notwithstanding the above viewpoints that KOSAP has selected the best sites, mini-grid development under KOSAP does not necessarily become easier. KOSAP underserved counties are highly dispersed, and the population density is four times lower than the national average (Ministry of Energy, 2022). A development partner in Kenya explained:

> So, there will also be those small pockets of villages that will be left, and this is where we now also need private sector money, as I told you some of the private companies are also looking to this, keen to expand their businesses and to expand their reach and increase their customer base and increase their incomes (IDO K1).

The above quote may seemingly contradict the earlier view that there would be 'no motivation' to develop these more difficult sites, but both sentiments can be true. While there may be a general keenness to expand and build mini-grids in the underserved counties, there may be a lack of motivation of the part of some developers to prioritise these more difficult areas. Arguably the remaining sites outside of KOSAP will be more challenging to build a viable business case, as KOSAP has selected some of the best sites from a viability perspective. The development partner further elaborated:

> The left sites are harder to reach and that is where we now call on the government upon completion of KOSAP, we need to identify these sites and have a structure of supporting the private companies to reach these unreached sites, maybe also the KOSAP participants and the private companies and the participants who will be implementing the KOSAP and now they will be active in these areas and be assisted by the government to be assisted to reach these left out sites (IDO K1).

While the above quotes call for private sector involvement of the sites outside of KOSAP, they also suggest that that some form of government support or collaboration will still be needed beyond KOSAP, particularly in the more challenging areas. This goes back to the idea that parallel approaches to off-grid development are needed (private sector and government led) and that neither can fully achieve the country's electrification goals alone (see Section 2.2.4). This also links back to the IDF principle of a single entity (or a few) that are specifically contracted to electrify a particular territory, so that you don't have pockets of unelectrified regions. Within the IDF framing this would ideally be achieved through a territorial concession, but in countries where concessions are not the predominant models and other 'looser' forms of PPPs are being implemented or explored, the challenge of who fills the gap would need to be considered. This further presents a challenge for meeting the criteria of inclusiveness, because although KOSAP incentivises electrification beyond the 'low-hanging fruit' as the interviewee describes, outside of KOSAP there will still be villages left that will not be electrified. This leaves a gap in electrification and ties into the idea of a provider of 'last resort' which the IDF proposes where an entity would need to be responsible for ensuring that all households and businesses within a geographic territory are electrified. As the development partner explains government support to catalyse private sector investment would be important for the areas beyond KOSAP to further incentivise private sector capital and 'crowd in' the investment needed for the sites.

Nevertheless, KOSAP will be a learning curve for the implementers and partners in the project. A respondent from the Ministry of Energy in Kenya acknowledged this.

> We want to learn each step as we also implement, so the business models will be refined (Ministry K1).
>
> KOSAP ... is an emerging concept, and we think in it there lies a lot of lessons that we can draw, for example to be able to say with certainty what workable business options are available, but for now we are looking at the entire range of the business options, just based on the initial understanding of the communities (Ministry K1).

Similarly, a development partner in Kenya commented:

> Let's see how this and this works in the KOSAP plan. It will be an advantage for the utility to learn. Maybe own operation from the utility is the best – maybe private sector operation is the best. By the time we have this project running for five years we will have good lessons and that could now actually bring in the private sector much more into the electricity space because if the utility sees it advantageous to have private sector operation of the mini-grids they could actually bring them into the grid areas to manage sections of their grid (IDO K1).

KOSAP provides a steep learning curve for project custodians, implementers, and broader stakeholders. While mini-grid component of KOSAP is still at an early stage (i.e., the construction of the KOSAP mini-grids have not yet started, despite the project starting in 2017), there are early lessons which can be drawn from the empirical interview data that can be valuable for the shift to larger scale mini-grid deployments. One of these, as demonstrated in the second part of the above quote, is new avenues of partnerships which could arise from the KOSAP project which may be mutually beneficial for public sector and utility actors.

7.3 Discussion

It is evident that a model like KOSAP can offer key benefits for addressing the viability gap and developing larger scale mini-grid projects, but there are also trade-offs that begin to emerge. Key benefits include a contractual agreement between public and private sector actors that reduces risk associated with irregular revenue collection, as the private sector developers will be paid for O&M. There is also a positive impact on *permanence* having the main utility have a responsibility for retailing to customers in perpetuity. It further includes *external finance* through a World Bank loan to the Kenyan government, to be able to fund a larger scale mini-grid deployment. The design of KOSAP also facilitates *inclusivity* through the focus on unelectrified and under electrified parts of the country. The grid tariff which will apply to KOSAP enables inclusivity because mini-grid customers under KOSAP will be charged the grid tariff. Mini-grid development involves the interests of various stakeholders including private developers, the utility, government, international development partners and importantly the customers. Inevitably when developing a model for universal access, there will be trade-offs for different stakeholders. Using the IDF as the overarching framework, this section will discuss the key emergent themes from the interview data in relation to the grounding principles of the IDF.

7.3.1 Inclusivity

Inclusivity is a key part of the IDF approach, built on the premise that no one should be left behind, and forms part of *IDF pillar 1, A focus on universal access and leaving no-one behind*. The KOSAP project facilitates inclusivity, by expanding the geographic reach of energy access to geographically remote and marginalised parts of Kenya, by incentivising private sector participation in partnership with the utility and the rural electrification agency. However, as shown in the interview data, with the KOSAP approach inclusivity is only facilitated *in part* and not entirely as there will be areas outside KOSAP mini-grid sites that will remain unelectrified, unless through stand-alone[85] systems, where appropriate (or other options like diesel or paraffin, which from health and emissions perspective are less optimal). Options like stand-alone solar systems would offer a lower tier of service than mini-grids, which relates to the trade-off between achieving greater speed of electrification and lower tiers of

[85] KOSAP also has a dedicated facility (RBF and debt finance) for stand-alone systems.

service versus higher tiers that may not be viable within a particular timeframe. Moreover, the sites that remain are arguably more challenging to electrify, because KOSAP implementers have selected the most viable sites, and it will be difficult for the private sector to develop without government support and the necessary subsidies to make up for the viability gap. Furthermore, inclusivity is also interlinked with affordability as physical access to an energy service does not automatically translate into energy consumption. So, while there is a need for geographic inclusivity, this should be coupled with broader socio-economic inclusivity considerations with particular attention to the affordability and viability gap.

Within the broad concept of the inclusivity in the IDF, there are further trade-offs that begin to emerge. These include open market freedom versus directed development and the link between inclusivity, affordability, and viability.

Open market 'freedom' versus directed development

From the data presented above, directed development can facilitate positive impacts that further the objective of the IDF (see Section 7.2), especially *inclusivity*, but also *permanence, a combination of electrification modes* (as will be elaborated in the sections below). KOSAP demonstrates how *inclusivity*, both geographic and socio-economic, was built into the design of the project, by targeting parts of Kenya that have been historically marginalised. Without more public sector guidance there would arguably be more 'cherry picking' of regions to electrify. One emerging theme is that the degree of 'open market freedom' impacts the level of inclusiveness that can be achieved. One area which this directly impacts is site selection. Mini-grid developers not being able to select their own sites in KOSAP, was a concern for some private developers and organisations working closely with them (see Section 7.2.1). Invariably depending on whether a country prioritises inclusivity in electrification or economic viability, there will be trade-offs for various actors in the sector. From the above it seems that realising inclusivity and economic viability objectives seem to be at odds. In the KOSAP project there is a *primary inclusivity objective*, but KOSAP has selected the most viable sites within these underserved counties. However, creating a viable mini-grid project goes beyond selection sites that show the most promise for viability. Factors like demand for energy and affordability must be considered. However, the IDF framework aims for greater inclusivity, while actively addressing viability gap challenges.

In the absence of directed development of mini-grid sites, there is the risk that the underserved counties will remain underserved, with a few mini-grids being developed, but without the scale of the impact required in the region to make a dent in the electrification gap. Therefore, it stands to reason that the underserved, marginalised counties might lose out in the absence of more guided and directed development through programmes like KOSAP[86].

Speed and Scale

The trade-off between speed and scale is one of the trade-offs evident from the emerging PPP models. When speaking of universal electrification there is both a time and scale imperative, i.e., reaching the largest number of unelectrified and under electrified households within the shortest timespan financially viable and physically possible.

From the PPP models in Section 6.2, scaling through bundling or aggregating sites through competitive tenders would achieve larger scale mini-grids, but with time delays due to the processes mentioned above, but with anticipated delays in the procurement process. For example, KOSAP was first announced in 2017, but the mini-grid component is still in the procurement phase. Furthermore, developing sites through competitive bidding and public tenders would take time for bids to be evaluated and awarded and sites to be developed and commissioned. In contrast, private mini-grid development could happen relatively quickly, subject to licensing procedures timelines[87] and the time taken prior to securing private investment.

As the KOSAP sites are 'ring-fenced' and not open to pure private models, unelectrified households in these territories would arguably remain without modern, safe and reliable access until KOSAP mini-grids are completed. However, when they are completed, much larger numbers would gain access. Private sector developers could develop these sites more quickly but have not yet been able to demonstrate significant scale. Even though they may theoretically be able to get the mini-grid running within a shorter timeframe, it would be difficult to get investors to invest in those sites, instead of more viable sites. Potential mini-grid customers will be losing out in the short term in the period in

[86] KOSAP targets marginalised counties (which is inclusive) but only major economic centres within them (which is less inclusive) to balance viability and inclusivity.

[87] As noted in section 4.2.5, in Kenya the new Energy Act of 2019, the response time after applying for a license with the regulator in has been reduced from 90 days to 15 days, in an effort to streamline the process of mini-grid licensing approval.

which they are not served with an energy solution, but more households could stand to gain in the long term if the KOSAP project is successfully carried out.

7.3.2 Permanence

The concept of permanence, as envisioned in the IDF, means that there needs to be continuity in energy provision. A key challenge, however, with aligning centralised grid and off-grid infrastructure is a disjuncture between the relatively longer-term nature of national grid infrastructure and shorter term (or undefined) nature of private off-grid projects. While private sector mini-grid companies aim to have a long-term presence in a country of operation, regulatory and financial uncertainty can effectively prevent them from doing do. Notwithstanding the above, the level of permanence that can be achieved will depend on several factors including the stability of the regulatory environment, the ability to continuously bring in the necessary funding at different stages of the lifecycle of the mini-grid, and how the off-grid technologies fit within the broader electrification plans of the country. Funding gaps can also influence how long an entity will be able to remain in the market. It also depends on the nature on the nature of the partnerships structure and incentive programmes. For example, within the KOSAP model, while it builds in continuity by having the utility take over the mini-grid after 7- 10 years, it does not necessarily incentivise a long-term role (other than operation and maintenance) for the mini-grid provider as the assets will be sold back to the utility. So, while there may be a long-term vision for the power sector, it may imply a shorter-term vision for the different sector actors. This therefore implies the co-existence of multiple timelines. This creates potential challenges with balancing different energy sector stakeholder expectations and defining clarity of roles and operation timelines. This could range from balancing private sector compensation mechanisms in PPP structures or in the event of grid arrival, to understanding the respective timeframes in which private, public and donor stakeholders are expected to operate or contribute to off-grid projects.

7.3.3 Combination of Delivery modes

Competition between sector actors and programmes is revealed at different levels. As KOSAP[88] was a larger programme in scale and scope, written into the KNES, smaller programmes needed to re-

[88] Because KOSAP is a national programme that is embedded in the countries national electrification strategy in takes priority over smaller donor led programmes – in the electrification programme preference is given to KOSAP for sites

consider some of the sites selected as these were now ring-fenced as KOSAP sites. In addition, other privately developed mini-grid sites are also competing with KOSAP sites; interviewees highlighted the KOSAP project has selected some of the best sites for mini-grid development. Consequently, the remaining sites in the underserved counties will be more challenging to electrify without government or development partner support in the form of subsidies. Furthermore, private mini-grids are also to an extent competing with the KOSAP mini-grids in terms of the tariff charged, as the KOSAP mini-grids charge grid tariffs while privately developed mini-grids will charge tariffs that are slightly more cost reflective. It is thus necessary for there to be coordination between programmes so that larger programmes like KOSAP don't crowd others out[89]. One aspect is the differential tariff and how that would need to be resolved or finding other mechanisms through additional subsidies to non- KOSAP sites or other mechanisms to reduce costs. This also speaks to the need for stronger coordination between public, private and donor actors and consultation between these stakeholders in these sites.

Another important aspect of *a combination of electrification modes* as described in Section 6.4, is that KOSAP also has an RBF and debt financing facility for solar home systems. As discussed in Section 7.2 while the mini-grid component of the KOSAP project is still to be constructed, and the sites have been ring-fenced and secured; households who don't have access to electricity within the mini-grid territory can be given the option of a solar home system as an interim option for households transitioning between different tiers. The KOSAP window for solar home systems is underway, with companies selected for finance already operating. This implies the need for a less strict demarcation between mini-grid and solar home systems, under KOSAP, where new providers operating through the KOSAP project, as well as those providers already operating in the KOSAP territories are able to serve households who have been earmarked for a mini-grid connection, but not served yet.

7.3.4 External resources

External resources to enable IDF pillar 3, *financially viable business models,* is another key aspect of addressing the viability gap. Through the example of the KOSAP project in Kenya, external funding through a World Bank loan to the Kenyan government was provided. The PPP model addresses the viability gap of mini-grids by spreading the risk among public and private sector actors, with the private

[89] The differential tariff may be an issue and lead to comparison and fairness concerns where KOSAP mini-grids (which apply the grid tariff) are located close to mini-grids developed under pure private sector models, or under other programmes e.g. the GIZ Talek model. In this sense off-grid mini-grids located in proximity to each other could be seen as being in competition for location or customers etc.

sector having a contract for the construction and O&M of the mini-grid. The private sector, however, will not be exposed to the revenue risk of serving low-income households, as the utility will retail electricity, charging the grid tariff. The project funding enables the cost of mini-grids to be subsidised, so that mini-grid customers are charged the same tariff as grid customers, which is significantly less (up to a third of the cost of the grid tariff). As shown in Sections 6.2 and 6.3, RBF serves as an important avenue for mini-grid developed in both Kenya and Rwanda, where developers can privately develop their own sites, subject to regulatory approval, and bring in finance through a combination of grants, equity or debt. The private route to mini-grid development offers more agility and less rigidity in the model for developing mini-grids. Under a PPP like KOSAP, mini-grid developers would enter into different contracts with the utility (e.g., O&M) and are paid based on agreed contractual provisions. In a privately developed model, developers are open to raising finance through several avenues, which depending on their track record may have access to more or less financing options. This creates a greater onus on mini-grid developers to raise the finance themselves but also the flexibility, choice and 'control' of value chain functions like retailing to customers, which has inherent risk, but also 'reward' for developers who are able to make the model work.

7.4 Conclusion

This chapter has analysed how PPPs could be used as a tool to address the viability gap and achieve scalable mini-grid models through the case study of KOSAP in Kenya. Specifically, this study applied an IDF framing to understand how principles of the IDF could be applied to the case of KOSAP, with a specific focus on projects like KOSAP could achieve objectives like *inclusivity, permanence, a combination electrification modes and external finance* to achieve scalable models for electricity access.

The chapter found that within the IDF pillar of *inclusivity* an emerging sub-theme was o*pen market freedom* versus *directed development.* From the data presented above, directed development can guide sector developments towards positive impacts that further the objective of the IDF (see Section 7.3.1). Without more directed development there would arguably be more 'cherry picking' of viable sites. However, this comes with trade-offs of the more control of the value chain e.g., retailing to customers (with the freedom and risk that offers) as opposed to being open to playing roles in only parts of the value chain to be able to work effectively in a PPPs, to achieve the objectives of SDG 7. While KOSAP on the one hand addresses cherry picking by being more geographically inclusive, it also involves a degree of cherry picking within the KOSAP territories to choose the most viable mini-grid sites. This relates to balancing inclusivity and viability objectives.

Regarding *permanence,* within an IDF approach there are multiple electrification objectives from different sectors actors that must aligned, including alignment of short term and long-term objectives and multiple timelines. This is in turn impacted by the regulatory regime in the country of operation and having incentives in place to ensure quality mini-grid components, regulatory and financial uncertainty can effectively prevent them from doing do.

Turning to a *combination of electrification modes*, the theme of competition is revealed at different levels. For example, KOSAP mini-grids competing with other incentive programmes, like the EnDev GIZ Pro-solar for viable sites. GIZ Pro-solar pilot and KOSAP project both have sites within underserved counties, which created competition between these programmes.

Lastly *external finance* impacts how off-grid projects are financed, and the level of *permanence*, which can either be hindered or helped by the continuity of funding in the sector. As demonstrated in Section 6.3.3, the pipeline for local financing also needs to be strengthened, to enable greater permanence of supply. Chapter 7 demonstrated the role of external finance through the World Bank loan to the Kenyan Government to develop mini-grids under KOSAP. A PPP model that is well designed could reduce the risk of irregular payment when serving low-income customers, and in a model like KOSAP can buffer mini-grid developers against revenue risks as they will not be the retailers of electricity, but compensated through the construction and O&M contracts.

This chapter found that there are new roles that need to be navigated when transitioning from private sector models to PPP models, where private and public partners are required to play different roles and work synergistically. This chapter argued that the private sector would need to be open to shifting its roles in the mini-grid value chain when entering into PPPs in large electrification programmes such as KOSAP.

Chapter 8 – Towards Operationalising the Integrated Distribution Framework (IDF) in Kenya and Rwanda

8.1 Introduction

Chapter 7 analysed the PPP model used for KOSAP in Kenya and demonstrated how the principles of the IDF could be applied to reduce the viability gap, improve inclusivity of the programme design and strengthen partnerships for scalable mini-grid models. It further illustrated that there are several trade-offs needed to make such partnerships work. These include balancing speed and scale and the long- and short-term objectives of different institutional actors in the public, private and international development partner domains. This chapter brings together the key findings from Chapters 2, 4, 5, 6 and 7, with a focus on key findings from Chapters 5, 6 and 7 as the main analytical chapters, to articulate the new knowledge contributions of the study, building on the framing of the IDF. In so doing, this chapter addresses research questions introduced at the beginning of the thesis in Section 1.4. It distills important insights on the drivers of the viability gap and applying principles of the IDF to address the barriers to viable electrification models and reaching scalable models for mini-grids and off-grid stand-alone systems to provide new practical and theoretical insights.

One of this chapter's contributions to knowledge is a deeper analysis and nuanced understanding of the levels of integration in an IDF framework for off-grid stand-alone solar and mini-grids within the different geographic and institutional contexts of Kenya and Rwanda. This chapter also reflects on the tensions between theory and practice of integrated distribution models. While the IDF offers many advantages for delivering energy access beyond the 'low-hanging fruit', there are many practical considerations and challenges that need to be overcome to foster greater synergies and collaboration, in a paradigm that is still largely dominated by competition in the off-grid sector. These considerations are detailed in the sections that follow.

8.2 Determinants of the viability gap through an IDF lens

8.2.1 Key determinants of the viability gap in Kenya and Rwanda

This section responds most directly to research question 1: *What are the key factors impacting viability gap for off-grid stand-alone solar and mini-grid businesses in Kenya and Rwanda?*

The viability gap is a central aspect of this thesis, and as described in Chapter 5, is intricately linked to a complex array of factors including the regulatory environment in which these models operate, affordability, financing and geographic considerations. These factors all contribute to the complexity of building viable and scalable business models needed to reach universal access to electricity. Specifically, this study found that for mini-grids, determinants of the viability gap include: (i) revenues, which are influenced by tariffs and demand; (ii) affordability and (iii) measures of cost reduction and funding to address the viability gap, the (iv) policy support and regulatory environment (see section 5.2) and (v) institutional priorities and long-term planning. For stand-alone solar systems the viability gap was influenced by (i) affordability, (ii) quality standards and (iii) financing (see Section 5.3). Importantly this study moves beyond identifying key determinants of viability but identifies how these factors impact the pillars of the IDF.

Tariffs, as demonstrated in Sections 5.2.1, are important for viable mini-grid business models, as it impacts revenues and is interlinked with regulatory oversight and affordability of end users (Blodgett et al., 2017). Interviewees concurred that tariffs significantly impact the viability of mini-grids and what customers can afford (IDO K1, Mini-grid K1, Mini-grid K3, ME K1, Mini-grid R1, IDO R2). Without commensurate subsidies it will be extremely difficult to build a viable business that is also affordable (Mini-grid R1, IDO K2). Indeed, as discussed in Sections 2.2.4 and 5.2.2 subsidies for off-grid systems need not be controversial (Davies & Tilleard, 2019). In many countries in the global North and South, subsidies have played a critical role in reaching remote and rural populations (Davies & Tilleard, 2019; Phillips, Plutshack & Yeazel, 2020; Musonda et al., 2021). As highlighted in Section 5.2.1, tariffs in both Kenya and Rwanda require regulatory approval, with regulators factoring in a margin of return for developers and the affordability of customers being served (Regulator K1, IDO K1, Mini-grid K1). This study finds that tariffs fit with in the *regulatory*, *affordability* and *financing* domains discussed in Section 5.4 (see Table 15), with tariff regulation being in the sphere of control of regulators, while affordability and financing to reduce the viability gap in the sphere of control of both private mini-grid developers and international development partners (and viability gap financiers) who mostly finance the viability gap for these systems. As discussed, in Section 5.2.1, regulation and affordability are both determinants of the tariffs mini-grid developers can charge, and therefore affect the *socio-economic inclusiveness* and *permanence* in an IDF framing and are critical considerations for addressing the viability gap.

While the interviews in the Kenyan case study situated tariffs more within the *regulatory domain*, with a policy ambition to keep the tariffs close to grid parity (Mini-grid K1, IDO K1, MEK1), the Rwandan interviews mphasizes *affordability* as the overarching consideration impacting the tariffs mini-grid developers charge (Mini-grid R1, IDO R5). In both country case studies tariff regulation and affordability impact the viability gap, but the emphasis on affordability in the Rwandan context shows that country contexts may influence overriding or overarching drivers of the viability gap. As argued in Section 5.2.1, in Rwanda although tariffs are also subject to regulatory approval, the ability and willingness to pay in many instances could naturally drive the tariffs lower, especially in geographic regions and across socio-economic categories where people can afford to pay very little. While this results in Rwandan developers being more conscious of affordability (Mini-gird R1, IDO R5), it still leaves a viability gap, which to date has been primarily addressed through RBF grants in particular in Rwanda, but also in Kenya, with the Rwandan EnDev programme offering up to 70% CAPEX subsidy, compared to the Kenyan EnDev programme offering up to 50% (see Sections 6.3.1).

Along with tariff considerations, this study identified demand stimulation and productive uses of energy as essential to improving the viability of mini-grid projects, as expressed in both the Kenyan and Rwandan interview data. Development partners managing an RFB programme in Rwanda emphasized how productive use applications could significantly improve the viability of the projects they provide grants to (IDO R2) (see Section 5.2.3). In this example, EnDev partnered with Energy4Impact (now Mercy Corp Energy4Impact) to improve demand stimulation and productive use applications. This finding is supported by studies conducted by the CrossBoundary Mini-grid Innovation Lab on appliance financing and the impact of grain milling and solar refrigeration on increased revenues on the mini-grid sites in which they do innovation trials (Crossboundary, 2021). As Pérez-Arriaga et al. (2020) argue, a key aspect of the IDF is a *focus on development* to maximise the development benefits of electricity access and improve the viability of off-grid projects. Productive uses of mini-grid sites can do both: improve the viability of mini-grid business models and support income generating opportunities for end-users. This also shows the interlinkages between IDF pillars: i.e., IDF pillar 3*: financially viable business models* and IDF pillar 4*: a focus on development.* The interview data support this; an interviewee from a mini-grid innovation lab mphasizes how they mphasizes increased electricity consumption by paying mini-grid developers the difference between their original tariff and reduced tariff, to measure the impact on consumption (MG IL 1) (see Section 6.2). Thus, when considering the design of grants and incentives it is equally important to consider how the longer-term sustainability of connections can be enabled, and effectively mphasizes mini-grid developers to prioritise the quality of connections. This requires considering the performance of mini-grid sites, including the quality and reliability of supply, the sustainability connections and productive uses of energy.

In addition to tariff regulation for mini-grids, another key regulatory consideration is planning and certainty. Section 4.2.5 discussed key regulations for mini-grids in Kenya and Rwanda, including the Mini-grid Regulations (2021) in Kenya and the Simplified Licencing Framework (2019) and the NEP in Rwanda. These regulation and planning documents have been developed and introduced to provide greater clarity on licensing conditions, regulatory approval and what happens in the event of grid arrival (see Sections 4.2.5 and 4.3.4). However as demonstrated in Sections 5.2.4, having regulations is not enough, as regulatory certainty and clarity depend on how regulations are understood and applied and can be affected by periods where there are regulatory changes (Mini-grid K1, IDO K1, ME K1, IDO R2, Mini-grid R1, IDO R3, Mini-grid R2). This thesis argues that periods of regulatory uncertainty can delay the deployment of mini-grids and stifle investment needed to achieve viability and scale in the sector (see Section 5.2.4). In Rwanda, while the NEP was being revised, there was uncertainty for mini-grid developers which also slowed down the disbursement of RBF finance. Considering that the NEP is a key electrification planning document, it is important that necessary revision was made, but this inadvertently caused considerable uncertainty for mini-grid developers during this time. This demonstrates how intricately linked the regulatory environment is to the IDF pillar of *external finance* (ESMAP, 2017, IDO K1, Mini-grid R1, IDO R5).

Importantly, for mini-grids in Rwanda, the prioritisation of the national grid as the preferred electrification mode for universal access in Rwanda beyond 2024, has had tangible impacts on reducing the viability of private models for mini-grids in Rwanda. The impact can be traced from the early trepidation and uncertainty on the part of mini-grid developers and development partners from as early as 2019 (see Section 5.2.4), to the halt in disbursement of EnDev RBF finance in 2022 (See Section 6.3). Presently, very few mini-grids are currently operating in Rwanda (with MeshPower and ARC Power being of the few remaining developers). Reflecting back to Section 4.3.4.2 on the

Ministerial Guidelines for mini-grid development and the discussion of solicited versus unsolicited proposals, the direction the Rwandan sector is taking would suggest that the territorial concession model for mini-grids (in close collaboration with the government) would likely be the main avenue for any future mini-grid development in Rwanda.

In Kenya the KOSAP project created 'competition' for viable sites where some interviewees expressed that KOSAP had selected the best sites for mini-grids (Mini-grid K1, IDO K1), with fewer viable sites outside of KOSAP, and sites already developed privately. Furthermore, private mini-grids close to the KOSAP sites would have a higher tariff than the KOSAP grid tariff. Comparatively this can create a challenge for equity of energy services, with different models being implemented in proximity. From a regulatory perspective, while private models would ordinarily allow the private sector to select sites, subject to regulatory approval, the KOSAP sites were 'ringfenced' and not open to private sector development. The above example shows how the structure of a PPP model used in KOSAP also has unanticipated impacts of competition for viable sites.

This study further affirms that subsidies are needed to close the viability gap (see Section 2.2.4 and 5.2.2) and reach the universal electrification objectives (Mini-grid R1, Mini-grid K3, Ministry KE, IDO R5, Mini-grid K2). This concurs with the findings of the literature that the viability gap cannot be closed without subsidies, and that this is most commonly through RBF (Melnyk & Kelly, 2019; Phillips, Plutshack & Yeazel, 2020; TEA, 2022). This study adds to the literature on how an IDF framing can contribute to improved design, and long-term sustainability of these funding mechanisms, by considering the longer-term sustainability of connections (e.g., through coupling RBF incentives with demand stimulation types of incentives done through e.g., the CrossBoundary Innovation Lab) and a need for continuity of funding (see Section 6.2 and to be further elaborated in Section 8.3). This study further mphasizes the importance of aligning incentives between public and private sector actors for roles of retailing to customers and stimulating demand (see Section 5.2.3; Mini-grid R1).

In contrast to mini-grids, solar home system companies are not regulated on the prices of their products, but indirectly through regulation on import duties and quality standards (see Section 4.2.5). In Kenya, although import duties on solar products were initially favourable, revisions to import duties increased the prices of stand-alone solar products for a period, where industry associations lobbied to get favourable policies back (Sections 4.2.6). In Rwanda 2021 regulations for Minimum Standards effectively increased the prices of products sold (see sections 5.3.2) as higher quality products were more expensive than the lower quality tier products (IDO R3, IDO R1).

Emphasising aspects of affordability and quality, a mini-grid expert articulated that the viability gap is in essence a disjuncture between the cost associated with providing a high-quality service and what low-income households can afford:

> On the viability gap, to me it's relatively straight forward–- you're trying to provide a high-quality service to very low-income end-customers. The central challenge is how do you provide high quality electricity services… that's what changes lives (EI 4).

The impact of standards on affordability was mphasizes in Rwanda (see Sections 5.3.3) where affordability was highlighted as the overall context in which off-grid electrification models should be developed (EC R1, IDO R3, Power Africa, 2020). Only through subsidies can low-income households afford these systems (IDO R3, OGS R1). To address the affordability gap subsidies were highlighted as an essential aspect of delivering energy services and bringing down the cost (Interview IDO R4). Thus, to effectively address the viability gap, issues around affordability need to be addressed, as this has a direct bearing on IDF pillars of *inclusivity* and *permanence.* This affirms findings from the literature review (Sections 2.2.3, 2.2.4 and 2.6) that affordability is a key driver of the viability gap for both mini-grids and stand-alone systems, without which socio-economically inclusive models cannot be achieved. Affordability is a key 'missing link' in the core framing of the IDF pillars. Thus, as highlighted in Section 2.6, this study recommends that affordability becomes a sub-pillar of *inclusiveness* in the IDF.

This study found that regulatory, affordability and financing considerations, as key determinants of viability are thus essential to the pillars of the IDF (see Section 5.2). The IDF pillar of *permanence* is influenced by the ability of off-grid companies to have a sustained presence in the regions where they operate. For mini-grids this was impacted by regulatory planning and certainty in addition to a continuum of finance to enable their sustained operations. For stand-alone solar companies, especially those operating in unelectrified or underserved counties, permanence is influenced by the design of targeted incentives and subsidies to address the viability gap (e.g., the RBF Pro-poor subsidy in Rwanda) where up to 90% of the price of these systems is mphasizes for households in Ubudehe 1. As interviewees mphasizes the sustained presence of these entities would depend on their ability to make a viable business case with and beyond the initial subsidy and if expanding and operating in the underserved regions would make business sense (EI 1, EI 3).

Another key pillar is the IDF is having a *combination of electrification modes* and for this study focuses on mini-grids and stand-alone systems. As the revised framing of the IDF articulates (see Section 2.2), it is important to effectively coordinate grid and off-grid modes and multiple electrification technologies. Section 5.3.3 highlighted that the IDF *pillar of a combination of electrification modes* (i.e., having mini-grids and off-grid solar co-existing in the market with grid technologies) is influenced by institutional priorities (see Sections 4.2.4, 4.2.2, 4.3.2, 4.3.5) but also by the level of *permanence* private sector companies can have to maintain operations in specific areas. This level of permanence is in turn influenced by regulatory certainty. For mini-grids this largely depends on clearly demarcated grid and off-grid areas and assurance that grid encroachment will not be an imminent threat, and the tariffs mini-grids can charge. This is also determined by the national electrification planning. In Rwanda off-grid solar systems are included in the *Imihigo* joint performance targets where off-grid solar companies work with the utility to achieve off-grid targets. In contrast, mini-grids in Rwanda (particularly private models) have a less certain future due to grid extension plans beyond 2024 and the likelihood of grid arrival. The imminence of grid arrival posed a real threat for mini-grid developers, hampering their certainty of operation (see Mini-grid R1, IDO R2, IDO R5). In Kenya mini-grids and stand-alone solar systems also are part of the national electrification plan, with the KOSAP project providing RBF grants and a debt facility for off-grid solar companies to supply underserved regions and specific lots for mini-grid sites.

Figure 19 below shows the sub-pillars of the IDF, as per the original IDF framing introduced in Section 2.2. It combines Figure 11 and Figure 14 from Chapter 5 for mini-grids and stand-alone systems in Kenya and Rwanda. It shows the key factors impacting the viability gap in relation to the IDF sub-pillars, derived from the empirical analysis in Chapter 5 through the interview data. Comparing this to Figure 4 in Section 2.6 , *affordability* was found to be a key finding in both the literature review and Chapter 5.

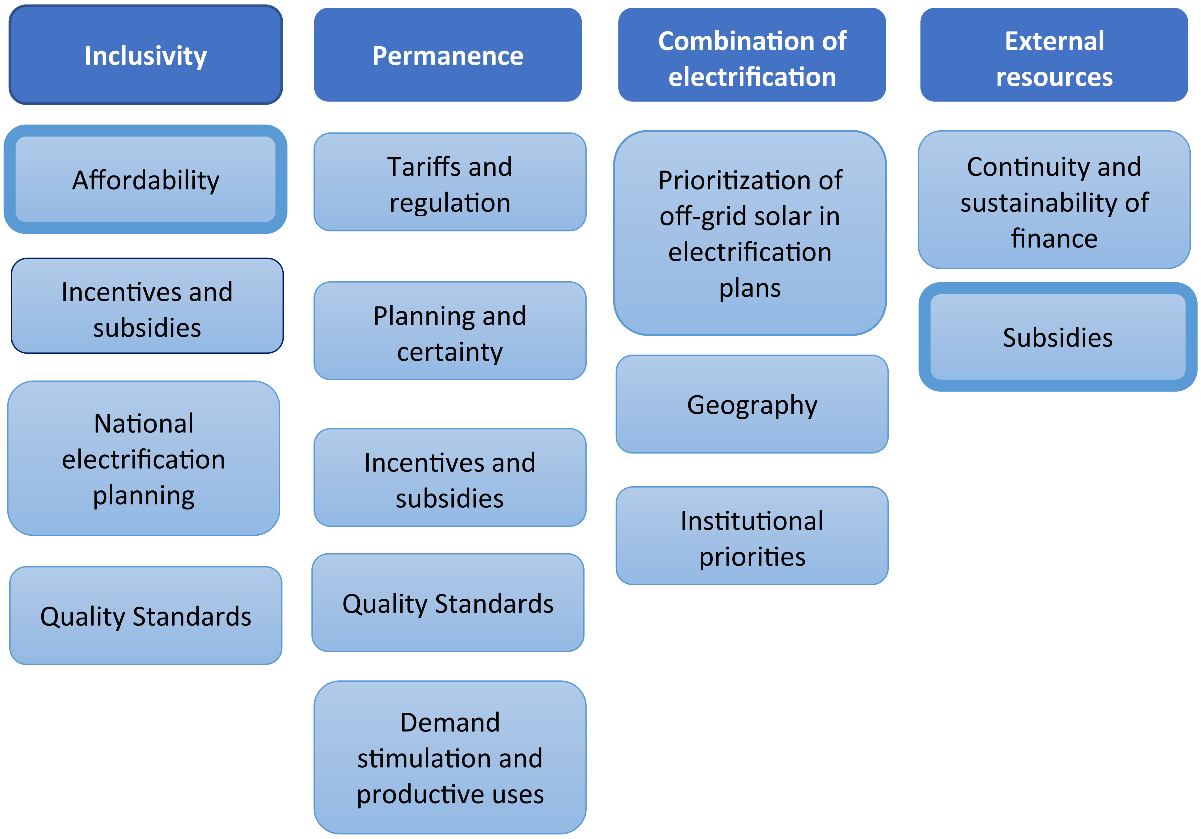


Figure 19: Linking viability gap determinants to the IDF (Author's figure)

In addition to affordability, this study found that to achieve inclusiveness there is a need for appropriately designed and directed incentives (i.e., including grants and subsidies). Furthermore, *national electrification planning* is important for mphasizesi subsidies for different off-grid models and technologies and the geographic regions in which these technologies will be implemented. For example, RFB and debt finance in KOSAP only applies to the KOSAP counties in Kenya and the Ubudehe Pro-poor subsidy was also geographically specific. In Rwanda quality standards affected the affordability of stand-alone solar systems, particularly as the higher quality products were more expensive, thus the Pro-poor subsidy was important for cushioning eligible households against higher prices. Under the IDF sub-pillar of *permanence* this study identified tariffs and regulation and the need for planning and certainty. Periods of regulatory uncertainty should be reduced, wherever practically possible, as this adversely affects private sector off-grid providers and had a notable impact on mini-grid developers in Rwanda. This study also draws an interesting and counterintuitive observation about national electrification planning and certainty. In Rwanda the purpose of the NEP was to create more clarity about grid and off-grid demarcations. However, during the NEP revision period there was considerable uncertainty while off-grid actors were awaiting the revisions. This requires careful attention, especially in periods and to processes in which electrification planning happens, and to account for the in-between periods where there is regulatory lacuna. This is important as key regulatory and legislative developments happen where off-grid business models are actively operating and being planned. For the IDF pillar *external finance*, continuity and sustainability of finance and subsidies were identified as a key need.

8.3 Addressing the viability gap through financing and partnerships with an IDF lens.

This section directly addresses research question 2: *Which business model and financing approaches are currently being implemented to overcome the challenges of viable and scalable electrification models in Kenya and Rwanda and how can an IDF lens improve the implementation of these approaches*? And research question 3: *What are the key empirical factors that influence the conceptual IDF pillars of inclusivity, permanence, a combination of electrification modes and external resources in the Kenyan and Rwandan contexts?*

This study identified RBF and PPPs as two dominant approaches for addressing the viability gap and achieving scalable models for universal access in Kenya and Rwanda and provided a 'deep dive' on these approaches in their case study sites. Chapters 6 and 7 shifted from identifying the drivers of the viability gap to an in-depth analysis of RBF and PPP models to address the viability gap and enable greater scale for the deployment of mini-grids and off-grid solar. For off-grid electrification models to foster greater inclusivity, the more challenging areas should be prioritised with suitable incentives to address the viability gap.

Building on Section 2.4.2, which identified RBF as one of the possible ways to fund the viability gap and increasingly used in many sub-Saharan African countries, Section 6.3 provided in-depth country case studies on RBF programmes and their applications in Kenya and Rwanda. In both Kenya and Rwanda RBF programmes have played a pivotal role in developing the mini-grids (EnDev, 2022; Power Africa, 2020). Key RBF programmes[90] in Kenya and Rwanda, as analysed in Chapter 6, include the Pro-Solar RBF managed by GIZ and funded by DFID (now FCDO) and the EnDev RBFs for stand-alone solar systems and mini-grids also managed by GIZ. In Rwanda, RBF was instrumental in sector development,

[90] Other RBF programmes in Kenya included the Green Mini-grids Facility funded by FCDO through the TEA project, with Shell Foundation funding (TEA, 2022).

with most mini-grid projects being financed by RBF (EnDev, 2019, IDO R2). EnDev's RBF programme saw the sector grow from no formally developed private mini-grids in 2014, when the RBF was launched, to the development of two solar AC mini-grids, one hydro mini-grid and twenty-two DC nano-grids by 2020. These reached three hundred and sixty-four businesses, social institutions is furthermore a key part of IDF pillar 4, *a focus on development.* However, despite RBF finance, regulatory uncertainty in the disbursement of RBF finance and the overall prioritisation of the grid, private sector models for mini-grid development have become increasingly unviable in Rwanda.

One of the challenges RBF models identified in this study is that they mainly mphasizesi electricity connections, which does not automatically translate into the longer-term quality of connections (IDO KI, EI4), nor is RBF necessarily intended for that purpose. To ensure the IDF pillar of *permanence,* the long-term sustainability of connections needs to be mphasizesi, which means that the design of grant programmes ensures quality of connections and the overall performance of mini-grid sites. Thus, achieving the IDF pillar of permanence is also dependent on the IDF pillar of *external resources* and the funding that can be leveraged by off-grid companies operating in the sector. As a recommendation from the findings of this study, this could be an opportunity to couple RBF subsidies with the grants that mphasizes demand stimulation beyond connections (e.g., the approach the CrossBoundary Innovation Lab uses). This type of grant mphasizesi increased demand on sites and considers certain performance metrics like the downtime of sites. In this way the focus on connections can be complemented by demand stimulation incentives, thus combining performance-based grants for new connections with grants more closely tied to the longer-term performance of the mini-grid sites.

Section 6.4 further identified that to foster *inclusiveness,* RBF grants need to mphasizes and enable off-grid energy companies to go into the areas they would not ordinarily go into, to enable *greater geographic inclusivity,* but that this also needs to be targeted to households that need it the most, to ensure *greater socio-economic inclusivity*. Here additional incentives could be explored over and above what RBF programmes would normally have (EI4). As mentioned in the interview data it is possible to oversubsidise some end-users and under-subsidise others and hence achieving the correct balance for targeting the subsidy accordingly is important (IDO R3). The study further found that to achieve an inclusive energy market, RBF programmes need to be accessible to local developers (IDO G1, MG IL1). The interview data highlighted that local developers have not been able to access the same levels of funding as some of their international counterparts. This in part is driven by the insufficiency of local currency finance (SNV, 2021), which was echoed by a recent ESMAP Mini-grid

Learning event, in Nairobi (March 2023), where the need for local currency finance was highlighted as a key takeaway (ESMAP, 2023). To address this, the debt finance component of the KOSAP programme extends local currency finance to off-grid solar companies.

As argued by Phillips, Attia & Plutshack (2020), RBF could be used as a mechanism to nudge the private sector to develop projects in the more difficult areas, where they ordinarily would not go without an incentive. However, RBF programmes do not necessarily always support inclusivity objectives. This means that if *inclusivity* (as per IDF sub-pillar 1) is not specifically built into the design of RBF programmes, low-income unelectrified communities may not effectively be reached through RBF finance models. For example, in Kenya, the geographic specificity of the KOSAP counties provides for a degree of geographic inclusivity by focusing on underserved counties. In Rwanda the Ubudehe Pro-Poor subsidy is tied to certain *socio-economic inclusivity* criteria, i.e., lower Ubudehe households who can generally afford less would receive a higher subsidy. In addition, the Ubudehe Pro-Poor subsidy was also focused on certain geographic locations (IDO R1). Thus, these two examples show where inclusivity was specifically written into the design of RBF programmes. However, the RBF programme for mini-grids in Rwanda was not restricted to specific geographic locations and is open to applications from mini-grid developers without specific areas being prescribed. Thus, balancing geographic specificity in RBF programmes to facilitate inclusivity with an approach that does not restrict off-grid providers to specific regions is important to consider and pertains to IDF sub-pillars 1 and 3 on *inclusivity* and *external finance*.

Chapter 6 demonstrated the role of RBF in addressing part of the viability gap, but that RBF models have limitations on the amount of funding, sustainability of connections as well as the subsidy period, before being phased out. This concurs with challenges identified in the literature Section 2.4.2 (see Johnstone & Garside, 2019; Nagpal & Pérez-Arriaga, 2021). Section 6.2 showed that the deployment mini-grids could be slowed down if there is no clear provision for long-term financing. A development partner explaining the mechanism of RBF commented that RBF incentives go down over time and that programmes are of limited duration (EI 3, Ministry K1). Thus, it is imperative to have long term vision of the financing needs in the off-grid energy sector, with full acknowledgement of the limits of RBF finance, and what will be needed beyond that.

This study finds that other avenues of funding beyond RBF are needed to close the viability gap (Mini-grid expert 1, IDO K1). The literature also highlights that RBF is dependent on match funding and will really be slowed down without the required match funding. If companies are unable to obtain pre-financing, to finance the construction of the mini-grids, they will not be eligible for disbursements under the RBF (Shell Foundation, 2019). This is illustrated in the Kenyan RBF experience, as a development partner in Kenya commented that their RBF programme provides financing based on pre-determined milestones and does not provide pre-financing, which is often a challenge for mini-grid developers. The above shows an example of where coordination between institutional funders can be useful to create more seamless transitions to meet the funding needs of different companies at different stages of growth. This is imperative for the sustainability and continuity of *external finance* in IDF sub-pillar 3 and impacts *permanence* of off-grid energy models (i.e., IDF sub-pillar 2). As argued in Section 2.4.2, the strengths of the IDF framing, promoting a long-term vision of the power sector, can enhance RBF models, by improving the overall design of these models. This is a key finding related to research questions 2.

In Rwanda EnDev has worked proactively with the Rwandan Development Bank BRD to get financing for their pipeline of mini-grids (see Section 6.3.3). Through this example (illustrated in Section 6.3.3), development partners are acting as intermediaries; in this case between themselves and other financial institutions. However, the implementation of the REF has not been a smooth process as the REF had its own challenges regarding disbursement of funds and eligibility for debt finance. This shows that fostering synergies between financial institutions requires an understanding of different funding criteria and processes, and companies who may have been eligible for funding under one fund, may not necessarily be eligible under another. Nonetheless, it is still necessary to work towards creating a pipeline of funding and assisting companies to transition from different type of funding as their funding needs evolve.

This study identified the following entry points for stronger financial integration and continuity of funding within the financing pipeline, including RBF and bridge funding for RBF programmes, within an IDF framing, with reference to IDF sub-pillar 3 *external finance*:

I. Develop mechanisms to build in continuity of funding beyond initial funding period so that when a particular RBF grant phases out, businesses would be able to tap into additional funding. Design RBF incentives with greater continuity in mind, building a pipeline of funding so that companies who have set up operations in the more challenging areas are placed (e.g., on a database) and are prioritised for continuity of funding, subject to meeting minimum performance criteria.

II. Development partners and public sector funders should work with companies to understand their financing requirements throughout the project life cycle. Specifically, this should include an assessment of funding needs and subsidies for private sector companies who have established operations within specific regions of the country. For example, looking at continuity of finance for companies operating in the KOSAP underserved counties in Kenya or territories allocated for the Ubudehe pro-poor subsidy in Rwanda.

In Chapter 7, *inclusivity* in the design of the geographic regions covered in programmes like KOSAP was explored. Section 7.3.1 demonstrated that the design of the mini-grid component of the KOSAP project only partly facilitates inclusivity, by focusing on electrifying underserved counties in Kenya, but outside of the KOSAP there will still be undeveloped sites that will need mini-grid developers to go into (Utility K1, IDO K1). However, developing new mini-grid projects outside of KOSAP is arguably more challenging, as KOSAP has selected the best sites for mini-grid development, which leaves fewer viable sites. Thus, it will be difficult to develop projects outside of the KOSAP territory without government or donor support to address the viability gap in these regions remaining outside of KOSAP see section 7.2. This draws the link between the role of external resources in making mini-grid business models viable within the more challenging counties. Ringfencing the KOSAP mini-grid sites excludes private mini-grid developers from operating with the usual flexibility offered in a fully private model. Thus, the *inclusivity* objective which the KOSAP project facilitates, to an extent, limits the inclusion of private sector actors to the selected providers under the KOSAP model.

Within the concept of inclusivity, Section 7.3.1 further discussed the sub-themes of *open market freedom versus directed development* and *speed* versus *scale* in deploying energy off-grid energy access solutions. When mini-grids are developed within open market conditions they have more control over the value chain and decision-making aspects that are pertinent to site selection and the construction and operation of their sites. In contrast, as shown through the example of KOSAP mini-grids, site selection is predetermined by the government, and the utility and private developers enter a PPP for operating and maintain the sites. This model invariably comes with trade-offs. Phillips, Attia & Plutschack (2020) argued governments playing a key role in mini-grid site selection would achieve greater inclusivity and benefit last mile customers more than private sector selection. However, this needs to be balanced against viability objectives as mini-grid sites that cater to low-income end-users, would not necessarily be the most viable. Within the IDF pillars there is a balance between *inclusivity* (IDF sub-pillar 1) objectives and *financial viability* (IDF pillar 3). This trade-off is important to consider, as government prioritisation of unelectrified areas is needed for directing investment into underserved regions of a country (e.g., like the KOSAP investment into 14 underserved counties and 5 regions prioritised for the Ubudehe pro-poor subsidy) to enable inclusivity objectives. However, subsidies in tandem with business model innovation are needed to reduce costs and improve affordability, thereby addressing the viability gap.

Figure 20 presents a summary of the consolidated findings of the key factors affecting each pillar of the IDF, in relation to the determinants of the viability gap. The corresponding table shows how each determinant of the viability gap impacts the original core pillars of the IDF (originally outlined in Sections 2.2 and 2.6), showing how mini-grids and stand-alone solar systems are impacted differently. These factors provide specificity for the understanding of the drivers of the IDF in relation to the viability gap in Kenya and Rwanda, contributing to the development of the IDF framing.

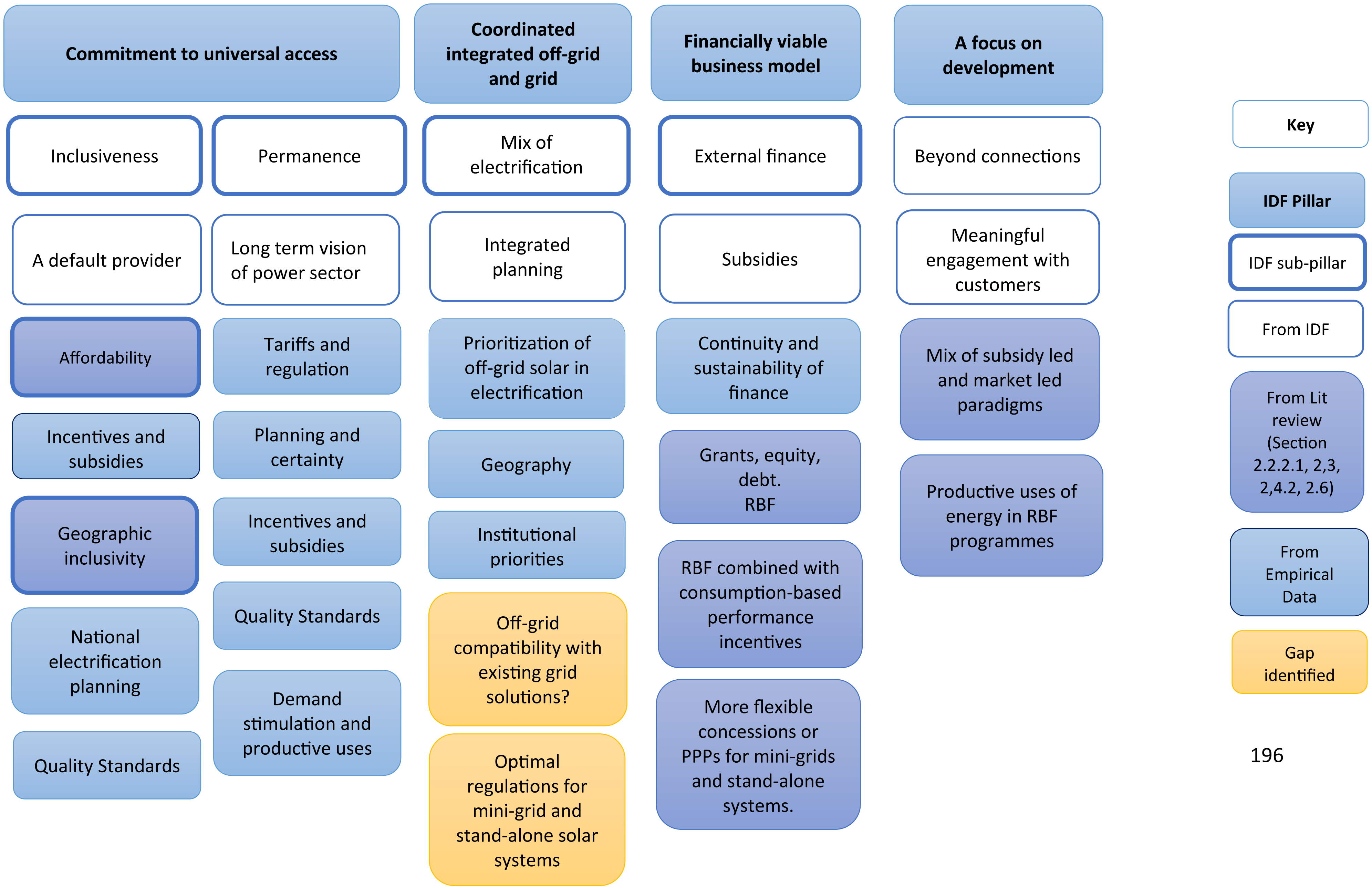


Figure 20: IDF (V3) (Author's figure)

Table 16: Factors influencing IDF pillars (Author's table from analysis)

IDF Pillar	Factor influencing IDF pillar	Impact on IDF pillar	Technology specific factors
Inclusivity			
	Affordability *Mini-grids and stand-alone solar systems*	(+) more affordable off-grid energy products and services increase the socio-economic *inclusivity* of energy access models	Affordability is key for mini-grids and stand-alone solar system business models. For stand-alone systems this can be influenced by quality standards on pricing (see increased costs in Rwanda and fluctuating VAT duties in Kenya). For mini-grids affordability is impacted by costs of developing mini-grid systems (also impacted by density of connections, geographic location and are dependent on subsidies to reduce the viability gap). This is a balance between regulatory requirements and oversight for ensuring the balance between affordability and regulatory requirements.
	Incentives and subsidies *Mini-grids and stand-alone solar systems*	(+) incentives in the form of grants and subsidies designed to enable companies to go into the more challenging 'hard to electrify areas improves affordability and thus *inclusivity* – both socio-economic and geographic	Appropriately designed subsidies are needed for solar home systems and mini-grids. Subsidies that are designed with to include geographic inclusivity of areas e.g., KOSAP underserved counties.
	National electrification planning *Mini-grids and stand-alone solar* -	(+) incorporating a mix of off-grid technologies into national electrification plans, and specifically including underserved or under reached areas increases geographic inclusivity. (+) incentives developed part of national electrification programmes that encourage companies to go beyond the low-hanging fruit increases inclusivity.	Mini-grids, especially, are directly impacted by national electrification planning and require regulatory clarity and certainty. Regulatory consistency and clarity is needed to secure mini-grid investments and serve to de-risk the sector. Regulatory uncertainty therefore should be decreased or minimized wherever possible.

Permanence			
	Tariffs and regulation *Mini-grids*	(-) push for grid parity without subsidies increases the viability gap negatively impacting affordability and permanence of supply. (+) subsidies to reduce the viability gap can lower the tariff and affordability for end-users/customers, which impacts the ability to continue to pay for energy services.	These impacts mini-grids particularly. Mini-grids cannot offer grid parity (or reasonably low or affordable tariffs for the communities being served), without sufficient subsidies and/or in tandem with implementing appropriate cost reduction mechanisms.
	Planning and certainty *Mini-grids and stand-alone solar systems*	(-) periods of regulatory uncertainty negatively decrease investment certainty and increased risk for mini-grid operations/ companies to continue to have a sustained presence	Particularly for mini-grids (and to a less extent solar home systems) periods of regulatory uncertainty can adversely impact operations of mini-grids and as they require physical infrastructure.
	Incentives and subsidies *Mini-grids and stand-alone solar systems*	(-) incentives and subsidies can impact what end-users are able to afford for off-grid energy services and positively impacts the ability of companies to make a sustainable business.	Appropriately designed subsidies can not only improve the socio-economic inclusivity of mini-grids, but also enhance permanence by enabling customers to continue to use electricity at a tariff or monthly charge that is affordable for end-users.
	Quality Standards *Stand-alone solar systems*	(-) quality standard regulations that increase prices of solar products decrease affordability. (+) quality standards that increase the durability of off-grid products	Quality standards mainly applies to off-grid stand-alone systems (as shown in case of Rwanda), improves quality and durability of stand-alone solar products, which supports permanence. Subsidies, with flexible payment models are needed to ensure higher costs are reduced for end-users.

	Demand stimulation and productive uses *Mini-grids*	(+) demand stimulation activities can improve the viability and performance of mini-grid sites which improves the chances of being able to operate a mini-grid over the long-term	Demand stimulation and productive uses is especially relevant for mini-grids and also essential aspect *of IDF pillar 4: a focus on development*, by being able to support income generating opportunities coupled with gaining access to an electricity connection.
Combination of electrification modes			
	Prioritization of off-grid solar in electrification plans *Mini-grids and stand-alone solar*	(+) clearly incorporating off-grid solar technologies like mini-grids and stand-alone enables better co-existence of these technologies with the grid and with each other.	
	Geography *Mini-grids and stand-alone solar*	(-) (+) the physical size of a country (e.g., in case of Rwanda) can enable possible the expansion of the grid to nearly 100a % of the country in line with institutional priorities and the electrification vision. (-) certain geographies can make it challenging to electrify geographically and socio-economically marginalized counties – as shown with those in the KOSAP project	In Rwanda geography of the country makes it theoretically possible to electrify 100% of the country by 2024, which is positive for universal access but can negatively affect private sector off-grid models, particularly mini-grids without adequate provision for grid arrival.
External resources			
	Types of finance and affordability of finance *Mini-grids and stand-alone solar* - Continuity of finance	(+) pipeline of finance to support companies beyond the initial subsidies and RBF grants can enable companies to sustain and continue their operations and grow and expand where needed.	A pipeline of financial support to off-grid companies is needed to support both mini-grids and stand-alone solar efforts (see recommendations in 8.2 above).

	- How incentives are designed - Do grant/finance subsidy programmes encourage more than just connections	(+) targeted subsidies are needed like Ubudehe pro-poor subsidy for stand-alone solar systems in Rwanda and RBF subsidies for stand-alone solar in Kenya.	

The sections above showed the key empirical factors impacting the conceptual framework of the IDF, answering research question 3, which is a key knowledge contribution of the thesis. The above section illustrated that to facilitate the IDF pillar 1 *a commitment to universal access*, off-grid business and financing models needs to be socio-economically and geographically *inclusive.* This requires prioritising affordability, for which subsidies and incentives play a key role along with national electrification planning in guiding how these subsidies are directed. This should be coupled with approaches to achieve greater *permanence* in the sector, which should be guided by a long-term vision of the power sector with tariff regulation that allows for adequate cost recovery for mini-grid developers and subsidies to balance cost recovery with affordability. In addition, regulatory clarity is imperative for safeguarding mini-grid investments and preventing bottlenecks in the speed of finance disbursement.

Attention should also be given to the types of finance and incentivising longer-term sustainability of sites beyond connections, with demand stimulation being an important aspect for improving mini-grid economics. Regarding the mix of electrification modes, this needs to be done through effective coordination between off-grid and grid technologies, and between different off-grid technologies. This requires the prioritisation of off-grid technologies and a clear role for the off-grid sector in national electrification planning. For IDF pillar 3: financially viable business models are dependent on external finance, like RBF models, but this needs to be coupled with strengthening local finance including local currency finance for local companies to enable greater permanence and continuity in the sector. In addition, there is a need for greater flexibility in partnership models for mini-grids and stand-alone solar systems, e.g., regarding roles public and private partners play in the value chain e.g., allowing for private sector participation in demand stimulation and being appropriately incentivised to do so. Lastly the abovementioned pillars should be guided by a focus on development, to enable the maximum benefits of electrification to positively impact end-users.

8.4 Operationalising the IDF in Kenya and Rwanda

The above sections presented key knowledge contributions on drivers and solutions to address the viability gap and achieve scalable models for off-grid models in Kenya and Rwanda through an IDF lens. This section looks at the key considerations for operationalising the IDF in Kenya and Rwanda. This section most directly answers research question *4: How can the IDF be applied to Kenya and Rwanda's mini-grid and stand-alone solar system models to facilitate progress towards SDG 7?*

8.4.1 The role of institutional integration in achieving the IDF pillars

Institutional integration, which entails both coordination[91] and collaboration, is needed across all electrification modes, both grid and off-grid (Pérez-Arriaga et al., 2019, 2020, 2021; Power For All, 2019; SEforAll, 2019) and in the context of this study applies to off-grid stand-alone solar and mini-grids. As argued in Section 2.6, new integrated paradigms of energy provision require effective collaboration and coordination between a range of institutional actors including public sector actors, donors, investors, industry and technical experts (SEforALL, 2019; Tkacik, 2017). Bolton & Hannon (2016) and Goldthau (2014) emphasise that energy infrastructure is embedded in institutions, regulatory authorities, and market actors. Working towards the achievement of universal access is thus contingent on how well the roles of these actors are defined and managed in dynamic off-grid environments and forming stronger synergies between these actors.

The interview data support the call to action in the literature for more integrated approaches to expand energy access and achieve universal electrification targets (Urpelainen, 2014; Pérez-Arriaga et al., 2018; SEforAll, 2019; Jacquot et al., 2020). Interviewees concurred that coordination is important for achieving universal access (OGS R1 2, EI 2, EI 3). It however also provided a nuanced perspective that there are certain instances where collaboration and coordination may be more or less beneficial (EI3, Mini-grid R3). The interview data further provided conditions under which more integrated approaches could work. As one development partner in Rwanda expressed:

> Coordination is a crucial part for achieving … electrification targets because if we're realistic the public sector… cannot do it alone, it's just not realistic in terms of funding, also in terms of capacities…, so there is definitely a need to work together and to coordinate with the private sector and also obviously with donors who are supporting electrification efforts (OGS R1 2).

The above quote highlights that from a practical level, no single entity can close the electrification gap alone, within the context of the respective timelines Rwanda and Kenya are working towards to achieve universal access targets. As there are multiple players in the off-grid sectors in these countries, greater synergies between these actors would be needed. Effective and efficient coordination would therefore enable the respective strengths of different market actors to be harnessed more efficiently. However, a mini-grid developer who had been part of an integrated utility model pilot outside of

[91] While greater coordination can lead to more synergies – strong collaboration does not imply synergies – synergies is something that is more organic.

Rwanda, commented on how there needs to be a high level of commitment from all stakeholders involved to make an integrated model work. The interviewee explained:

> There's a lot of inefficiency unless there is commitment (Mini-grid R3).

Thus, while there is a clear rationale for effective coordination and collaboration, this needs to be coupled with the necessary pragmatism and efficiency in the execution.

A further rationale for effective coordination is providing clarity of the electrification vision of the country and the respective roles of different actors in the sector. As several interviewees emphasised clarity of roles within a country's electrification vision is essential for off-grid solar companies to be able to achieve energy access targets. Speaking more generally from experience in the off-grid sector across several countries in Sub-Saharan Africa, an energy expert commented:

> ..the biggest problem I see is lack of clarity and uncertainty and changes over time in the roles. If all the respective of players have clarity, I think you can make different configurations work (EI 2).

Similarly, an energy expert in Rwanda commented:

> It's like finding this balance on this pendulum and just keep it balanced and really understand what the goals of the energy sector in country X are and where do the private sector and decentralised off-grid solutions fit in (OG2 R1 2).
>
> ..It creates a sense of purpose and drive for the off-grid company to know that they are part of the big picture of the government under which they're working (OGS R1 2).

As institutional roles may change and evolve with time, clarity and certainty are essential for a dynamic sector within a long-term vision of the power sector (Goldthau, 2014; Bolton & Hannon, 2016). This links to the role of strong institutional governance to provide clarity of roles and functions within a country's broader electrification vision. Therefore, one of the key functions of institutional integration is to provide clarity in the sector by clearly defining roles of actors as well as where they may change over time within current and new partnerships. As Figure 21 illustrates, strong institutional coordination can improve clarity of roles and functions which would enable better synergies, and avoid a duplication of resources and efforts, and ultimately enhance the deployment of off-grid technologies. The figure shows that these factors have a causal effect on each other and collectively drive the improved deployment of off-grid technologies and business models. The (+) sign shows a positive effect or impact.

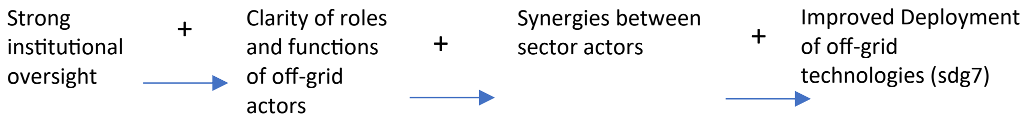


Figure 21: Impact of strong institutional oversight on institutional coordination (Source: Author's figure)

While there is a clear rationale for institutional integration, pragmatically facilitating coordination and synergies among various actors can be challenging (Tkacik & Smith, 2017). The literature highlights that synergies between actors in the sector will not necessarily happen organically and that mechanisms are needed to govern the interactions between public and private actors (Tkacik & Smith, 2017). This could be due to insufficient alignment of the goals of the different actors and seemingly competing institutional interests. This is echoed in the interview data which demonstrates that the perception of competition between and within the private sector and public utilities is a barrier for making synergies happen more organically. An interviewee commented:

> Utilities see mini-grid companies as competition….If they were playing on the same team, you would see rapid improvement in energy access numbers, in terms of connections and quality of those connections and kilowatt hours sold, and rural development would in general improve (Mini-grid association 1).

This links back to the alignment of interests and sector goals (see Sections 4.2.6, 4.3.5 and 7.3). This also relates to the requirement for a long-term vision of the power sector as set out in the IDF (see Section 2.2). Through a long-term vision and effective coordination and collaboration between different sector actors, sector interests could be better aligned. The challenges mentioned above are partly linked to multiple interests in the sector being insufficiently aligned, and the public and private sector not always realising commonality in the end purpose of expanding energy access. This illustrates the tension between what is needed in the sector and what is theoretically possible, as opposed to what is practical.

The case of the off-grid solar sector in Rwanda provides an apt example of strong institutional coordination and collaboration (see Section 6.4). Notably in Rwanda, there has been a greater level of coordination between the government, off-grid private sector and international development partners. Integrated and coordinated electrification planning was done very intentionally from the start by incorporating off-grid companies into the *Imihigo*[92] performance targets as shown is Section 6.4. A development partner in Rwanda commented on the role of formal policies and more informal coordination between donors.

> ..In Rwanda there was quite a bit of coordination and also planning. What also helped is that the government ended up putting in place several policies and plans which sort of gave guidance as to what is expected of the off-grid sector (IDO R1).
>
> We work very closely with the utility and we are also working with the companies. So having this informal network behind the formal technical working groups, and sector working groups is probably even more important. In Rwanda the fact that the donors are so well coordinated and quite a few of them are also very close to the private sector has helped a lot to feed the perspectives of the private sector back into those policy discussions (IDO R1).

From the two quotes above there is an interesting contrast between the formal policies and electrification planning at national level to give guidance to the sector (see Sections 4.2.1, 4.2.2, 4.3.1, 4.3.2), but also the informal networks that can facilitate collaboration, beyond formal forums. Through this example, development partners act as intermediaries between the public and private sector as they have established relationships between the government and private companies. By being a critical source of funding in the off-grid energy sector, development partners have considerable influence in the direction in which the sector is developing.

Even though off-grid stand-alone solar companies are working closely with the utility and MININFRA in accordance with the MOUs they have signed, some interviewees expressed that partnerships between off-grid solar companies and mini-grid companies in Rwanda are not as forthcoming, as evidenced in the quotes below:

> .. The perception of competition is still taking over the willingness to really work together…..(OGS R2).
>
> I think it is needed and it's certainly beneficial for everyone to understand what the plans are in terms of expansion, where is mini-grid company x going to go next. Unfortunately, they are still seen as competitors, which they are, and things like data sharing is still not exactly very popular, they share the bare minimum that they must because there might be a requirement to share certain data with the government of the coordination units (OGRS 2).

[92] *Imihigo* is a Rwandan word for performance contract, and is the name given to the official government targets for various areas including the off-grid electrification

…on an aggregated scale, obviously companies aren't going to want to share that (EI 1).

Therefore, the perception and reality of competition is something that poses a real challenge for companies working more closely together and needs to be addressed when transitioning to more integrated electrification paradigms. Figure 22 below, drawing from the empirical findings, shows how the perception of competition reduces the willingness of off-grid companies to work together and share data, which reduces the information available for off-grid planning and ultimate hinders coordination and the deployment of off-grid technologies. The (-) signs in the diagram show the negative impact of competition on coordination and integrated frameworks.

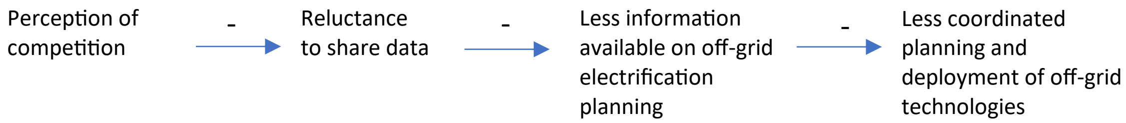


Figure 22: Impact of perception of competition on coordination and collaboration (Author's figure)

This requires mechanisms to facilitate and incentivise data sharing to protect company data and proprietary information. It is also worth noting that having aggregated data shared with the utility or central coordination unit might be more useful for sector planning than individual companies sharing data with one another. For example, in Rwanda, for off-grid solar companies to be able to apply for funding under the REF Window 5 (see Section 6.3), they are required to share certain information with the utility through periodic reporting in accordance with the MOUs signed (IDO R1). Here a financial incentive has been coupled with a data sharing requirement. In other instances, off-grid companies may choose to form synergies with each other, if it is opportune and mutually beneficial to work more closely together, and sufficient trust is established.

8.4.2 The need for a default provider and variations to a territorial concession

One of the key tenets of the IDF is the need for a default provider of electricity to ensure electricity provision to all households and entities within a pre-defined agreed territory, in order to facilitate *inclusivity* and *permanence* for universal access so that no-one is left behind (Pérez-Arriaga et al., 2019, 2020, 2021). KOSAP in Kenya, introduced in Chapters 1 and 4 and elaborated on in Chapter 7, provided an apt case study in which to apply the principles of the IDF to a mini-grid PPP within the pre-defined service territory of the 14 underserved KOSAP counties. For KOSAP, the national utility Kenya Power together with selected private sector mini-grid developers and REREC will effectively serve as the default provider of electricity through mini-grids and off-grid stand-alone solar systems. However, KOSAP deviates from the strict territorial concession model. Through the PPP, as discussed in section 7.2, the private sector will bid under a competitive tender to develop 8 lots of mini-grid sites within the underserved counties. It will also be responsible for construction and operation and maintenance, while Kenya Power will retail electricity to customers. Section 7.3.2 discussed how this model could facilitate *permanence* and the long-term presence of public and private sector entities to the partnership. However, this needs to be coupled with sufficient provision for O&M when needed. This could be through a part of the revenue set aside in a maintenance reserve account, or something similar, and this needs to be accounted for in the financial modelling. This still leaves a gap for sites developed outside of KOSAP territories, where off-grid models are implemented largely by the private sector. These remaining non-served areas need to be accounted for in the national electrification plans and implementation strategies.

Turning to Rwanda, Pérez-Arriaga et al. (2020) argue that that Rwanda is well placed for a simpler implementation of the IDF[93]. Favourable conditions for implementing the IDF pillars include strong governance (see Bisaga, 2018; IDO R1) and a national utility that can co-exist with mini-grid developers and stand-alone solar product providers (Pérez-Arriaga et al., 2020). Importantly, universal access has been prioritised by the government for 2024. Pérez-Arriaga et al. (2020) argue that the above factors all auger well for the implementation of a territorial concession to cover electrification throughout the country. As shown in the interview data (see Section 6.4.1), the idea of having a strict mphasizesion of territories for off-grid stand-alone systems, was not viewed favorably by off-grid providers and development partners in Rwanda due to the rigidity of such an approach and what that would mean for the off-grid solar market in Rwanda (OGS R1, IDO R1). This view concurs with literature review findings in Sections 2.3.1 and 2.3.2 (Hosier et al., 2017; Jacquot et al., 2019; Jacquot, 2021). Jacquot et al. (2019) argue that the dynamism of solar home system sector model would soon render the concession model obsolete. Thus, a more dynamic approach is needed for off-grid solar models allowing for a lighter touch approach to the zoning of off-grid solar, not constraining off-grid operation to a specific zone. For mini-grids in Rwanda, however, a territorial concession, or another form of close partnership with the government is likely the direction Rwanda would take for mini-grid development going forward.

[93] Implementation of the IDF, includes meeting IDF criteria as well as evaluating policy and programme design by considering IDF criteria.

While it may make sense to have regions designated specifically for mini-grids, as mini-grid investments are in physical infrastructure that cannot be as readily relocated as a *solar in a box* offerings, a less restrictive approach may be needed for stand-alone solar companies. A development partner explained:

> If you over-regulate and that was the case with that early idea of dividing Rwanda – mostly from the Rwanda experience, but it goes for every country if they were to do that, if you were to zone your country completely and prohibit companies from entering certain areas that's also a detractor, because they are like, I already have an established business here and you're telling me I have to go somewhere else, so it becomes too burdensome (OGS R1).

In this case it may be necessary to have off-grid solar companies operate according to their footprint and presence, allowing for opportunities for expansion into other territories, but not necessarily exclusivity. Notwithstanding, there should be incentives for companies to go into specific zones that are not being served, and it would not make sense to have a concentration of mini-grid providers and solar home system providers all in one area while some areas are left largely unserved. In other instances, for example in the case of mini-grids, allowing one mini-grid company to have a cluster of sites and exclusivity in a territory may be necessary to enhance the viability of the particular sites and reduce regulatory risk, particularly grid arrival.

Off-grid solar systems can work alongside grid extension and mini-grids and are not necessarily in direct competition with other electrification models. While there may be a degree of competition between off-grid solar companies and mini-grid providers, particularly if serving households or territories in very close proximity, the market forces of competition can give households or users choice about which options they wish to opt for if more than one electrification option is available within a specific region. Part of the challenge though, is that these might be perceived as being in direct competition with each other within a certain territory, as the off-grid sector still operates very much in a competitive paradigm, more than it does a collaborative one. The respondent further explained:

> That's why we also did not support the idea that you guys go there, you guys go there.. It makes sense that people can choose. In some cases we will lose, in some cases we will win customers because there are different needs and those different needs have to be supported, because they currently cannot all be supported by the grid (OGS R1).

To enable the integration of stand-alone solar into IDF models, the following strategies can be implemented:

I. Allow for a lighter touch approach for the zoning of off-grid solar, not constraining off-grid solar operators to specific zone, i.e., companies who have existing operations in specific areas, but putting in place greater incentives for companies to set up their operations in areas not connected by the main grid or served by mini-grids.

II. Ensure quality standards are in place and that only companies that provide products that comply with a minimum level of certification (e.g., Lighting Africa and Lighting Global standards) would be eligible for subsidies. However, a balance is required as imposing certain minimum levels of standards also has an influence on the affordability of products as higher tier systems cost more. This relates to the allocation of subsidies and providing a subsidy for the higher quality systems.

Mini-grids would require a higher degree of regulation than solar home systems, in light of higher risk associated with the establishment of fixed assets. Generally, off-grid solar would not need the same level of strict regulation as needed with mini-grids, but quality standards and monitoring mechanisms should be in place for quality assurance and accountability. With mini-grids the level of regulation needed could vary as well, for example, whether to allow companies to charge cost reflective tariffs, or a lower subsidised tariff, and site selection. Generally, companies would want the least possible regulatory restrictions, but there needs to be a balance of all the interests, including end users. Even in the case of mini-grids there are different degrees of regulation that would be needed under different scenarios, but regulatory clarity and consistency is paramount as argued in section the sections above and in Section 2.5 (see Bhattacharyya & Palit 2016).

This section has discussed the need for a default provider as one of the key principles of the IDF. Section 8.4.3 below discusses regulatory considerations for stand-alone solar and mini-grid business models and integration in the IDF.

8.4.3 Lightly or tightly integrated? Regulatory Design and the IDF

As illustrated in Sections 5.2.4 and 5.3.3 the type or degree of regulation required in the off-grid sector, will vary according to the technology type and different degrees of regulation that will be needed for off-grid solar and mini-grids (IDO R1, EI 3). As discussed in Section 6.4 and Section 5.3.3, a light touch approach to regulation is more conducive for the deployment of off-grid stand-alone solar systems. As seen in the case of Rwanda, off-grid solar companies have been working very closely with the utility and MININFRA, to reach joint *Imihigo* off-grid electrification targets. However, the line between guidance and coordination, and overregulation is a tricky one to navigate as evident from the interview data. For example, the period in which Rwanda was considering designating specific zones in the country for solar and others for mini-grids was raised as a concern by some interviewees in the off-grid solar sector, as it would adversely impact off-grid solar companies who already have operations in areas that could be designated for mini-grids (OGS R1).

Regarding the overlap or tension between collaboration and regulation, a mini-grid developer in Kenya commented on how they would want to see more collaboration between the utility and private sector off-grid companies, through data sharing and clarity within the broader electrification plan of the country (Mini-grid K1). However, this should be coupled with less stringent regulation, giving the private sector enough space to move with greater speed (Mini-grid K1). The above is an example of the private sector supporting more collaboration, but with less stringent regulation in the sector, emphasising the importance of quality and affordability, but with a *light touch* approach that could still facilitate the speed needed to achieve universal access targets.

Beyond institutional coordination and collaboration, mini-grid PPPs require a higher level of contractual commitment. As the level of risk becomes higher contractual measures can reduce risk, along with regulatory instruments. This could be through a power purchase agreement in a Build Own Operate model or a territorial concession for the electrification of a designated territory, or part of the conditions of mini-grid tenders as seen with KOSAP. Within the varying types of partnerships you will have stricter or less strict regulation, and for mini-grids contractual integration is needed that may come with more stringent regulation e.g. regulated tariffs (Nagpal & Pérez-Arriaga, 2021).

Another more nuanced perspective from the interview data is that there are instances when stronger coordination may be more important and needed depending on the type of technology, but that it could also be administratively cumbersome for companies to have to coordinate with the public sector more than what is absolutely necessary. This further requires the needed institutional capacity for regulators and public sector actors to take on additional roles involving more collaboration. As one development partner commented:

> I think where public sector and private sector depend on each other you need that coordination […], so in mini-grids that is much more than in stand-alone solar that coordination is needed, you see that on stand-alone solar that is on taxes and duties, trying to get tax exemption and other regulations you will have in place, to (pay) for expansion of solar home systems. At that level the coordination is important. For the rest you see the

companies prefer to limit coordination as much as possible, because it also implies cost, time and effort, so you will only do that for where it is needed (EI 3).

This ties in with the idea of increasing degrees of collaboration that may be needed in accordance with the type of technology and how that links with the regulatory environment. Therefore, tighter coordination and regulation may be more beneficial for mini-grids than stand-alone solar, to enable greater interconnectivity with mini-grids and the grid and are subject to various approvals and regulatory oversight with respect to tariff approvals and licensing, processes which require regular communication with the regulator. However, it may impose additional burdens to require off-grid solar companies to work more closely with the utility than needed. There needs to be a degree of caution on how this is approached to derive the maximum benefits for all actors but not imposing conditions that could make processes unnecessarily bureaucratic. Figure 23 shows the potential impact of over reregulating the off-grid sector and how this could increase the time and cost burden of companies to comply with additional process which slow down the deployment of off-grid technologies and reduce the willingness of off-grid companies to participate in integrated distribution approaches[94].

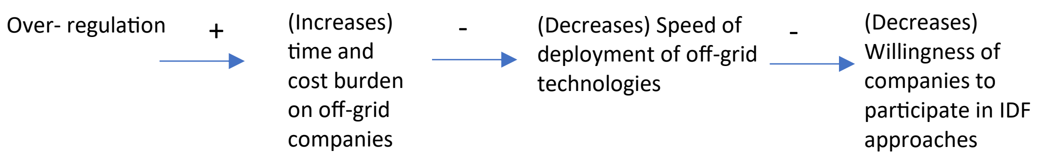


Figure 23: Effect of over-regulation on integrated electrification approaches (Author's figure)

This section has demonstrated that in the case off-grid standalone systems a lighter form of coordination and regulation may be more appropriate and conducive for the rapid deployment of off-grid solar, subject to quality standards and checks to ensure system quality and durability, which also ties into the idea that they require a more loosely regulated approach. For mini-grids there may be a need for both: strong institutional coordination and contractual integration – as the level of risk becomes higher you need contractual measure in place to reduce the risk.

Figure 24 below summarises the key barriers and opportunities for institutional integration. Barriers include regulatory uncertainty, overregulation, bureaucracy, and the perception and reality of

[94] It also entails being willing to participate in more 'regulated approaches' which may involve access to subsidies but also more regulatory oversight depending on the context.

competition. Opportunities include clearly defined roles, regulatory clarity and consistency, policy clarity and facilitating data sharing to improve synergies[95] between sector actors. Figure 25 shows the key factors affect the institutional integration. The figure shows that institutional oversight, policy clarity, regulatory clarity and consistency have a positive impact on institutional integration and consequently the IDF pillars of *inclusivity* and *permanence*. Conversely, overregulation, competition and time and cost burdens decrease synergies between actors and institutional integration. Furthermore, institutional oversight, policy and regulatory consistency, overregulation and synergies between actors are interlinked (as shown in the connecting arrows in the figure). Regulatory clarity and consistency can improve synergies between sector actors, providing clear direction to the off-grid sector with respect to where they fit in the country's electrification future and where there are opportunities for the public and private sector to collaborate.

Barriers

- Periods of unclarity around regulations between drafting of regulations
- Overregulation can disincentivize off-grid companies from investing in mini-grids/ off-grid solar
- Bureaucracy
- Perception and reality of competion can reduce willingess to share data with utilities and other off-grid companies
- Onerous or stringent reporting requirements

Opportunities

- Clearly defined roles can increase institutional oversight
- Regulatory clarity and consitency for the development of mini-grids (around issues of grid arrival and tarrifs and off-grid solar)
- Policy clarity as part of national electrificaiton planning on energy technologies and the outlook for mini-grids and off-grid solar systems in a county's national electrification plan
- Factilitating data sharing through financial incentives to increase willingness to participate in national electrification programmes and in improve synergies betweeen key sector actors

Figure 24: Barriers and opportunities for institutional integration

[95] Synergies refer to identified commonalities for achieving universal access and opportunities for public, private sectors to work collaboratively towards the common objective being SDG 7.

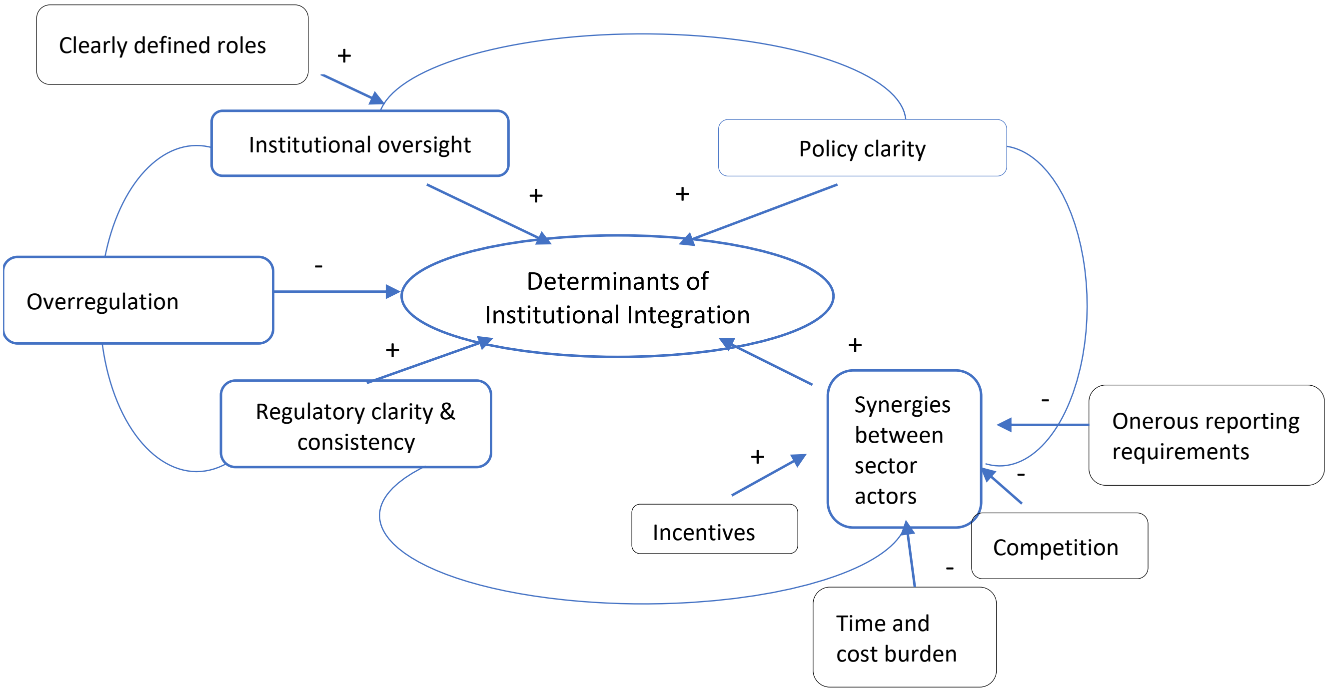


Figure 25: Conceptual model for the drivers and barriers for institutional integration

Considering Figure 25 and building on Figure 20, it is evident that institutional integration requires both coordination and collaboration and becomes an 'overarching pillar' of the IDF as it impacts on national electrification policies and planning, the electrification vision of a country and consequently the technologies and business models that will be prioritised. Coordination and collaboration between various sector actors and stakeholders impact how finance for the sector is leveraged and how combinations of technologies would effectively work together. It also impacts the level of permanence of off-grid electrification providers and modes of electrification. The figure below shows the expanded framework this thesis proposes.

Figure 26 shows the further development of the IDF framework from Figure 20. Importantly this figure shows how Institutional Integration (discussed in Section 8.4.1), becomes an overarching pillar that stretches across the other IDF pillars as it has an influence on each of them. Similarly, institutional oversight, policy clarity, regulatory clarity and consistency and synergies between actors in the sector also are overarching pillars as they affect the degree of institutional coordination and collaboration.

Within a mix of electrification modes, it adds *light touch regulation* as an answer to the remaining gaps indicated in Figure 20 based on the discussion in this section. The expanded IDF, building on the core IDF principles highlighted in Section 2.2.1, details key facets that should be considered when designing and delivering off-grid energy programmes and projects. It emphasises the value of institutional oversight with respect to both coordination and collaboration, and the importance of regulatory clarity and consistency. It further provides a nuanced perspective of when coordination and collaboration may be the most useful. The preceding analysis, informing the expanded framework, shows the intricacies of balancing a regulatory design that is sufficiently robust with incentives and protection for customers. This relates to cost and quality of supply and 'open market freedom' needed to give the private sector leeway to move into markets and 'crowd in' finance and scale their models. With respect to the original pillars, the expanded framework extends the definition of inclusiveness beyond a default provider of electricity (responsible for electrifying everyone within a pre-defined region). It emphasises the important of financial inclusivity and the incentive design and structures that could facilitate greater geographic and socio-economic inclusivity. The expanded framework further includes specific consideration to RBF approaches and the complementary finance need through appropriately structured equity, debt and other grants to support off-grid innovations, to grow and scale. Importantly it considered variations to strict territorial concessions through alternative PPPs models as demonstrated through the KOSAP project, demonstrating the applicability of the framework to dynamic models currently used or emerging on the African continent.

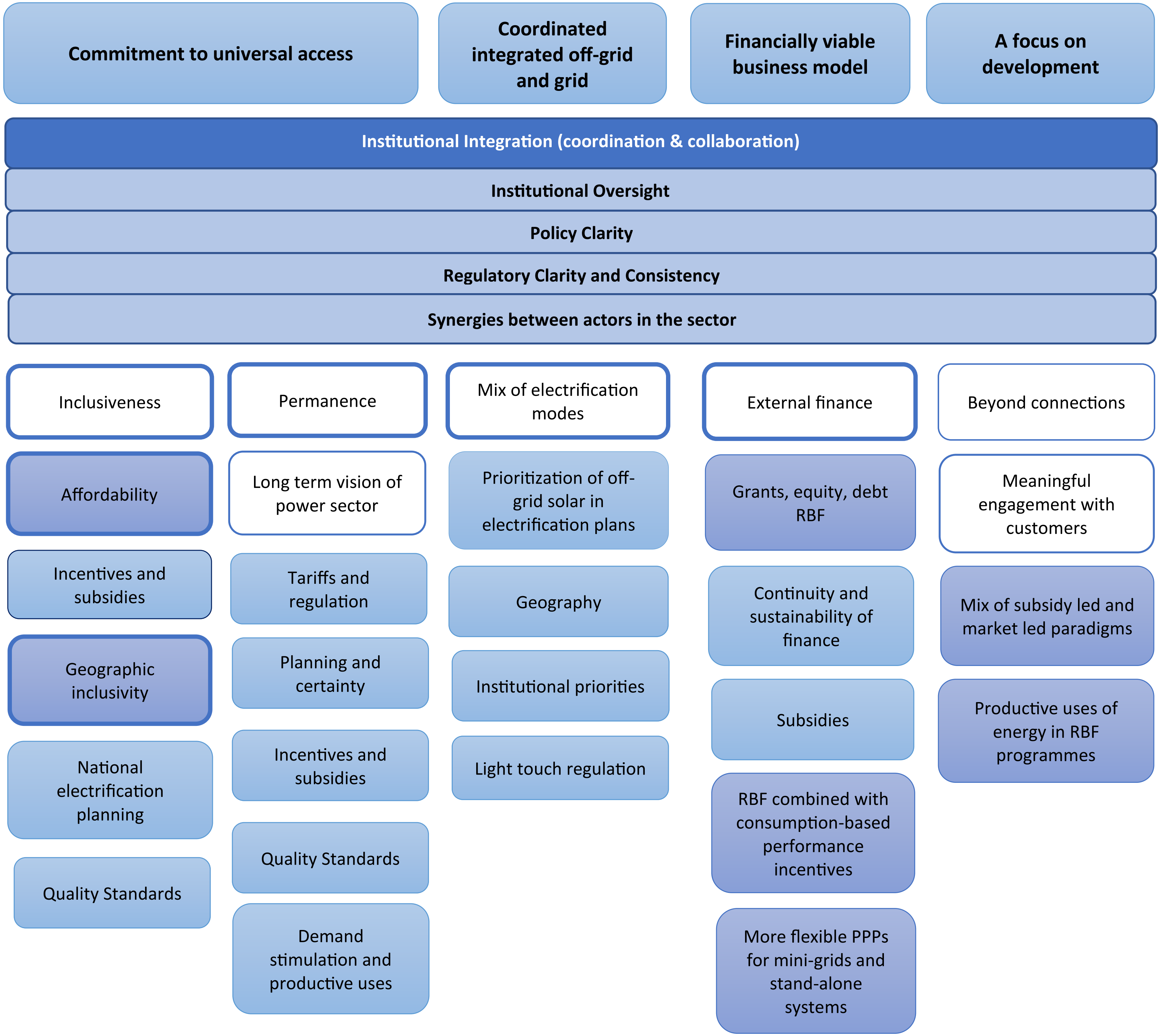


Figure 26: IDF(V4) Expanded IDF framework from analysis (Author's Figure)

The sections above have illustrated key considerations for integrating off-grid solar stand-alone business models into the IDF, looking at the value IDF approaches can offer to these models and what this means for SDG 7.

8.5 Conclusion

This chapter has brought together the findings of chapters 2, 4, 5,6 and 7 to analyse key contributors to the viability gap and financing and partnership models to address the viability gap in Kenya and Rwanda. To this end it explored the drivers of the viability gap and how IDF principles could be applied to address the barriers to viable electrification models and achieve scalable models for mini-grids and off-grid stand-alone systems, to provide new practical and theoretical insights.

Regarding tariffs and affordability this chapter, and study, have emphasised the need for suitably designed subsidies and a continuum of finance support to address the viability gap and improve the affordability of tariffs for end-users, especially those within low-income brackets. Regarding finance to address the viability gap, this study found that the suitability and sufficiency of finance is imperative when designing and implementing energy access models that can households, businesses, and communities beyond the *low-hanging fruit*.

For stand-alone solar systems the viability gap was mostly influenced by affordability, quality standards and financing. This study also demonstrated the link between quality standards and affordability, where in Rwanda new standard regulations increased the prices of off-grid solar systems, with only a certain minimum quality permitted. While this is important for ensuring a minimum level of quality in the off-grid stand-alone solar products sold (which is imperative), it impacts affordability and the inclusivity of the reach of these systems. This requires suitable subsidies to address this gap, which in Rwanda was done through the tiered RBF Pro-poor subsidy for stand-alone systems. This re-iterates the interview findings that the viability gap is essence a disjuncture between providing low-income customers with quality energy services, which requires suitable mechanisms to address.

Importantly this study draws links between the drivers of the viability gap and determinants of the IDF. It shows how tariffs, demand, affordability, viability gap funding and policy and regulatory environment, which have been identified as key drivers of the viability gap, are critical to consider when looking at an IDF framework. The 'solutions' proposed to address the viability gap all relate to the IDF framing.

This chapter also demonstrated how applying the principles of the IDF to RBF models can improve the permanence and inclusivity of RBF, by identifying ways in which longer term sustainability can be built into RBF programme design. It further showed how combinations of electrification modes can impact the roll-out and success of RBF programmes and how a wider financing ecosystem is needed beyond RFB. This chapter has demonstrated that there are many trade-offs and factors that need to be considered when integrating existing off-grid private sector models and PPPs into IDF paradigms, particularly when serving unelectrified communities in the most geographically remote areas, where affordability is key and ability to pay is low. Aligning incentives between different actors is a key part of building a successful partnership for off-grid electrification.

Chapter 9 Conclusion

9.1 Introduction

This thesis has investigated how the principles of the IDF can be applied to partnerships and financing models for mini-grids and stand-alone solar systems in Kenya and Rwanda. It demonstrated how the IDF's tenets can be operationalised in these countries to facilitate the achievement of SDG 7. Specifically, it applied the IDF, as the main conceptual framing for the study, to the business model, partnership, financing and regulatory aspects of off-grid stand-alone solar and mini-grids. This included an analysis of RBF models for stand-alone solar systems in Kenya and Rwanda and mini-grids, and PPP models for mini-grids through the case study of KOSAP. This thesis argued that integrated approaches are needed to achieve SDG 7, coupled with a range of off-grid business models and appropriate regulatory frameworks to address the viability gap and deliver energy access more inclusively, building on the growing body of knowledge in this area (see Pérez-Arriaga et al., 2018; Rahnama, 2018; Pérez-Arriaga et al., 2019, 2021; Power For All, 2019; SEforAll, 2019). The IDF enables an analysis of different levels of the energy system from institutions and entities involved in electrification and enables *inclusiveness* and *permanence* as well as the *mix of technologies* and external *finance* needed to create viable business models and achieve universal access goals.

Four core principles, namely (i*) inclusiveness, (ii) permanence, (iii) a combination of electrification modes and (iv) external* resources were used as a foundation for the analysis presented in the analytic chapters 5-8, and which builds into the expanded articulation of the IDF framework below, first presented in Sections 1.1 and 2.2 (see Pillars 1-4 detailed below).

- **Pillar 1: A commitment to universal access that leaves no-one behind** through ***inclusiveness*** and ***permanence*** *with off-grid providers privately or in partnership with national utilities delivering off-grid energy access within assigned specific geographic territories.*

- **Pillar 2: Efficient *and coordinated integration of off-grid solutions*** *by focussing on the integration of off-grid technologies in tandem with the existing grid infrastructure.*

- **Pillar 3: *A financially viable business model supported*** *through* **external financial resources** *integrating financing and partnership models to address the viability gap.*

- **Pillar 4: *A focus on development to ensure that electrification produces broad socio-economic benefits*** *by looking beyond electricity connections but at the wider socio-economic impact and benefits for end-users through e.g., productive uses of energy.*

The knowledge contributions this thesis makes to the framework are expounded in Section 9.3. This study has built on and expounded the IDF as its main theoretical framework. It has addressed a gap in the academic literature for operationalising IDF principles in off-grid settings for financing and partnership models like RBF and PPPs for stand-alone solar systems and mini-grids. It has identified and filled knowledge gaps on the IDF and its implementation in off-grid settings in Kenya and Rwanda, building on the pioneering work of the MIT- Comillas Energy Access Laboratory (see Pérez-Arriaga et al., 2018; Rahnama, 2018; Jacquot et al., 2019; Pérez-Arriaga et al., 2019, 2020, 2021; Jacquot, 2021). It contributes to a granular empirical analysis of the determinants of the viability gap in relation to the IDF and demonstrates how the IDF principles can improve the viability and inclusivity of mini-grid and stand-alone system business models in Kenya and Rwanda. It further has identified and addressed the paucity in the literature in terms of incorporating RBF into IDF paradigms, building on Nagpal & Pérez-Arriaga (2021), one of the only prior papers exploring this link. This thesis has also explored how the IDF could be applied to variations of PPPs and concession models.

This study used qualitative research methods to carry out the empirical investigation, and a case study design through in-depth case studies of Kenya and Rwanda. A total of 49 semi-structured interviews were conducted with key stakeholders in the off-grid energy sectors in Kenya and Rwanda, including mini-grid developers, stand-alone solar companies, international development partners, industry associations, the national utilities and Ministries of Energy.

The purpose of this chapter is to (i) present the key empirical finding of the study (ii) highlight the key knowledge contributions of the study and (iii) present the implications for further research.

9.2 Key empirical findings

The first research question this study answers is: ***What are the key factors impacting the viability gap for off-grid stand-alone solar businesses in Kenya and Rwanda?*** In the context of this study, the viability gap in Rwanda and Kenya is largely caused by a disjuncture between the cost of providing an energy service and the quality of service. The viability gap is especially pronounced when serving end-users with low ability to pay or who are in remote or geographically dispersed settings. This study found that for mini-grids the viability gap in Kenya and Rwanda is impacted by financial, regulatory, policy and geographic considerations. To achieve electrification models that are both viable and *inclusive*, revenue requirements of mini-grid developers and their commitments to their financiers must be balanced with affordability for end-users. Subsidies through grants, cross subsidies and appropriate cost reduction mechanisms are critical for achieving this. The study affirms the findings in the literature from other geographical contexts that subsidies are needed to close the viability gap; without this it would be incredibly difficult to build a viable business model that is also affordable for end-users (Davies & Tilleard, 2019; Phillips, Plutshack & Yeazel, 2020; Musonda et al., 2021). This study contributes to the academic literature showing how the IDF framing can improve the *inclusivity* and *permanence* of these subsidies, through the RBF grant programmes analysed, as elaborated below.

This study finds that viable mini-grid models, and integrating mini-grids in the IDF, require balancing regulatory requirements and national policy objectives for grid parity mini-grid tariffs, as tariffs are impacted by policy objectives for grid parity tariffs and equity between grid and mini-grid customers. Within the sphere of control of mini-grid developers, demand stimulation and productive uses of energy can substantially improve the viability of mini-grid sites but require funding and partnerships with organisations who have relevant experience in this area, for example, Mercy Corp Energy4Impact who partnered with Rwandan developers at the time. Regulatory clarity and consistency are imperative for de-risking mini-grid projects in Kenya and Rwanda and buffers mini-grid companies against unanticipated grid arrival and a duplication and wastage of financial resources.

For solar home system models and their integration into the IDF, affordability, finance and regulation on quality standards were identified as key determining factors impacting the viability of stand-alone solar system models in Kenya and Rwanda. As emphasised in the section on mini-grids, affordability for off-grid solar systems emerged as one of the key factors affecting off-grid solar business models, particularly emphasised in the Rwandan interview data, but relevant to Kenya and many countries in Sub-Saharan Africa, the global South and even globally. A key finding in Rwanda was that the low-hanging fruit of serving customers with higher ability to pay has been exhausted and that companies really struggled to venture out into solar home system markets where ability to pay was lower. This challenge was exacerbated due to COVID-19, which affected affordability and product supply chains, and was compounded by the Ministerial guidelines that had been issued for stand-alone solar systems in Rwanda. These regulations effectively prevented the sale of the most affordable products as they did not meet minimum criteria for hours of lighting and tiers of service. While these new regulations were important for minimum quality products they also directly impacted affordability. Similarly, the literature on Kenya and other markets in East Africa highlighted that the low-hanging fruit have been exhausted, which reiterates the importance of subsidies to address the viability gap in order to assist with the affordability of off-grid products and services (Lepicard et al., 2017). Thus, affordability needs to be strongly considered and operationalised within an IDF framing, which includes appropriately designed subsidies i.e., through modified RBF grants considering long term sustainability of funding and partnerships to facilitate greater inclusivity and viability. Changing or inconsistent regulations impact solar businesses in the sector as seen through fluctuating VAT requirements for off-grid solar products in Kenya or the uncertainty for mini-grid developers about grid arrival when the NEP was being revised in Rwanda. Affordability is therefore imperative for bridging the viability gap, for mini-grids and stand-alone systems, and influences the IDF pillars, particularly *inclusivity, permanence and a financially viable business model.* This needs to be coupled with clear and consistent regulation tailored to different nature of mini-grid and stand-alone solar models.

The second research question this study answers is: ***Which business model and financing approaches are being implemented to overcome the challenges of viable and scalable electrification models in Kenya and Rwanda and how can an IDF lens improve the implementation of these approaches*?**
The empirical evidence of this study found that RBF for stand-alone solar systems and mini-grids in Kenya and Rwanda and mini-grid PPPs, through tender-based programmes for mini-grids like KOSAP in Kenya, are currently two of the main financing and partnership approaches used to address the viability gap and develop scalable models to address SDG 7 in the study case studies. This concurs with the findings of Phillips, Attia & Plutchack (2020) who identified RBF and mini-grid tenders as two incentive-based approaches increasingly used to develop and scale mini-grids. This holds true for stand-alone solar systems as well. RBF models are gaining prominence in countries across Sub-Saharan Africa with the rise in Pan African RBF facilities like UEF and Beyond the Grid Fund Africa and are increasingly one of the dominant approaches used to finance mini-grids and stand-alone solar systems in Kenya and Rwanda. Through the analysis of the EnDev RBF programmes in Kenya and Rwanda this study assessed how such programmes address the viability gap and enable scalability in these countries, and explored how the grant programmes could be used for greater geographic and socio-economic *inclusivity*. While this study supports the findings of Phillips, Attia & Plutshack (2020) who argued that RBF projects can be used to nudge the private sector to develop projects in the 'harder to electrify areas', this study adds to the academic literature that in addition to this, RBF programmes need to be intentionally designed with inclusivity objectives woven into the fabric of these programmes. The KOSAP project in Kenya and the Ubudehe Pro-poor subsidy in Rwanda are two examples of how geographic and socio-economic inclusivity can be written into the design of RBF programmes. KOSAP focusses on previously marginalised underserved counties, with an electrification rate approximately 23% compared to the national average of 78% in Kenya, by providing incentives (i.e., RBF grants) for off-grid companies who sell stand-alone solar products in this area. In Rwanda the tiered Ubudehe Pro-poor subsidy was targeted at households who ordinarily would not be able to afford many of the stand-alone systems on the market. The new Ministerial Guidelines on solar systems in Rwanda effectively increased the prices of the most affordable systems. As the higher quality systems were more expensive this subsidy was especially needed to address the affordability

gap. One of the key challenges of RBF models identified and supported by the literature is that it mainly incentivises electricity connections and does not sufficiently incentivise the quality of connections. Thus, to enable the IDF pillar of *permanence* and support the long-term sustainability of connections incentives are required. This could include designing RBF grant programmes with incentives for the quality of connections e.g., through a modified RBF design with the types of energy consumption-based incentives the Crossboundary Innovation Lab provides. This would enable a focus beyond new connections, but also provide the incentive and finances to sustain connections and the quality of supply and engage in productive uses of energy. Mini-grid providers should be incentivised to keep up and maintain their sites, but there needs to be sufficient funding to do this. This could be through a modified RBF design or a new variation of grant finance that facilitates the longer-term sustainability of mini-grid projects.

The third research question this study answers is: ***What are the key empirical factors that influence the conceptual IDF in the Kenyan and Rwandan contexts?***

The study identified key determinants of the IDF pillars, informed through the case studies of Kenya and Rwanda. As Illustrated in Section 2.2, IDF pillar 1 *A commitment to universal access in essence comprises* sub-pillars *inclusiveness* and *permanence*. The core IDF pillars namely *permanence, inclusivity*, *a combination of electrification modes* and external *resources* are critically interlinked, and this study expanded the understanding of these pillars by identifying that in the contexts of Kenya and Rwanda they are impacted by affordability, the regulatory environment as well as demand stimulation, cost reduction and financing. The study found that in Kenya and Rwanda *inclusivity* of electrification models was impacted by affordability, incentives and subsidies, and national electrification planning. Affordability, as highlighted above, significantly impacts socio-economic and financial inclusivity, which is important when serving low-income end-users and end-users who are the most vulnerable to changing socio-economic circumstances. A notable distinction from the empirical interview data in Rwanda was the stronger emphasis on affordability as the overall context impacting energy delivery, compared to Kenya. In Kenya, grid parity tariffs and institutional priorities to keep tariffs as low as possible were emphasised more by interviewees. However, in both countries affordability and regulatory considerations impact the viability gap, albeit to varying degrees. Another finding is that financial inclusion is impacted by regulatory certainty and consistency and can be affected by standards and regulation. In Rwanda, while regulations on stand-alone solar impacted affordability, the Pro-Poor subsidy particularly targeted households with lower ability to pay. As with *inclusivity*, the study found that *permanence* depends on regulatory clarity and stability. As demonstrated through the empirical findings, periods of regulatory uncertainty increase risk and reduces investor confidence in the sector. Permanence was also impacted by *external resources* as many off-grid projects in both Kenya and Rwanda, and increasingly in many countries in sub-Saharan Africa and the global South, are dependent on external donor funding and private investment into the sector. The EnDev RBF programmes in both Kenya and Rwanda and the KOSAP project in Kenya are indicative of this. However, this thesis argues that while this external international finance has catalysed off-grid energy markets, it is not sufficient nor sustainable for countries to primarily rely on international donor finance or external private sector funding, as this does not necessarily encourage the establishment of long-term sustainable markets with local actors. How projects are financed also impacts the level of *permanence* that can be achieved. This study supports the literature that local finance institutions, companies and value chains should be enabled to take a more prominent role in energy access markets and adds to it by showing through empirical data that local company inclusion and local finance institution strengthening needs to be incorporated into IDF thinking, especially for permanence.

Pillar 2, coordinated and efficient combinations of electrification modes was influenced by the prioritisation of off-grid technologies in electrification plans, the regulatory environment, the physical geographies of the country case studies, institutional priorities and the availability and affordability of finance. The *combination of electrification modes* is strongly influenced by a country's institutional priorities and the regulatory environment. While having a clear place in a country's national electrification plan is important for both stand-alone systems and mini-grids, this clarity is arguably more critical for mini-grids, which require relatively 'fixed' infrastructure investments and are less agile and modular than stand-alone systems. Another notable distinction between Kenya and Rwanda is Rwanda's objective to electrify most of the country with the grid beyond the 2024 universal access target. Thus mini-grids and stand-alone systems are considered largely as transitional technologies to support universal efforts, but the focus in long term planning is on the grid. Considering Rwanda's prioritisation of the grid in its long-term electrification planning, off-grid technologies and mini-grids were given less priority in the country's electrification plan as Rwanda has the objective of 100% grid electrification post 2024. In contrast, in Kenya the 30% earmarked for off-grid technologies will remain an integral part of Kenya's mix, with the national grid not planned to reach certain areas earmarked for off-grid development. This reflects that a country's choice, strategic decisions and preferences with respect to the mix of technologies that will ultimately be prioritised impacts the sustainability of operations and degree of permanence off-grid providers can have, directly impacting IDF pillar 2 *a commitment to universal access through inclusiveness and permanence* and IDF pillar 3 a *financially viable business model.* Institutional priorities impact regulations that govern the sector and are needed to guard against grid encroachment without clear directives and adequate compensation for stranded assets. Lastly, this study identifies that IDF pillar 4, *a focus on development* with attendant socio-economic benefits *needs to* be more deliberately built into the design of off-grid business models, where mini-grids especially can be coupled with demand stimulation and productive uses of energy to support income generating opportunities for end-users connected to the mini-grid.

The fourth research question these answers is: ***How can the IDF be applied to Kenya and Rwanda's mini-grid and stand-alone solar system models to facilitate progress towards SDG 7?***
This study has demonstrated that Kenya and Rwanda have varying approaches to institutional collaboration and coordination in the energy sector. This thesis argues for institutional coordination and collaboration as essential components that can drive greater permanence and inclusivity in the IDF framing and as overarching tenets of the IDF pillars. It nuances the findings of Pérez-Arriaga et al. (2020) who argued that in Rwanda a more 'straight forward' application of the IDF is possible. Indeed, Rwanda is an apt example of strong institutions and collaboration between public sector electrification actors, the private sector and international development partners. This study has identified that Rwanda has strong donor coordination and interactions between donors, development partners and the private sector, which acts as a collective voice for stakeholder interests through technical and sector working groups, helping to drive SDG 7. As Pérez-Arriaga et al. (2020) contend, Rwanda's 100% electrification objective and national utility co-existing with mini-grid developers augers well for the application of the IDF framework. While Pérez-Arriaga et al. (2020) argue that a territorial concession could be the main implementation modality of the IDF in Rwanda, this study's empirical findings provide a more nuanced understanding that contrasts this view, highlighting key challenges with applying a strict territorial concession to Rwanda's off-grid market, particularly for stand-alone solar products. Although it is likely that Rwanda would adopt a territorial concession considering its more 'hands on'[96] approach to energy sector development, this study contends that a light touch regulatory approach is more conducive for the deployment of off-grid solar stand-alone systems without strict geographic restrictions. In contrast, this thesis recommends that governments and RBF programmes should have priority areas, where additional incentives are created to enable off-grid operators to expand their operations into underserved or marginalised regions. The idea of strictly dividing Rwanda up into different zones for off-grid applications e.g., designating specific zones for stand-alone solar was not viewed favourably in this study's findings as this was too restrictive. This concurs with findings of Jacquot et al. (2019) who found that the traditional concession model for solar home systems could be rendered obsolete due to the dynamic nature of off-grid stand-alone solar models and markets.

[96] From empirical data Rwanda wanted designate certain zones for off-grid stand-alone systems and mini-grids

Rather than the strict territorial concessional approach, this thesis recommends that a 'looser' concession or PPP model may be more favourable for an integrated approach. Similarly, this study found that it would be important to allow stand-alone solar companies to continue to operate within the regions where they have already established operations. However, programmes like the Ubudehe pro-poor RBF subsidy in Rwanda or the KOSAP RBF facility in Kenya can incentivise the private sector to expand into the harder to electrify regions of the countries. With respect to mini-grids, the overall institutional prioritisation of grid extension beyond 2024, makes the environment for mini-grids less conducive for mini-grids in Rwanda than in Kenya, particularly private models. A territorial concession, or a variation of this, is likely the approach Rwanda may adopt going forward.

For Kenya, the KOSAP model is a variation of a strict territorial concession, where the national utility, selected mini-grid providers and the rural electrification agency are responsible for electrifying households, businesses and social institutions in the 14 underserved counties. Regarding *permanence*, an important emerging theme from this study was that of open market freedom versus directed development, and trade-offs between these approaches (see Section 7.3). The KOSAP project facilitates geographic inclusivity through its focus on underserved regions. However, with models like KOSAP, inclusivity is only facilitated within the geographic confines of the project. There will be areas outside the KOSAP sites that will remain unelectrified, unless there are other private sector models that specifically serve these regions or complimentary national electrification programmes that further extend the reach of KOSAP. This study found that within the IDF pillar *inclusivity* an emerging sub-theme *was open market freedom versus directed development*. From an inclusivity perspective, directed development can further inclusivity objectives of the IDF (see Section 7.3). Without more directed development there would arguably be more 'cherry picking' of easier to electrify mini-grid sites. However, this comes with trade-off of forgoing more control in the value chain and being open to playing different roles in the value chain to collectively achieve the objectives of SDG 7.

9.3 Contributions to knowledge

The first conceptual contribution this study makes is identifying the **context specific drivers of the viability gap and IDF in Kenya and Rwanda**, countries with different approaches to off-grid development and priorities regarding electrification technologies to achieve universal energy access targets. Among the drivers identified, this study identified that **affordability was a key consideration affecting the viability gap** which was particularly emphasised in the Rwandan case study. This is especially important to consider as many private sector business models offer electricity services or products at a price higher than the grid tariff. This also creates a paradox as lower tiers of service are offered at a price higher[97] than grid connection. This impacts the level of *inclusiveness* in the IDF framing and since inclusiveness requires not only geographic inclusivity but socio-economic inclusiveness. Inclusiveness, in the IDF literature thus far, has mainly focused on geographic inclusivity and a default provider responsible for ensuring that all end-users within a specific geographic zone would be catered for through e.g., a territorial concession. However, when deviating from strict territorial concessions, particularly with private sector stand-alone solar and mini-grids, the affordability gap is more pronounced as costs of systems or tariffs are normally higher than the grid tariff and the need for subsidies through for example innovative grant finance, becomes imperative. Even for end-users who are charged a grid tariff, affordability is still a key consideration. This thesis therefore centralises affordability in the IDF framing, and the attendant financing mechanisms that would enable this. This study thus proposes affordability as one of the sub-pillars of the IDF (see Figure 26 in Chapter 8).

The second conceptual knowledge contribution made is **applying the principles of the IDF to off-grid electrification models that fall outside of a strict territorial concession,** through tangible examples of how the IDF applies to RBF and PPPs in Kenya and Rwanda. The findings of this study demonstrated how emerging partnership and financing models in these countries can be incorporated into integrated distribution models and improved, through the lens of the IDF. This was demonstrated through the findings of the KOSAP project for mini-grids in Kenya and the EnDev RBF programmes in Kenya and Rwanda which are increasingly used in many countries in Sub-Saharan Africa to facilitate their universal energy access objectives. This study has demonstrated key considerations for integrating RBF and variations of PPP models into an IDF paradigm. It showed how an IDF framing can help strengthen existing PPP models. Whereas Pérez-Arriaga et al. (2020) advocate for territorial concessions as the primary implementing contractual arrangement for the IDF, this study shows that IDF principles can equally be applied to off-grid electrification business models contexts that deviate from strict territorial concessions, for example 'looser' PPPs and RBF. Although the IDF allows for different applications and implementation models, this study specifically demonstrates how the IDF can be implemented for variations of PPPs and RBF. This thesis has shown how IDF thinking can be applied to RBF to strengthen its permanence and inclusiveness, by emphasising the financing continuum and sustainability of finance beyond a specific funding mechanism. It has used practical examples from the field, drawing on expert insights of implementers and recipients of RBF finance and expertise on mini-grid best practices. For example combining RBF incentives with more consumption-

[97] As illustrated in section 5.2 private mini-grid tariffs in Kenya and Rwanda are almost always higher than the grid tariff. For solar home systems, depending on the prices, customers might be paying more per month to pay of a solar home system, than those connected to the grid within certain consumption brackets.

based demand stimulation approaches can be one way of strengthening RBF design. It also showed the interdependence of RBF finance and off-grid finance with regulatory clarity and consistency, drawing a specific linkage between regulation and finance. This has a direct bearing on permanence of energy provision and de-risking the sector. With respect to off-grid PPPs it showed how the IDF lens could be applied to national scale electrification projects like KOSAP, which represents a variation and deviation from a strict territorial concession.

A third, and related contribution to knowledge is the **application of the IDF principles to PPPs and RBF to improve the design, and long-term sustainability of these funding mechanisms,** by considering the longer-term sustainability of connections. A key finding was the need for a greater degree of permanence and sustainability of RBF finance, in the Kenyan and Rwanda RBF programmes analysed, but also for the modality of RBF more broadly. One of the challenges from the study's findings is that RBF disbursements only happen once certain milestones are met. This requires pre- and post-financing, which has to varying degrees represented challenges for private sector companies. As indicated above, approaches to addressing this challenge could include coupling RBF incentives with demand stimulation types of energy consumption-based incentives, and disbursing a percentage upfront to enable projects to start. This study further identified the key importance of aligning incentives between public and private sector actors for roles of retailing to customers and stimulating demand. This builds on the knowledge of IDF authors who have started exploring linkages between the IDF and RBF (see Nagpal & Pérez-arriaga 2021).

A fourth, contribution **is identifying and drawing out the interlinkages between the four pillars of the IDF and core sub-pillars**, namely *inclusiveness*, *permanence*, *a combination of electrification modes and external financial resources*, to aid operationalising the framework**.** While the four pillars have largely been discussed as separate principles within the framing, this thesis has drawn out these linkages, for example, eliciting the types of external resources and funding are needed to ensure that there is inclusiveness in electricity provision, and that the 'hard-to-reach' areas are reached sustainably.

As shown in Chapters 5 and 8, the IDF sub-pillars *permanence, inclusivity* and *external finance* are interlinked and impacted by affordability, the regulatory environment as well as demand stimulation, cost reduction and financing. Affordability impacts financial inclusiveness especially when serving low-income households. Improving end-user affordability and lowering the tariffs could drive increased electricity consumption at lower costs. IDF sub-pillar 1 *permanence* is impacted by pillar 2, *combinations of electrification modes* and its determinants identified in this study (i.e., prioritisation of off-grid technology in electrification planning and institutional priorities) and how these technologies are regulated. *Permanence* is also influenced by IDF sub-pillar 3 *external finance*. For example, this study showed how the types of financing could impact the degree of permanence achieved; the shorter-term nature of RBF grants does not ordinarily facilitate a degree of permanence, without building and supporting the wider financing pipeline. It showed the need for greater continuity in financing mechanisms, and how shorter-term grant programmes like RBF would need to be strengthened and complemented by a suite of financing mechanisms. This also affects the ability of off-grid operators to operate in a space or region without any degree of permanence or certainty.

IDF pillar 2, *efficient and coordinated off-grid solutions* is interlinked with institutional priorities, but also a long-term vision of the power sector which was part of the original IDF framing in pillar 1 under the sub-pillar of permanence (Figure 26, Section 8.4). IDF pillar 2 is also impacted by regulatory governance and long-term and short-term objectives of the power sector. This further affects IDF sub-pillar 1, *inclusiveness* as the geographic priority areas for off-grid programmes are impacted by institutional priorities and how governments and development partners direct funding into the sector (see e.g., KOSAP in underserved counties and Ubudehe Pro-poor subsidy).

IDF pillar 3, a financially viable business model is affected by regulations and the relative prioritisation of off-grid technologies which is in turn influenced by the level of permanence these technologies can achieve. The viability gap is indeed influenced by affordability, regulation, geography, under IDF sub-pillar 2. Pillar 3 is also in turn influenced by institutional priorities, and the types of finance governments prioritise, for example a World Bank loan to the Kenyan Government for KOSAP and the RBF and debt facilities within the programme.

IDF pillar 4, requires a *focus beyond connections* and linking productive use income generating opportunities to off-grid projects. This could be coupled with the necessity of demand stimulation and related efforts for growing demand and productive uses on e.g., mini-grid sites and ensuring transitions from lower tiers of energy access to higher tiers, which also links back to IDF pillar 2 and 3.

The fifth contribution to knowledge is identifying key **trade-offs** that come with more integrated electrification approaches as demonstrated through the case studies of KOSAP and Rwanda's coordinated approach for the off-grid energy sector: the compromise between **speed and scale**. As shown the KOSAP mini-grid component has the potential for larger scale mini-grid deployment with 137 mini-grids in the process of being tendered. However, since the KOSAP project started in 2017 the mini-grid component of the programme has taken considerably more time to get off the ground than the solar home system RBF and debt financing windows under KOSAP. This has meant solar home system providers who have been successful in receiving funding under the KOSAP RBF and debt financing windows could move faster than mini-grid companies in serving their customer bases. This also relates to the greater agility of off-grid stand-alone solar models and that stand-alone solutions can be deployed quicker than mini-grids. Although mini-grid construction has not commenced, KOSAP sites have effectively been ringfenced, i.e., private developers cannot develop these sites privately. Only selected developers can develop the sites in partnership with the utility. Whereas mini-grid sites developed under a purely private model could arguably move more quickly, tendered procurement in PPPs can take longer, with households gaining access in the shortest possible time.

This also brings to light a **second trade-off** in **quality of service** as off-grid stand-alone systems can offer a quicker entry level of service but are not on a par with mini-grids or a grid connection. This directly links to institutional priorities of governments working with development partners to channel finance into their off-grid sectors and the types of technologies that will be prioritised in different regions. From an 'open market freedom' perspective this is also impacted by end-user choice, availability of different off-grid options or a grid connection, and affordability. This moreover relates to the long term and short-term power sector objectives and the trade-off of longer term and shorted term electrification objectives of sector actors and aligning these objectives.

Encompassing the above contributions, the sixth important contribution this study makes **is contributing to the expanded articulation of the IDF, enhancing knowledge on the pillars and sub-pillars identified** in this study (see Figure 26) which builds on the original articulation of the framework set out in Section 2.2. Firstly, this study analysed the progression of the IDF from its earlier core building blocks i.e., *inclusiveness*, *permanence, a combination of electrification modes* and *external resources to* its updated framing, and integrated the original pillars into the updated framing used for the study (see Section 9.1). Particularly for pillars 1 and 3, this study integrated elements of the original and the most recent IDF framings. Specifically, it integrated the pillars of *inclusiveness* and *permanence* into IDF pillar 1 and *external resources* through financing and partnership models like RBF and PPPs into IDF pillar 3, a financially viable business model.

Secondly, this study has used the modified framing of the IDF to further propose additional sub-pillars for each of the IDF pillars (see Figure 20 and Figure 26) which enable the end-goals of the original core pillars, drawing from the empirical analysis of the Kenyan and Rwandan case studies. This adds to the

IDF and broader literature on integrated electrification approaches. Each of the sub-pillars and the interlinkages between the pillars and sub-pillars contribute to an enhanced understanding of the types of finance, regulation, business models and partnerships needed to advance SDG 7 and address the viability gap.

Crucially, the expanded framing of the IDF is a valuable analytical tool for electrification planners, policy makers and the implementation of current and emerging RBF programmes and off-grid PPPs across Sub-Saharan Africa. This expanded framing used the empirical case studies of EnDev RBF programmes in Kenya and Rwanda, and KOSAP in Kenya, to better understand how the IDF framing would apply pragmatically to contexts beyond strict territorial concessions, while embedding a more nuanced understanding of the contextual drivers of the viability gap within the expanded pillars. This allows for greater consideration of the multi-faceted drivers of the viability gap, and ways to address it to advance universal energy access in dynamic off-grid markets. While this thesis argued for more integrated and coordinated approaches, it also acknowledged the limitations and potential challenges of more integrated approaches, institutional oversight, or tighter regulation. Further application of the IDF could thus be strengthened by examining in more detail the potential 'trade-offs' in the IDF pillars, with consideration to the optimal mix of subsidies and tariff regulation, or how much institutional oversight is needed for different technologies in different settings and contexts.

9.4 Areas for future research

This study's focus is on financing and partnership models for mini-grids and stand-alone systems. While acknowledging that the IDF framing encompasses a mix of grid and off-grid technologies, this thesis was limited in scope to two off-grid technologies (and associated delivery models) in Kenya and Rwanda's off-grid sector. This narrowed focus allowed for an in-depth inquiry into key off-grid sector dynamics in Kenya and Rwanda's off-grid sectors and government led and donor funded programmes that are relevant for addressing the viability gap and useful case studies in which to apply an IDF perspective. This study only considered grid interaction with mini-grids regarding the regulatory considerations detailed in the preceding chapters, including the regulatory risk unanticipated grid arrival poses for private mini-grid developers in Kenya and Rwanda, and how Rwanda's prioritisation of the grid impacts mini-grids. For future research studies, grid models and interactions with off-grid technologies could be included in further studies on the IDF and partnership and financing models.

A further area of future study is applying the IDF to a wider subset of the off-grid energy market and programmes in Kenya and Rwanda, to analyse how the IDF can be applied to key electrification programmes and funding avenues in the sector. The IDF, in principle, should apply to the whole energy access sector and while this thesis's focus does not allow for the analysis of all key off-grid programmes in the case study countries using the IDF lens, it singles out key initiatives which these countries have implemented to achieve their off-grid energy access targets. Furthermore, as previously highlighted the selected case studies are illustrative of the types of electrification initiatives that are being adopted in many countries in sub-Saharan Africa, which enhances the applicability of the findings to other country contexts. For example, these findings could be applicable to prominent pan African RBF programmes like the UEF (for strengthening programme design or continuity) or variations of PPPs or programmes like KOSAP being implemented on the continent. Through the example of the KOSAP project in Kenya and the EnDev RBFs in Kenya and Rwanda, this thesis allows for a more granular application of the IDF as it applies at a programme level. For future studies other key sector initiatives including larger grid scale electrification initiatives or changing the unit of analysis to make this focus wider should be explored.

9.5 Summary

This thesis has contributed to the growing literature on the IDF to help operationalise its tenets, with a focus on financing and partnership models like RBF and PPPs for stand-alone solar systems and mini-grids in Kenya and Rwanda. This further builds the wider knowledge base on integrated electrification approaches and models. It highlighted the complexities of integrating private sector off-grid models and existing PPPs into IDF paradigms to facilitate the achievement of SDG 7. The IDF is an important framing for linking viability and universal energy access imperatives, and for analysing key parts of the energy system including the institutions and regulatory oversight that guide off-grid development. This thesis used the IDF to explore and analyse innovative partnership and financing models that have emerged as a response to the challenges and complexities affordable and sustainable electrification models that are both viable and inclusive. The study emphasised the need for long-term thinking around the sustainability and suitability of existing financing models and the need to enhance the longevity of these models through appropriate regulation, financing pipeline, a focus beyond connections but also the sustainability of connections. It furthermore argued for fostering greater synergies and more effective coordination between, private, public and international development actors, to advance individual and collective efforts for universal access. Importantly, this study illuminated the trade-offs that come with transitions to more integrated paradigms including balancing speed and scale of electrification initiatives and the longer term and shorter-term objectives of the power sector.

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Appendix A

UNIVERSITY OF CAPE TOWN

IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Information Sheet & Consent Form

I am a PhD Candidate in Energy and Development at the University of Cape Town. My research explores integrated electrification business models and regulatory approaches that could accelerate universal access to electricity in Rwanda and Kenya.

I hereby kindly request permission to conduct an interview of approximately 60 minutes. A semi-structured interview schedule will be used with guiding questions relating to key thematic areas. Please note that your participation is voluntary. The interview will broadly cover the following themes:

- Integrated business models for grid and off-grid electrification.
- Sustainable financing for electrification business models
- Viability and scale of electrification models and
- Partnerships to accelerate universal access goals: including PPPs.

Audio recording, confidentiality and anonymity

I kindly request your consent to do an audio recording of the interview. The recording will only be used to supplement the notes taken during the interview. The interview will be personally transcribed, and the transcript will be sent to you for an opportunity to comment (if requested). All interview notes, audio recordings and transcriptions will be stored securely and be used exclusively to draw research findings in the manner consented to. Audio recordings and transcriptions will be discarded three years after completion of the study. After transcribing, the data will be anonymised with names and company names omitted, and generic codes used to cite findings in the dissertation and other potential publications emanating from the study.

Name of Participant: _________________________________
Signature of Participant: _______________Date _____________

Your participation is highly appreciated.

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Appendix B: Semi-structured Interview Schedule (Example of Guiding Questions)

Electrification business model viability (Linked to IDF pillar 3: a financially viable business model and RQ1)

1. *What are some of the key factors impacting the viability and scalability of (e.g. your company/utility business model/ business models for the companies you provide finance to) with respect to:*
   - *Mini-grids (micro-grids)*
   - *Off-grid solar systems*

Probing question:

- *Affordability (linked to IDF pillar of inclusiveness)*
- *demand and demand stimulation*
- *the role of tariffs (cost reflective vs grid parity) and subsidies*
- *the role of the regulatory environment (licensing, tariffs, grid arrival compensation, standards for off-grid solar systems)*

Sustainable finance for electrification *(linked to IDF pillar: permanence and external resources)*

2. *How can electrification models be sustainably financed:*
   - *Role of RBF – what are the advantages, challenges and limitations?*
   - *What types of finance (debt, equity, grants) beyond RBF is needed to scale the sector?*
   - *What is the role of DFIs and Development Finance*
   - *Role of subsidies – types of subsidies and sustainability of these subsidies*

3. *How can larger pools of long-term finance be attracted to finance mini-grids and stand-alone solar systems at scale?*
4. *What types of funding is needed for solar home systems and how can the affordability gap be bridged for very low-income households? Solar home system subsidies?*

Public Private Sector Roles, Collaborations (towards Integrated Partnership models) *(Linked to IDF pillar: combination of electrification modes)*

5. How do you see the respective roles of public and private sector players and partnerships in reaching universal access to electricity in Rwanda (and Kenya)?
   - *Role of the utility in electrification (predominantly grid extension?)*
   - *The role of private sector (predominantly off-grid mini-grids and solar home systems?)*
6. What are your thoughts on more integrated electrification approaches where utilities partner with the off-grid sector?
   - *Public Private Partnerships – where utilities develop mini-grid projects or provide solar home systems in partnership with private sector companies?*
   - *Territorial concessions where grid and off-grid technologies are used by the concessionaire, be it the current utility, private companies or both to provide electricity all households within a certain geographic region.*
7. Are market based private sector models for off-grid electrification compatible with a more coordinated and integrated approach, where utilities work in close partnership with off-grid private sector companies?

Appendix C: Interview Codes

	Interviewee Category	Designation	Interview code
1	Ministry of Energy Kenya	Senior representative in Electricity Directorate	ME K1
2	Ministry of Energy Kenya	Senior representative in Electricity Directorate	ME K2
3	Ministry of Energy Rwanda	Senior Engineer	ME R1
4	Utility Kenya	Senior representative/ Company executive management	Utility K1
5	Utility Kenya	Senior representative	Utility K2
6	Utility Kenya	Engineer	Utility K3
7	Utility Rwanda	Senior representative – head of investment	Utility R1
8	Regulator Kenya	Senior representative	Regulator K1
9	Mini-grid developers Kenya	Senior Company representative	Mini-grid K1
10	Mini-grid developers Kenya	Company representative	Mini-grid K2
11	Mini-grid developers Kenya	Company representative	Mini-grid K3
12	Mini-grid developers Rwanda	Head of company	Mini-grid R1
13	Mini-grid developers Rwanda	Manager	Mini-grid R12
14	Mini-grid developers Rwanda	Head of company	Mini-grid R2
15	Mini-grid developers Rwanda	Senior representative	Mini-grid R3
16	International Development Organisations Kenya	Off-grid energy lead advisor	IDO K1
17	International Development Organisations Kenya	Energy advisor	IDO K2
18	International Development Organisation Rwanda	Off-grid energy advisor	IDO R1
19	International Development Organisation Rwanda	Off-grid energy lead advisor – mini-grids	IDO R2
20	International Development Organisation Rwanda	Off-grid energy advisor	IDO R3
21	International Development Organisation Rwanda	Off-grid energy advisor	IDO R4
22	International Development Organisation Rwanda	Manager and 2 company representatives	IDO R5
23	Energy Consultant	Independent energy consultant	EC R1
24	Off-grid solar/ solar home system Rwanda	Off-grid solar company representative/ energy researcher	OGS R1
25	Off-grid solar/ solar home system Kenya	Senior company representative	OGS K1
26	Off-grid solar/ solar home system Kenya	Senior company representative	OGS R2
27	Energy organisation	Company representative	IDO R6
28	Mini-grid association	Senior company representative	Mini-grid association 1

29	Industry organisation Kenya	Company representative	Industry association K1
30	Industry organisation Rwanda	Company representative	Industry association R1
31	Rural Electrification Authority Kenya	Company representative	REA K1
32	Energy expert	Energy expert	EI 1
33	Energy expert	Energy expert – mini-grids	EI 2
34	Energy expert	Energy expert	EI 3
35	Energy expert	Energy expert – mini-grids	EI 4
36	Development partner	Lead advisor	EI 5
37	Development partner	Off-grid energy advisor mini-grids	EI 6
38	Development partner	Partnerships lead	EI 7
39	Development partner	Off-grid advisor	EI 9
40	Energy expert	Energy expert -mini-grids	EI 10
41	Energy expert	Energy expert/energy consultant (follow-up)	OGS R1(2)
42	International Development partners	Off-grid energy advisor (follow-up)	IDO R1 (2)
43	International Development partners	Off-grid lead programme advisor (follow-up)	IDO K1 (2)
44	Energy practitioner	Energy practitioner	EI 8
45	Expert interview	Academic energy expert interviews	EI 11
46	Project Developer	Company representative	RE DEV 1
47	Project developer	Company representative	EI 9
48	Expert interview	Company representative	EI 12
49	Expert interview	Lecturer/utility	EI 12

Appendix D: Interview coding structure – illustrative examples

Initial coding structure applied to first set of interviews (Illustrative coding structure)		
Code	**Example of coded text**	**No of References**
Build-own- operate	The pure private sector model where they do generation, distribution and retailing – everything – financing and all that and it is advantageous in that deployment will be faster and there will be not much conflict between them and the shareholders, because they are fully private, their only shareholders.	15
Demand stimulation	The problem is in these villages we serve there aren't really many anchor loads – there isn't that much existing latent demand because we deliberately chase some of the harder places to demonstrate mini-grids. So, introducing productive loads and driving increased demand is critical to our business model right now.	10
Evolving utility business models	We are revising our strategic plan, we are revising our business model, because remaining with the same traditional business model will not help us in a competitive environment	2
Financing	The entire sector is about trying to create a new asset class of these microgrid portfolios- and de-risk them, to draw in as much private investment as possible – simultaneously convincing the public sector that we are doing the same work as national utilities - and would like subsidy parity - if that happens you would see microgrids explode	24
Grid-off-grid modalities of electrification	We cannot really undervalue the role of micro-grids in universal energy access and the private sector as well. We have to involve the private sector	3
Partnerships	Off-course there are several levels to partnerships that I'd see	9
Regulation - grid arrival	…because the private sector wants to bring in capital into this - then they need to be assured that, particularly in the far-flung areas, when the grid arrives there would be a way integrating so that they are able to recoup their investments.. if the grid gets to where you have your system, it was forcing so many developers, from my previous experience the main grid to the two sites where I worked, we didn't have an option, the only option we had was just to decommission that system, we had to remove the entire system and try to deploy it somewhere else – and we've invested heavily	9
Regulation - New Energy Bill	…Government has also targeting to get to places where there is no grid, in areas where there is no grid, there are private developers, they have mini-grids there, and this is why this need really to get this Bill passed by parliament.	6
Subsidies	And now that the private sector is coming in, sometimes getting that cross subsidy may be very difficult. The private sector will not have that kind of overall billing like Kenya Power and Lighting have. And that is why we are coming up with mini-	23

Initial coding structure applied to first set of interviews (Illustrative coding structure)		
Code	**Example of coded text**	**No of References**
	grids that will have their own tariffs and the tariffs may actually be higher, but if you look at it, what the consumers were paying for their energy needs before the mini-grid arrives, and you do that comparative analysis, you find that the consumer is left better off with the mini-grid..	
Tariffs	I would say it's a big conflict of tariff parity, the thing is where we are installing these mini-grids is also where the government mini-grids are existing. Regarding the tariff we are currently using a cost reflective tariff for mini-grids which is important. This is still supported in the simplified license and the tariff issue is regulated by RURA. However, it's also a policy decision, because it's not at grid parity. [...] It's a political discussion, it's a political decision. For now, its cost reflective, but there is always a threat here that a policy decision can be taken to revert to a grid parity tariff, which	19
Utility business model	The pure private sector model where they do generation, distribution and retailing – everything – financing and all that and it is advantageous in that deployment will be faster and there will be not much conflict between them and the shareholders, because they are fully private, their only shareholders.	1

Example of themes identified from codes and links to IDF framing			
Theme	**Code**	**IDF pillar/sub-pillar**	**Example of coded text**
Trade-offs with partnerships and integration	Partnerships – *open market freedom vs directed development*	IDF Pillar 'Inclusiveness'	The left sites are harder to reach and that is where we now call on the government upon completion of KOSAP, we need to identify these sites and have a structure of supporting the private companies to reach these unreached sites, maybe also the KOSAP participants and the private companies and the participants who will be implementing the KOSAP and now they will be active in these areas and be assisted by the government to be assisted to reach these left out sites

Example of themes identified from codes and links to IDF framing			
Theme	**Code**	**IDF pillar/sub-pillar**	**Example of coded text**
Regulatory certainty and clarity	Regulation - grid arrival	Linked to IDF sub-pillar permanence and long-term version of power sector	…because the private sector wants to bring in capital into this - then they need to be assured that, particularly in the far- flung areas, when the grid arrives there would be a way integrating so that they are able to recoup their investments. if the grid gets to where you have your system, it was forcing so many developers, from my previous experience the main grid to the two sites where I worked, we didn't have an option, the only option we had was just to decommission that system, we had to remove the entire system and try to deploy it somewhere else – and we've invested heavily
Tariff parity conflict and inclusive subsidies	Subsidies	Linked to IDF pillar – 'financially viable business model' and sub-pillar pillar 'inclusiveness'	And now that the private sector is coming in, sometimes getting that cross subsidy may be very difficult. The private sector will not have that kind of overall billing like Kenya Power and Lighting have…
	Tariffs		I would say it's a big conflict of tariff parity, the thing is where we are installing these mini-grids is also where the government mini-grids are existing.