Guiding principles for universal energy access: integrated distribution frameworks and their implementation

by

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M.Sc. in Engineering
École Nationale Supérieure des Mines de Paris, 2016

Submitted to the
INSTITUTE FOR DATA, SYSTEMS, AND SOCIETY
and
DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE IN TECHNOLOGY AND POLICY
MASTER OF SCIENCE IN ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 2021

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Acknowledgments

As I now prepare to embark in the next chapter of my life, I must say that this thesis is the culmination of years of work and personal and professional discoveries that could not have been possible without the presence and unfaltering support of a group of people. My years at MIT remain the most dense, challenging, and enriching years of my life. While it might be hard for me to thank all those who were present with me during this long and inspiring journey, I will give a try.

First of all, I would like to thank Christian de Gromard for never failing to challenge my ideas, making me discover one of the fields that had excited me the most, and being there as a beacon of strength and hope in difficult times. *Thank you Christian!*

I would also like to thank John Hazan for his precious advice and guidance as I navigated MIT and all the opportunities offered to me. Thank you for being there and for your wise words as I went through difficult times. *Thank you, John!*

I would also like thank my advisors, Ignacio Pérez-Arriaga, Rob J. Stoner, and George Verghese. Ignacio Pérez-Arriaga, for his continuous professional and personal support and allowing me to study the ideas that I wanted to explore at MIT. For his patience, understanding, flexibility, patiently listening as I was coming with a number of crazy research ideas that proved more or less promising and fruitful, and always giving me a chance to pursue what I like. And, most importantly, for always being there and supportive in the most difficult times. *Thank you, Ignacio!*

Rob J. Stoner, for believing in me, challenging my ideas, broadening my horizon to new research questions that I had never thought of, and reminding me of all the opportunities that MIT has to offer. *Thank you, Rob!*

George Verghese, for his unfaltering support, his wisdom, and the discussions that we had on a range of very serious topics – from Paris' best cafés to research on Haitian Creole at MIT. *Thank you, George!*

I am forever indebted to the doctors at MGH who saved me and allowed me to understand the real value of life. Thank you very much for your time, your dedication, and having been there. I will never forget what you did for me. *Thank you, MGH!*

I am very grateful to have been surrounded by incredible friends throughout my time at MIT. Thank you to all of you for having been such a source of inspiration and motivation in good and tough times. For showing your passions and love for what you do. For our serious and not-so-serious discussions. In particular, thank you, Sujay, for sharing your expertise in kryptonite synthesis and surviving the heat and humidity of Yucatán with me. Thank you, Marc, for our very insightful discussions and dinners, and having been there in February 2020. And thank you to all my others close friends. I would never have learnt so much about shrimp trading, Pakistani music, the Red Fort of Lahore (oh sorry, I mean the Royal Fort), US fighter jets, the Super Bowl, Tiger King, the art of farming, French politics and philosophy, Old Delhi’s spice market, and so many other things. *Thank you to all of you, dear friends!*

Nothing would have been possible without the unfaltering support of the technology & Policy Program. Thank you, Noelle, for your precious advice as I was pondering possible PhD programs and wasn’t sure of what options to pursue. *Thank you, Noelle!*
Thank you, Frank Field, for your understanding, your flexibility, and helping me navigate MIT. *Thank you, Frank!*
Thank you, Barbara DeLaBarre, for her listening my stories, being so understanding, and always joking about the crazy ideas I was routinely coming up with. *Thank you, Barb!*
Thank you, Ed, for your precious support as I was going through difficult times and for all the fun discussions we had on our respective experiences in US hospitals and the decipherment of ancient languages. *Thank you, Ed! And thank you, TPP!*

These past years would have been very different without the support of Liang Li, who I would like to thank especially. Thank you for being a beacon of humility, a source of inspiration, for challenging my ideas, and showing that the world belongs to those who know what they want and aren’t afraid to chase their dreams *contre vents et marées*. *Thank you, Liang!*

Lastly, and perhaps most importantly, I would like to thank my family for having always been there with me and for me. It is thanks to you and your support that I have made it through these years and that I became who I am now. *Thank you.*

"Στους γονείς οφείλομεν το ζην, στους δε διδασκάλους το ευ ζην."

Μέγας Αλέξανδρος

Guiding principles for universal energy access: integrated distribution frameworks and their implementation

Abstract

Holistic approaches to energy access have the potential to break the current status-quo. They can accelerate energy access efforts, and make universal energy access *possible* through tight coordination among the national grid, mini-grids, and standalone solar systems, and with optimal allocation of technical, human, and financial resources among all three electrification modes. Realizing these benefits requires careful identification of the key bottlenecks in energy access and the design of adequate frameworks based on an integrated approach that includes institutional, regulatory, economic, financial, technical, and operational analysis of the distribution sector.

This dissertation demonstrates how integrated approaches can be applied in practice to advance the universal energy access agenda, through a detailed analysis of the Integrated Distribution Framework (IDF) and possible regulatory vehicles allowing for its implementation. From a study of past and ongoing African experiences in energy access, it shows that the IDF is a prime avenue to address key bottlenecks in distribution sector reforms for universal energy access. To explore the practical feasibility of integrated approaches, this thesis examines the role of concessions as a possible regulatory vehicle for the implementation of IDF. It examines the potential of utility concessions, briefly mentions the role of mini-grid concessions, and concludes with a much more thorough analysis of solar concessions as a promising mechanism to integrate off-grid solar into regulated approaches to energy access such as IDF.

The primary contributions from this work include establishing the strong connection between the concept of integrated approaches to energy access and past and ongoing experiences in Sub-Saharan Africa; the identification of the key high-level institutional, regulatory, economic, and financial challenges facing the implementation of the Integrated Distribution Framework; a review of the potential of territorial utility concessions for the implementation of IDF and outlining possible guidelines to design IDF-like utility concessions for universal energy access; a brief analysis of the limitations of current mini-grid concessions in energy access and the need for further reforms to bring mini-grid concessions into the realm of IDF; an assessment of the role of solar concessions in harnessing the full potential of solar in universal energy access, and the challenges facing planners in the integration of off-grid solar into IDF; finally, a framework for the design and implementation of solar concessions.

This thesis is grounded in a detailed study of past and ongoing African experiences and, to a lesser extent, Latin American and Asian experiences in energy access to inform distribution sector reforms in Sub-Saharan Africa. Most of the insights and recommendations can be generalized and applied to similar contexts.

Thesis Summary

1. Introduction

The electricity access landscape has evolved significantly over the past decade. Decades of efforts and political engagement have recently led to dramatic improvements in electrification rates in several countries - most particularly in South Asia[1]. New off-grid solutions have emerged in the form of mini-grids and standalone solutions and experienced dramatic growth over the recent years, reviving a previously moribund electrification sector. However, despite these positive developments and decades of experience, the world is still not on track to meet the Sustainable Development Goal #7 of universal electricity access by 2030[2].

Past experiences have shown the limitations of siloed grid-, mini-grid, and solar-specific electrification programs[3] and highlighted the importance of holistic and coordinated approaches to energy access making use of all possible electrification modes – i.e. the national grid, mini-grids, and standalone solar systems[4]. However, despite a growing body of literature on power sector reforms in developing countries, on avenues to increase the financial viability of distribution companies, mini-grids, and solar companies, and on possible ways to accelerate grid, mini-grid-, and solar-driven electrification, a scant amount of work has focused on actionable frameworks allowing for the coordinated use of all three electrification modes for universal energy access at a country scale. A few implementation oriented programs cover various facets of an integrated approach to electrification, including financing[5] (e.g., SE4All's proposed Universal Electrification Facility) and business and financing model pilots[6] (e.g., Utility 2.0 in Uganda), but remain at a conception stage and offer little guidance to planners on holistic approaches to electrification.

This dissertation aims to fill this gap through a detailed analysis of actionable regulatory arrangements enabling integrated approaches to universal energy access. Drawing on past experiences in energy access, this thesis first identifies the lack of a coordinated approach to energy access within the three sub-sectors of distribution – namely the national grid, mini-grids, and standalone solar – as the key bottleneck in energy access. It then introduces the Integrated Distribution Framework (IDF), developed by the MIT-Comillas Universal Energy Access Laboratory as a possible high-level blueprint toward universal energy access, and identifies the concession model as a promising regulatory vehicle for the implementation of IDF at scale. The thesis then briefly reviews the potential and need for further research in utility and mini-grid

[1] IEA, IRENA, UNSD, World Bank and WHO (2020), Tracking SDG 7: The Energy Progress Report, https://trackingsdg7.esmap.org/data/files/download-documents/01-sdg7-executivesummary_0.pdf

[2] *Ibid.*

[3] Debeugny *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris.

[4] *Ibid.*

[5] C.f. SE4All Universal Electrification Facility. Details available at: https://www.seforall.org/results-based-financing/universal-energy-facility

[6] C.f. Utility 2.0 in Uganda.

concessions in IDF. It finally concludes by evaluating the potential of concessions for standalone solar-driven electrification, and defining guidelines for solar concessions aiming to harness the full potential of standalone solar and associated business-models within IDF. This thesis focuses on solar in order to fill a growing gap in the existing literature between abundant analyses of subsidy-heavy sectors – namely the national grid and mini-grids – prone to following regulated strategies and the lack of existing literature on standalone solar, more prone to reaching financial viability on its own and therefore less likely to join IDF-like structures without adequate incentives.

The analysis directly builds on the research of the MIT-Comillas Universal Energy Access Laboratory and a set of high-level frameworks for universal energy access developed by the lab. This includes the lab's first framework for integrated electrification, developed as part of the Energy Company of the Future project[7], that paved the ground for the later development of the Integrated Distribution Framework[8]. The key features of Integrated Distribution Frameworks, the challenges facing the design and implementation of IDF-like programs, and the guidelines for "IDF concessions" design build on the lessons learnt from MIT's advisory role for the Rockefeller Foundation-backed Global Commission to End Energy Poverty and academic papers prepared in this context. Paramount among these were the insights gained from the MIT Universal Energy Access Lab's involvement in the design of IDF-inspired power sector reforms in Rwanda (national electrification plan), Uganda (proposal of reform of Uganda's distribution subsector)[9], and Colombia (solar-driven electrification of the last five percent of the country's still unelectrified population)[10].

This dissertation also builds on the author's personal experiences in government, in international organizations, and in the private sector. These experiences, along with frequent interactions with public and private sector executives, have informed the development, together with the MIT Universal Energy Access Lab, of the Integrated Distribution Framework as an umbrella concept encompassing a set of policy guidelines for universal energy access and the later identification of concessions as a possible platform for the implementation of IDF.

Lastly, this thesis places a strong emphasis on Africa and builds on local African experiences to derive broader regulatory guidelines for universal energy access. It briefly mentions international experiences in concessions - and especially in *solar* concessions - in order to broaden the set of

[7] Developed with the support of the Shell Foundation, and later applied to the design and implementation of a new "integrated" utility in Nigeria.

[8] Developed with the Support of the Rockefeller Foundation as part of MIT's involvement as research unit of the Global Commission to End Energy Poverty.

[9] For more details: Pérez-Arriaga, I and Valdés, J.E. (2020), *Consultoría para la identificación y análisis de experiencias internacionales en la aplicación de modelos innovadores de acceso a la energía*, Consultancy Report for the InterAmerican Development Bank and the Colombian Ministry of Mines and Energy, Madrid.

[10] For more details: Pérez-Arriaga, I. (2021), *Stocktaking in the Energy Sector, Electricity Distribution*, The European Union Global Technical Assistance Facility on Sustainable Energy, European Commission, Brussels.

experiences to derive lessons from and complement the African track-record in electricity concessions whenever needed. While the review of ongoing Africa experiences in utility, mini-grids, and solar concessions aims to be as exhaustive as possible[11], the analysis of international experiences does not pretend such exhaustivity and should not be construed as a complete list of concession experiences in developing countries.

The remainder of Chapter 1 provides a brief introduction to the history and current situation of the energy access sector, the class of problems this dissertation aims to address, the contributions of this thesis relative to past and ongoing projects of the MIT-Comillas Universal Energy Access Laboratory, and the thesis outline.

1.1. Introduction to the energy access sector

The past decade has seen unprecedented surges in electrification rates in most developing economies. Between 2016 and 2018, an average of 136 million people gained access to electricity each year, outpacing by nearly 60% the annual world population growth of 84 million over the same period[12]. Off-grid technologies, such as standalone solar systems and mini-grids, have shown promise in bridging the electricity access gap and over 170 million people had access to off-grid systems in 2018[13]. Electrification programs remain however unequal in scale and ambition. The majority of those gaining access every year were limited to under Tier 1 solar systems. Globally, around 19,000 mini grids are currently operating in 134 countries, providing electricity to around 47 million people[14] and servicing less than a third of all off-grid consumers.

Despite recent improvements, international organizations estimate that around 789 million people still live without electricity access in 2018 – among which 70% in sub-Saharan Africa. In addition to unconnected populations, it is estimated that around 600 million people as well as enterprises continue to face unreliable or insufficient electricity access in developing countries. The International Energy Agency estimates that 620 million people will live without access in 2030 – not accounting for the impact of Covid-19 on trends in electrification rates and future investments[15].

Significant challenges have long impeded the expansion of electricity access at the necessary pace and scale to achieve SDG 7 by the stated deadline. Most importantly, a principal challenge has been the lack of investments into the sector to expand access. In 2017, an estimated US$12.5

[11] As of May 2021, and within the limits of the information and data available.

[12] *Ibid.*

[13] *Ibid.*

[14] ESMAP (2019), Mini-grids for half a billion people, https://openknowledge.worldbank.org/bitstream/handle/10986/31926/Mini-Grids-for-Half-a-Billion-People-Market-Outlook-and-Handbook-for-Decision-Makers-Executive-Summary.pdf?sequence=1&isAllowed=y

[15] IEA, IRENA, UNSD, World Bank and WHO (2020), Tracking SDG 7: The Energy Progress Report, https://trackingsdg7.esmap.org/data/files/download-documents/01-sdg7-executivesummary_0.pdf

billion[16] was invested in electrification projects compared to the US$40 billion estimated to be needed annually until 2030[17]. After decades of experience in energy access in low-access countries, and most notably in Sub-Saharan Africa, mobilizing investments at scale is still hindered by financial challenges in the distribution sector as well as the uncoordinated, silo-ed development of on- and off-grid electrification modes, resulting in financially unsustainable and geographically limited electrification programs – the legacy of decades of electrification attempts.

The past fifty years of electrification in Sub-Saharan Africa provide the international community with insights on the design and implementation of successful electrification policies. This chapter reviews the international literature on past experiences and identifies a historical trend moving from state-backed grid-extension initiatives to private sector and solar-driven electrification programs. We demonstrate that reaching universal energy access will require bridging the growing gap between public sector-driven grid extension and private sector-driven off-grid programs under the umbrella of an integrated electrification strategy tailored to each territory and leveraging all possible electrification modes.

1.1.1. The early failure of the "one-solution-fits all" approach

Following Western experiences, African States and Development Finance Institutions (DFIs) engaged as of the 1960's in long-term centralized grid extension projects. The limited results of this approach led to an early questioning of a model that had remained the *de facto* single electrification model until then.

The low priority given by colonial administrations to peri-urban and rural electrification led to overall electrification rates as low as a handful of percent at the time of the independence[18]. Back in the 1960s, newly independent African States faced single-digit electrification rates and an acute — two major bottlenecks for economic and social development. Power grids remained undersized for national consumption and their extension was limited to main urban centers as well as key industrial and mining installations[19,20].

A few countries engaged in early large-scale electrification programs. Convinced that energy access and rural electrification would play a critical role in economic and social development, Tunisia, Côte d'Ivoire and Kenya initiated electrification programs by grid extension or by

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[16] SEforAll (2019), Energizing Finance: Understanding the Landscape 2019, https://www.seforall.org/publications/energizing-finance-understanding-the-landscape-2019

[17] IEA (2020), SDG7: Data and Projections, https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity

[18] Gareth, Astin (2010), African *Economic Development and Colonial Legacies*, International Development Policy, Graduate Institute of International and Development Studies, Geneva.

[19] *Ibid.*

[20] Debeugny, C. *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris.

providing regional centers with small scale grids usually powered by diesel power generators. These initiatives constituted the first national attempts to address the issue of energy access and extended energy access to secondary cities and large villages[21].

However, rural electrification remained at an embryonic stage. The direct application of the Western model proved to be ill-suited to African contexts characterized by a sparse and low demand and the limited ability to pay of rural households — three factors increasing the cost of grid-based electrification and affecting the economic feasibility of electrification through grid extension[22].

1.1.2. The emergence of decentralized solar initiatives

A decade later, the oil shocks of 1974 and 1979 created a new momentum in favor of decentralized renewable energies, and solar energy emerged as a possible solution for rural electrification in developing countries. However, poor institutional arrangements, the high costs of solar, and the lack of local expertise limited solar projects to pilot scales.

Newly invented photovoltaic systems appeared as particularly well positioned to meet low demand levels in small urban centers and remote rural regions. This new technology raised high hopes among African States increasingly aware of the limits of grid-based electrification models. The emergence of solar energy in energy access triggered the development of North-South bilateral cooperation programs, as a handful of European technical agencies engaged actively in the diffusion of these disruptive photovoltaic technologies through technical assistance and grant funding[23].

Due to technological and logistic limitations, the first solar electrification programs were use-specific with direct applications in telecommunication, water supply, irrigation and rural health. Large-scale achievements remained limited to the localized development of irrigation systems in Mali, the installation of a few solar-powered televisions in Nigerian villages, and the installation of solar refrigerators in dispensaries in former Zaïre[24]. Concurrently, a substantial number of solar kits were deployed in African countries with a certain success among wealthy rural families. Nearly 5% of Kenyan and Moroccan rural households were equipped with solar home systems, most often with financial support from the diaspora[25].

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[21] CNRS (2011), Chronologie *évolutive des recherches sur les énergies solaires en France et à l'international*, available at: http://www.cnrs.fr/ComiHistoCNRS/spip.php?article61

[22] *Ibid.*

[23] Debeugny, C. *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris.

[24] CNRS (2011), Chronologie *évolutive des recherches sur les énergies solaires en France et à l'international*, available at: http://www.cnrs.fr/ComiHistoCNRS/spip.php?article61

[25] Liébard, N. (2015), *L'évolution de la politique des énergies renouvelables depuis les années 1970*, CGDD, Ministère de l'Écologie, Paris.

As African countries experienced non-traditional electrification pathways more suited to low-population density and limited power demand, poorly-suited governance arrangements for energy access and the lack of adequate business-models for the diffusion of solar home systems prevented solar projects from reaching scale. Solar products had not yet reached higher levels of cost efficiency and most solar kits and lanterns proved to be too costly for rural households. What is more, reliability issues affected the large-scale deployment of these solutions and led to widespread distrust among rural populations towards what was perceived as deceptive "high-price for low-quality" electrification solutions[26]. Also, most projects focused on setting up initial distribution channels while underestimating the critical importance of a broader issue: the development of *local* value chains for solar electrification. Without adequately trained local stakeholders and long-lasting debt financing, the success of grant-based solar programs proved to be unsustainable and largely rely on the support of international donors—mostly bilateral development banks[27,28].

In hindsight, the development of the first generation of solar projects allowed stakeholders to overcome the western "grid-only" dogma of energy access and to face, for the first time, the issue of multi-system electrification programs involving a range of electrification solutions and public and private stakeholders in remote and low population density locations that could not be reasonably reached by national grid on market terms. However, solar energy remained a marginal energy access solution and its use was limited to complementing national grid-based electrification projects when adequate grant funding from DFIs was available – if any.

1.1.3. The emergence of the first national electrification models

The 1980's and 1990's marked a change in the energy access sector as States recognized the value of integrated electrification strategies departing from grid extension models and tailored to the local demand in each territory. Building on the key lessons derived from the 1960's and 70's, international technical cooperation agencies launched in 1984 the concept of "pre-electrification", paving the way for nation-wide integrated electrification strategies.

The central idea of "pre-electrification" programs was to abandon the "one-size-fits-all" approach and to propose a new approach of rural electrification acknowledging radically different levels of demand by distinguishing several levels of electricity service[29,30,31,32]. The

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[26] *Ibid.*

[27] *Ibid*

[28] Christensen, J. *et al.*, (2012), *Enhancing access to electricity for clean and efficient energy services in Africa*, UNEP Risø Centre, Technical University of Denmark, Roskilde

[29] *Ibid*

[30] Liébard, N. (2015), *L'évolution de la politique des énergies renouvelables depuis les années 1970*, CGDD, Ministère de l'Écologie, Paris.

[31] Iskander, N. (2005), *Innovating State Practices: Migration, Development, and State Learning in the Moroccan Souss*, Industrial Performance Center, MIT, Cambridge.

advantage of this approach was that it aimed at providing electricity *"in little quantity, everywhere and right now"* while traditional national grid extension projects followed the much more ambitious goal of distributing *"potentially important quantities of electricity, but only here and there...and in the very long term".*

"Pre-electrification" programs leveraged a wide range of technological but also organizational innovations such as: (i) a fine analysis of the different services that electrification should provide, before ultimately choosing the most appropriate electrification technology and planning; (ii) the joint analysis of both uses and production of electricity, a practice previously unknown in conventional electrification; (iii) the search for large-scale complementarity between grid extension projects, local mini-grids, and individual PV systems; (iv) the introduction of batteries as possible vector of electricity distribution in remote regions characterized by low consumption levels; and lastly, (v) the introduction of efficient and low-consumption bulbs and portable lights, now affordable to low income households and bringing substantial energy savings[33]. These innovations proved to play a key role in the development of modern electrification programs[34].

Following two "pre-electrification" programs, Morocco launched in the 1990s an emblematic energy access project that highlighted success factors in integrated planning (c.f. **Box 1**). Aiming to achieve "global energy access" — i.e., full energy access at national scale — within 20 years, this first-of-a-kind national program involved on- and off-grid electrification solutions and relied on advanced public service delegation agreements adapted to the specific context of rural electrification. Grid extension and mini grids were developed by the State-owned utility, while well-defined territorial concessions allocated to privately-owned companies, more experienced than the national electricity company (ONE) in the installation and maintenance of solar systems, allowed for the limited diffusion of solar kits on market terms in remote areas. With the support of international DFIs, the Moroccan government and ONE launched in 1994 the Global Rural Electrification Program (PERG)[35]. Careful preliminary planning and sound governance allowed this program to effectively increase energy access rates up from 15% to 95% in less than 15 years[36]. Under the overall project agreement, electrification by grid extension was complemented in remote areas by solar initiatives[37]. However, the success of public service delegation agreements and territorial concessions remained limited to Morocco, where pre-existing

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[32] World Bank (1995), *Photovoltaic Applications in Rural Areas of the Developing World*, ESMAP, World Bank, Washington, D.C.

[33] Debeugny, C. *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris.

[34] Christensen, J. *et al.*, (2012), *Enhancing access to electricity for clean and efficient energy services in Africa*, UNEP Risø Centre, Technical University of Denmark, Roskilde.

[35] A detailed presentation and analysis of Morocco's electrification program is offered in Chapter 5.

[36] Islamic Development Bank (2013), *From darkness to light: Rural electricity in Morocco*, IsDB Success Stories, Islamic Development Bank, Jeddah.

[37] Choukri, K. *et al.* (2017), *Renewable energy in emergent countries: Lessons from energy transition in Morocco*, Energy, Sustainability and Society, Springer Berlin Heidelberg, Berlin.

institutional, financial, and technical frameworks for electrification allowed for a quick implementation of DFI-backed project.

Box 1. Morocco's experience in energy access: Lessons from one of the first integrated program[38]

Almost a decade after the conclusion of the country's electrification program, three key factors seem to have underpinned the success of the Moroccan experience. First, the ability of the national electrification program to leverage all possible electrification strategies, including renewables and off-grid at scale — a major innovation at the time. Second, the careful planning of the electrification program based on extensive pre-feasibility analyses matching demand estimates with various possible supply options for all Moroccan villages by using the computer-based models for the power sector available back then. Third, the ability to leverage all possible sources of funding available for energy access around a transparent and financially sustainable public sector/utility-driven model.

The Moroccan case thus demonstrates that the centralized electrification model, which was used successfully in Tunisia but discarded by the development community in the 1990s, can perform better than traditional rural electrification agency-driven approaches. However, several factors call for prudence as one may be tempted to generalize key success factors for universal energy access in African contexts. Morocco started out with a rural electrification level below those of its comparable neighboring countries - at the outset of the PERG, the rural electrification rate in Morocco reached 14% against 70% to 84% Tunisia, Algeria, and Egypt. The country also had — and seized — the opportunity to exploit a high level of cross-subsidization from urban consumers representing 55% of the country's population in 2000 and more than 70% of Morocco's GDP[39]. The Moroccan experience may well confirm the potential of utility-driven electrification policies, although it seems important not to relate the dramatic increase in electrification to the implementation model *alone*.

While the Moroccan experience allowed local stakeholders to develop advanced skills in the design, implementation and management of off-grid electrification solutions, most state-led electrification programs remained at an embryonic stage. In most countries, projects suffered from poorly informed stakeholders; strong short-term political interference; and more generally, the lack of a clearly-defined and inclusive technical, economic, financial, and institutional framework for electrification. Electrification rates stagnated at low levels and long-term grid extension projects remained the norm by default in developing countries.

[38] C.f. Annex for more details.

[39] World Bank (2018), Kingdom of Morocco, *Governing Toward Efficiency, Equity, Education and Endurance, A Systematic Country Diagnosis*, Washington DC.

1.1.4. Solar as new driver of rural electrification

It is not until the late 2000's that a conjunction of technological innovations reinvigorated a moribund electrification program. The emergence of digital-based businesses and individual solar kits as new drivers of rural electrification have reshuffled the cards of the energy access sector and propelled privately-owned digital off-grid solar solutions to the forefront of universal energy access initiatives[40].

Attracted by supportive regulations, mature solar technologies, and mobile money markets in the late 2000s, a handful of East African start-ups developed a new generation of solar home systems (SHS) providing remote rural markets with sustainable, affordable, and safe electricity on market terms. Usually limited to basic lighting and phone charging, the use of these kits is prepaid by mobile payments allowing companies to significantly reduce the costs associated with bill recovery in remote rural areas, and payments are made on a "pay-as-you-go" (PAYG) basis reconciling affordability and profitability. Specifically, companies set up prepayment pricing schemes based on the usual expense amount traditionally devoted by rural households to traditional energy sources such as kerosene and phone charging. Remote controllers blocking the system once the prepayment balance is spent out—or prolonging (or re-establishing) use after each new prepayment—create strong incentives for rural populations to prepay on time. Lastly, system durability is ensured through a technical warranty and after-sale service covering the whole repayment period, a key factor in establishing a trust relationship between private companies and local populations but also maintaining the profitability of the company's fixed assets[41].

Within less than a decade, digitally financed off-grid solar has transitioned from pilot scale to a substantial sub-sector of the global off-grid energy market. As of 2019, around 5500 PAYG SHS were sold daily in Sub-Saharan Africa independently from public supervision or any national electrification plans[42].

The flexibility of "pay-as-you-go" business models allows solar companies to effectively address major economic and financial constraints of rural populations. By integrating within the same structure, the financial, technical, and operational functions previously split among a wide range of local actors — NGOs, MFIs, and solar product suppliers—PAYG solar business models reduce information asymmetries as well as bargaining and coordination issues, and ultimately increase connectivity along the entire solar value chain[43].

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[40] Debeugny, C. *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris.

[41] Alstone et al. (2015), *Off-Grid Power and Connectivity, Pay-as-you-go Financing and digital supply chains for pico-solar*, Lighting Global, IFC, Washington, D.C.

[42] GOGLA (2019), *Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data*, GOGLA, Utrecht.

[43] Winiecki, J. *et al.* (2014), *Access to Energy via Digital Finance: Overview of Models and Prospects for Innovation*, CGAP, Washington, D.C.

This model allows companies to focus their activities and investments on high-added value parts of the solar business — innovative and extensive low-cost distribution and maintenance channels—and seek the most appropriate capital structure for capital-intensive privately-owned start-ups. The major innovation of PAYG solar initiatives is thus to pursue rural electrification on market terms with high levels of profitability, in sharp contrast with the unattractive records of most traditional actors of the energy access sector. Unsurprisingly, exponential SHS diffusion rates have quickly attracted funding from foundations, international development banks, venture capital, and private equity investment funds at unprecedented levels at the expense of more traditional stakeholders.

So-called "pay-as-you-go" solar companies have now become the fastest-growing electrification actors in the sector, overshadowing the efforts of NGOs and microfinance institutions (MFIs) but also local utilities that have found themselves unable to compete with the dramatic growth of venture-backed private companies developing large-scale solar electrification activities on market terms. Within less than a decade, the private sector thus managed to completely redesign the dynamics of rural electrification by making energy access profitable. Strong political leverage, significant fundraising capabilities, and powerful networks within Western decision-making spheres allowed off-grid solar electrification companies to become among the most prominent actors of the energy access sector, with significant bargaining power in the design of national electrification programs and regulations[44].

In summary, the past fifty years have shown that reaching universal energy access requires approaches tailored to local contexts and demands. While grid extension may become the default electrification mode in the long term, standalone solar systems and mini-grids will fill the gap left by distribution companies (DISCOs) in the next decades until full grid coverage is achieved. The success of the recent business models for solar shows that now the key limiting factors for reaching universal access on the best possible terms are not technological or financing, but the optimal allocation of resources and the structuring of integrated and financially sustainable national electrification programs based on sound reforms of the distribution sector.

1.2. Research statement

To better understand how an integrated approach to distribution such as IDF can be implemented in practice to address the challenge of universal energy access in developing countries, this thesis discusses the potential of concessions as a means to implement IDF on the ground and develops a package of proposed regulatory guidelines for solar concessions. The thesis is not designed to be a comprehensive study of every aspect of concession design, but focuses on key issues identified as frontier challenges in the implementation of IDF and the design and implementation of concessions, and particularly of solar concessions, as a means to apply IDF in the real world. Specifically, this thesis addresses the following research questions:

1. *Are concessions a viable regulatory vehicle for the implementation of IDF? If yes, what*

[44] GOGLA (2017), *Providing Energy Access through Off-Grid Solar: Guidance for Governments*, GOGLA, Utrecht.

are the key challenges in the design and implementation of IDF-like concessions for the national grid and mini-grids?

2. *Are concessions an efficient way to integrate standalone solar systems into integrated distribution frameworks and effectively complement grid and mini-grid-based electrification? If yes, how to structure such concessions?*

This thesis reviews past experiences and shows that concessions could indeed play a major role for the diffusion of solar in areas unreachable by the national grid or mini-grids, provided that extensive long-term regulatory backstops are implemented, balancing universal energy access obligations for solar companies and financial incentives to expand into remote rural markets.

1.3. Thesis Outline

Chapter 2 identifies distribution and the lack of integrated approaches to distribution reforms as the key bottleneck in energy access. It builds on the historical analysis of Chapter 1 to introduce the Integrated Distribution Framework as a possible path toward universal energy access. The chapter concludes with a brief presentation of the major institutional, economic, and financial challenges to the design and implementation of IDF-like policies in practice.

Chapter 3 demonstrates the potential of concessions as a regulatory platform to implement IDF. Starting with a brief overview of the different possible concession models, it reviews past and current experiences in concessions and shows that territorial and utility concessions are both promising and complementary mechanisms for the implementation of IDF, provided that they integrate specific energy access clauses backed by adequate financial incentives.

Chapter 4 briefly examines the issue of mini-grid concessions as one possible avenue to foster coordinated mini-grid development for energy access. It shows the limitations of bottom-up development strategies for integrated planning and argues that while the relative success of mini-grid concessions validates the potential of such regulatory mechanisms to advance mini-grid deployment, more research is needed to integrate mini-grid concessions into IDF.

Chapter 5 demonstrates that integrating solar within regulated frameworks such as the Integrated Distribution Framework will likely prove more challenging that for other electrification modes. It argues that concessions are a promising vehicle to provide incentives and enforce obligations necessary to harness the full potential of solar for energy access in challenging contexts. It concludes with a detailed analysis of two African case studies and derives key success factors in the design and implementation of successful solar concessions.

Chapter 6 provides guiding principles for the design and implementation of solar concessions as a means to implement IDF on the ground. Starting with a description of solar concessions' objectives, it outlines the key regulatory, institutional, economic, financial, and operational features of solar concessions for universal energy access. It demonstrates that solar concessions are effectively a promising regulatory vehicle to harness the full potential of solar and make it fulfill its dual role of *enabling* access in remote areas, and *accelerating* access in regions closer to the national grid or mini-grids without impeding their later expansion, provided that planners balance stringent universal energy access and quality of service requirements with medium to long-term financial and legal incentives.

2. Toward integrated approaches: The Integrated Distribution Framework

Sound reforms of the distribution sector toward a more integrated approach will be paramount to the development of successful energy access strategies. Proper regulatory, business, and financial approaches in the distribution segment are necessary for ensuring adequate investments in networks, metering, billing and customer engagement, thereby directly impacting the number of new services provided and the quality of service.

2.1. An assessment of the core issues facing distribution[45]

In the majority of low-access countries, distribution companies (DISCOs) face significant challenges owing to poor performance and financial unviability[46]. Several key factors have compounded the financial difficulties of DISCOs.

A major issue facing DISCOs is the existence of regulated tariffs that are insufficient to cover the actual costs of supply. Raising tariffs remains politically sensitive given poor reliability levels and the limited quality of the service, both triggering large defection from the grid. Moreover, supply costs are inflated due to widespread technical and commercial losses. A large fraction of the electricity produced is lost due to technical network losses and tampering through illegal connections, or may be unbilled, or ― if billed ― not paid for.[47]

The combination of these factors results in insufficient collected revenues totaling below incurred costs. The resulting revenue deficit then accrues to the vertically integrated utilities or to the unbundled distribution companies. In the general case of state-owned distribution segments, DISCOs are kept afloat through annual public subsidies or, in certain cases, periodic bailout programs whenever the DISCO's financial situation becomes untenable. In a few countries, distribution has been unbundled and privatized, yet the DISCOs continue incurring losses and defaulting on their regulated obligations until the lead investor eventually divests from the distribution company. A third case is that of private firms holding long-term concessions to manage distribution activity in a given territory. Depending on the specific conditions of the concession and how efficiently it is managed, the business model for the concessionaire can be financially viable, even if the incumbent publicly owned utility may not recover its investment costs at the expected rate.

[45] Adapted from Pérez-Arriaga, I., Nagpal, D., Jacquot, G., Stoner, R.J., *Integrated Distribution Framework: Guiding Principles for universal Energy Access*, Global Commission to End Energy Poverty, MIT Energy Initiative, Cambridge.

[46] Kojima, M. and Trimble, C. (2016), *Making Power Affordable for Africa and Viable for Its Utilities*, World Bank, Washington, DC.

[47] *Ibid*.

Whether public or privately owned, a utility under the conditions of financial distress remains structurally ill-equipped to raise capital, and will be forced to limit maintenance and delay capital investments in order to prioritize essential costs, meet regulated obligations, and provide a minimal quality of service. Likewise, a distribution concessionaire, unless mandated and resourced to expand its network, will seek to meet minimum performance requirements while reducing costs and avoiding further investment. As a consequence, DISCOs find themselves trapped into cycles of decreasing reliability, and customer satisfaction, and increasing losses and customer defections.

A second challenge to financing rural electrification is the high cost of electrification programs. Supplying geographically dispersed low-level rural loads is more expensive per connection and kWh compared to urban areas. Per-unit costs further increase in isolated areas far from the existing grid, and introducing cost-reflective tariffs may prove challenging. Corresponding end-user tariffs would have to increase whenever new rural customers gain connection, as charging a cost-reflective local tariff in remote areas is politically fraught and often unaffordable to rural customers. In practice, in the vast majority of low-access countries, tariffs are set below costs and equalized for each category of customers, regardless of their geographic location. Therefore, expanding access in rural areas compounds DISCOs' remuneration deficits.

In these conditions, any attempt to electrify rural areas would result in additional deficits discouraging the DISCOs from expanding electrification. What is more, new low-cost, reliable distributed energy solutions backed by attractive business and financing models now compete with DISCOs in urban and peri-urban areas, eroding the utility's customer base and further compounding their deficit. While these off-grid solutions are the least cost option in many settings and certainly contribute to electrification, they are not a panacea: mini-grids remain unable to break even without grants or significant cross-subsidization from anchor loads, when they exist; and unsubsidized venture-backed standalone system companies only cater to profitable customers and areas, limiting their activities to "low-hanging fruits" in order to maximize profit margins. This legacy of decades of electrification attempts in energy access has led to a status-quo that decision makers should now overcome in order to reach SDG 7 at the earliest possible time.

The viability challenges in distribution and the siloed development of all three electrification modes raise questions as to whether the current electrification paradigm is set to leave behind segments of the population and whether it guarantees the permanence and quality of supply necessary to advance socio-economic development.

While investible approaches have been created for mini-grids and solar home systems, and have successfully mobilized external capital into electricity access[48], there is no comprehensive

[48] SEforAll (2019), Energizing Finance: Understanding the Landscape 2019, https://www.seforall.org/publications/energizing-finance-understanding-the-landscape-2019

framework ensuring that the sum of efforts in on-grid and off-grid will lead to universal electricity access and permanence of supply.[49]

2.2. Toward a unified approach to "integration" in distribution

The concept of integration has recently become a concept of choice, used to characterize a multiplicity of approaches to solving the structural issues facing distribution and accelerating electrification.[50] While past electrification programs have relied on different approaches to integration [51], it is not until the late 2010's that the value of integrated strategies has become recognized by practitioners and decision-makers as a key ingredient for successful reforms of the distribution sector.[52,53]

In practice, diverse organizations and initiatives use the term "integration" with different meanings and in different contexts. Past experiences have shown the importance of at least three levels of integration in distribution[54]:

i) integration of all three modes of electrification — grid extension, mini-grids and standalone solar systems — in dynamic least-cost electrification planning;

ii) integration of all end-customers under a common power supply and with tariff cross-subsidization programs;

iii) integration of the public and private sectors in the distribution sector, with clearly allocated roles and responsibilities, allowing for sustainable financing schemes and mobilization of capital for electrification to proceed at the necessary pace and scale.

Seeking to coalesce all such notions of integration into one broader framework, and further emphasizing the role of distribution in energy access, the next chapter introduces the concept of

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[49] Pérez-Arriaga, I., Nagpal, D., Jacquot, G., Stoner, R.J., (2020), *Integrated Distribution Framework: Guiding Principles for universal Energy Access*, Global Commission to End Energy Poverty, MIT Energy Initiative, Cambridge.

[50] SEorAll (2019), Energizing Finance: Understanding the Landscape 2019, https://www.seforall.org/publications/energizing-finance-understanding-the-landscape-2019

[51] Jacquot, G. *et al.* (2020), *Reaching universal energy access in Morocco: A successful experience in solar concessions*, MIT Energy Initiative Working Paper.

[52] Pérez-Arriaga, I., Nagpal, D., Jacquot, G., Stoner, R.J., (2020), *Integrated Distribution Framework: Guiding Principles for universal Energy Access*, Global Commission to End Energy Poverty, MIT Energy Initiative, Cambridge.

[53] Pérez-Arriaga, I., Nagpal, D., Jacquot, G., Stoner, R.J., (2020), *2020 Report: Energy Access*, Global Commission to End Energy poverty, MIT Energy Initiative, Cambridge.

[54] Pérez-Arriaga, I., Nagpal, D., Jacquot, G., Stoner, R.J., (2020), *Integrated Distribution Framework: Guiding Principles for universal Energy Access*, Global Commission to End Energy Poverty, MIT Energy Initiative, Cambridge.

the Integrated Distribution Framework[55] that embodies a holistic thinking of integration in distribution.

2.3. Formalizing "integration" into one coherent model: The Integrated Distribution Framework

The Integrated Distribution Framework (IDF) departs from the traditional one-size-fits all approach and represents a set of high-level guiding principles that can inform electrification program design and help evaluate ongoing efforts toward universal energy access. The Integrated Distribution Framework has been designed with three main objectives in mind: (i) to provide guidance for integrating energy access into financially sustainable reforms of the distribution sector toward universal energy access, (ii) to foster the emergence of an environment supporting the design and implementation of these reforms, and (iii) to accelerate the pace of electrification to meet SDG7 by 2030[56].

Building on past and current experiences, the Integrated Distribution Framework relies on four pillars[57]:

1. **An explicit universal electrification mandate**. The responsibility for providing universal energy access with predefined quality of supply should fall on well-defined stakeholders.
2. **An integrated and coordinated plan**. Energy access strategies should be based on extensive preliminary planning leveraging all electrification modes — grid extension, mini-grids, and standalone solar systems. Electrification plans should be defined holistically at the national level, leveraging all possible electrification techniques in a timely and coordinated manner.
3. **Economic and financial viability.** Arrangements for universal energy access should provide financial stability of local companies involved in the national electrification plan and preserve public finances. These arrangements will provide legal security to local companies and investors, foster the participation of external investors, and allow for necessary governmental subsidies at scale.
4. **Socio-economic development.** National electrification programs should maximize the socio-economic growth opportunities offered by electrification, linking access with critical public services — e.g., health, education — and priority economic sectors — e.g., water & sanitation, agriculture, and manufacturing.

The Integrated Distribution Framework encompasses diverse pieces of regulatory approaches and business models that have proved successful in several countries under different conditions, but have not yet been put together with the explicit purpose of achieving universal electrification.

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[55] As defined in *Ibid*. The Integrated Distribution Framework has been developed by the MIT-Comillas Universal Energy Access Laboratory.

[56] *Ibid*.

[57] *Ibid*.

It presents principles against which existing electrification program can be assessed, or as guiding principles for new initiatives. The IDF is also a useful framework to guide specific issues such as designing a mini-grid development program or enabling reliable power provision to rural health centers, a topic brought to the forefront by the COVID-19 pandemic [58,59,60].

2.4. Institutional, economic, and financial challenges to the implementation of integrated distribution frameworks

Integrated Distribution frameworks represent a departure from the traditional siloed approach to energy access in developing countries and aims to integrate all electrification initiatives under a broader umbrella. The multi-faceted nature of the integrated distribution framework creates multiple technical and operational challenges but also broader institutional, economic, and financial challenges that planners must face when trying to implement the IDF.

First, implementing IDF will require rethinking the structure of each of the three segments of distribution — the national grid, mini-grids, and standalone solar – and their associated regulatory regimes. This reconsideration of the distribution sector would have two objectives: first, to transform each segment into a dynamic and financially viable sub-sector in a position to contribute to universal energy access at country scale. Second, to harness the full potential for cooperation and coordination among the three segments to accelerate electrification and ensure the proper deployment of each electrification mode wherever makes the most sense from a technical and economic standpoint.

Second, planners should define the type of regulatory regimes, or contracts (e.g., public-private partnerships, concessions) that would enable IDF at scale and ensure the coordination of all electrification efforts. Past experiences have shown that a *laissez-faire* policy, delegating the issue of energy access to publicly and privately-owned utilities without proper incentives and obligations, is insufficient and does not lead to any meaningful increase in energy access[61]. Planners should find a regulatory vehicle (e.g., concession) permissive to all four pillars of IDF.

Third, universal energy access policies are capital-intensive and will require channeling new public and private investments into the energy infrastructure sector in amounts commensurate with the magnitude of the objective. A detailed assessment and breakdown of the costs associated with generation, transmission, and distribution will be necessary. Current estimates,

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[58] *Ibid.*

[59] Pérez-Arriaga, I., Nagpal, D., Jacquot, G., Stoner, R.J., (2019), *Inception Report of the Global Commission to End Energy Poverty*, Global Commission to End of Energy Poverty, MIT Energy Initiative, Cambridge.

[60] Pérez-Arriaga, I., Nagpal, D., Jacquot, G., Stoner, R.J., (2020), *2020 Report: Energy Access*, Global Commission to End Energy poverty, MIT Energy Initiative, Cambridge.

[61] Debeugny, C. *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris.

amounting to yearly financing needs of around $40bn per year until 2030[62], combine the financing needs of generation, transmission, and distribution's financing needs into aggregate numbers[63,64] that do not reflect the very different nature and complexity of each of the three segments and do not account for the specifics of integrated approaches. In particular, a detailed analysis of the costs of distribution reforms, and of the implementation of integrated distribution frameworks, will be necessary in order to create tailored financing mechanisms for universal energy access. As of 2020, yearly investments in generation, transmission, and distribution for energy access remain limited to $7.5bn, around 30% of the yearly needs in distribution only[65].

Fourth, the financial feasibility of IDF will face sovereign debt constraints, and integrated frameworks will likely have to be tailored to local macroeconomic conditions[66]. Under conservative assumptions, a yearly investment of $40bn until 2030 would lead to a nearly 5% increase in Sub-Saharan Africa's average sovereign debt ratio and bring the sub-continent average public debt level to the 50-60% range – a level considered as risky under World Bank/IMF guidelines[67]. Financing mechanisms for IDF should strike a balance between the need for public financing and the necessity of keeping public liabilities within sustainable boundaries. New financing mechanisms and adequate pacing in the implementation of IDF will be necessary in order to safeguard macroeconomic stability and allow countries to harness the long-term economic benefits of public investments in universal energy access.

Fifth, planners implementing integrated distribution frameworks should link energy and industrial policy in order to reap the full socio-economic benefits of energy access. While most energy access projects usual consist in the joint electrification of households and commercial and industrial consumers without overarching socio-economic objective, the economic outcomes of the two types of electrification remain very different. As governments engage in capital-intensive programs with limited fiscal space, universal electrification programs provide governments with an opportunity to foster the development of sectors with a high socio-economic impact, delivering economic dividends over the long term.

Lastly, the application of IDF and design and implementation of new financing mechanisms will require a change in the approach to making energy policy in developing countries. The

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62 SEforAll (2019), Energizing Finance: Understanding the Landscape 2019, https://www.seforall.org/publications/energizing-finance-understanding-the-landscape-2019

63 *Ibid*.

64 IEA (2020), SDG7: Data and Projections, https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity

65 SEforAll (2019), Energizing Finance: Understanding the Landscape 2019, https://www.seforall.org/publications/energizing-finance-understanding-the-landscape-2019

66 Debeugny, C. *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris.

67 World Bank (2013), *Staff Guidance note on the Application of the Joint Bank-Fund Debt Sustainability Framework for Low-Income Countries*, World Bank, Washington, D.C.

fragmentation of the responsibilities among local and international actors has led to a status quo in energy access[68] over the following four-faceted challenges: (i) placing of universal energy access at the top of the political agenda, (ii) identifying the approach to follow to reach universal energy access, (iii) defining the role of local and international stakeholders – such as international organizations ─ in the design and implementation of universal energy access programs, and (iv) creating and implementing adequate mechanisms to finance universal energy access programs. Setting up clear priorities between these four issues among public, private, local, and international stakeholders will be the cornerstone of *actionable* integrated distribution frameworks.

This thesis focuses exclusively on the second challenge, namely the role of concessions as a possible regulatory vehicle in advancing universal energy access through integrated distribution frameworks, leaving the other challenges for further research.

3. Integrated Distribution Frameworks in practice: toward concessions for energy access

Achieving universal access by 2030 will require electrification programs to guarantee universal coverage and minimum quality of supply while respecting all four fundamental principles of the IDF. Although different implementation models are possible, IDF principles posit that a utility-like company or entity will be best positioned to assume a universal energy access mandate with an assured minimum quality of service, provided that local arrangements offer sufficient legal security and safeguard minimum financial profitability levels to attract external capital under long-term arrangements.

In practice, concession contracts would typically offer such security. Among all possible concession models, utility concessions encompassing all distribution modes (grid, mini-grids and standalone solar systems) within a single contract seem the most promising avenue to implement IDF. While concessions have already been tested in a number of Latin American, Asian and African countries, recent technological breakthroughs and the experience derived from past experiences in the design and implementation of concessions may now offer new prospects for concessions integrating a universal energy access target.

The existing literature indicates a mixed record of concessions in stimulating faster rural electrification in Africa. Among the various types of concessions that have been tested out, namely technology-specific concessions (national grid, mini-grids, solar home systems), territorial concessions (where an entity is responsible for the supply of electricity in a given area) and utilities (where an entity is responsible for supplanting the national utility and supplying power at the regional or national scale), those focusing on utilities such as in Uganda, Cameroon, and Côte d'Ivoire have been more successful, achieving improvements in operational

[68] Debeugny, C. *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris.

performance, reduced financial losses, and increased electrification rates. Including explicit energy access requirements within concession contracts has led to the largest improvements in electrification rates[69,70].

Concessions exclusively focused on rural electrification (through specific technologies or zones) have demonstrated mixed results in Sub-Saharan Africa due to several factors, including concession design and the legal security it provides, the level of guarantee of cost-of-service remuneration, and information asymmetry on the nature of demand and real cost of service. What is more, the lack of financial visibility in rural electrification planning has long deterred private sector. However, with the availability of GIS-based integrated planning, cost-effective decentralized energy solutions, and a strong concession design that focuses on viability through cost-of-service regulations (for all modes) and transparent commitment of public financing, an effective utility concession approach can be pursued to increase access and improve services for connected areas, benefiting from the decades of experiences in sub-Saharan Africa, South Asia and Latin America. While these innovations would enable viable concession programs, they however unlikely to remove the necessity for subsidies, critical for the financial sustainability of rural concessions aiming for universal energy access.

Building on a historical review of past concessions, this chapter demonstrates that utility concessions represent interesting implementation platforms for IDF – provided that concessions contracts include universal energy access targets and the necessary technical, operational and financial arrangements.

3.1. The concession model

According to the World Bank, a concession can be defined as "any arrangement in which a firm obtains from the government the right to provide a particular service under conditions of significant market power."[71] While such arrangements "need not involve the private sector, since governments can award concessions to public enterprises," most concessions are usually granted to privately owned firms in order to fill the public financing gap.

Concessions have mainly been implemented in many different forms[72] (c.f. **Fig. 1**) but two predominate. In the *leasing model* (also referred to as *affermage concessif*), the private contractor takes responsibility over the exploitation and maintenance of assets as well as bill recovery while the public sector retains ownership over all existing assets and remains responsible for new investments. In the second important model, corresponding to what could be termed as a strict

[69] Hosier, R., Bazilian, M., Lemondzhava, T., Malik, K., Motohashi, M., and Vilar de Ferrenbach, D.. (2017). *Rural Electrification Concessions in Africa: What Does Experience Tell Us?* Washington, DC: World Bank.

[70] Jacquot, G. *et al.* (2019), *Assessing the potential of electrification concessions for universal energy access: Towards Integrated Distribution Frameworks*, MIT Energy Initiative Working Paper, Cambridge.

[71] Kerf, M., Gray, D., Irwin, T., Levesque, C., Taylor, J., and Klein, M. (1998), *Concessions for Infrastructure: A Guide to Their Design and Award*, World Bank, Washington, D.C.

[72] *Ibid.*

concession agreement, the private contractor is responsible for exploiting, maintaining, and expanding the assets according to pre-defined terms, with the obligation to return all publicly-owned assets to the public sector at the end of the concession period.

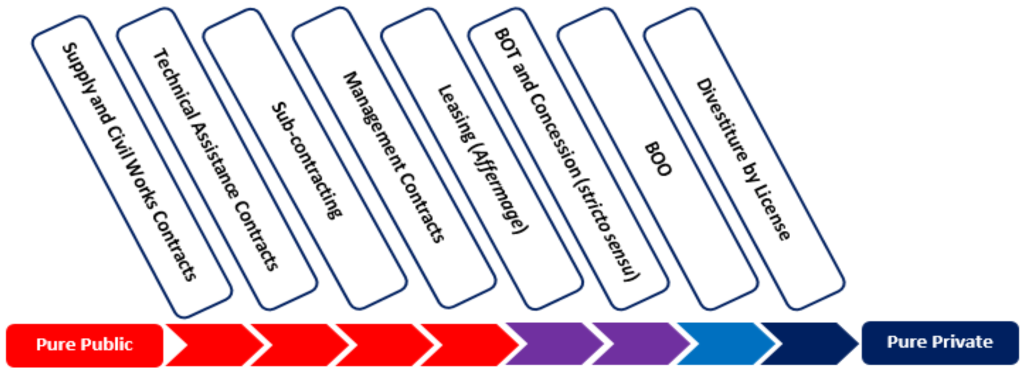

Figure 1[73]. Concession models: a middle ground between pure public and pure private approaches.

Concessions have been tried and tested in various formats in sub-Saharan Africa[74]. In their seminal paper on concessions in Sub-Saharan Africa, Hosier *et al.*[75] identified more than 200 electricity concessions of varying nature and scope in about 15 sub-Saharan African countries, and grouped them into four broad categories: national utility concessions, mini-grid concessions, solar home system concessions, and rural zonal concessions (c.f. **Table 1**). Overall, twelve countries attempted to implement distribution concessions and eventually either cancelled existing concessions or abandoned implementation plans. While utility concessions have yielded mixed to positive results, mini-grid and solar concessions have proven less impactful in the sub-continent[76]. The only sub-Saharan African experience in solar concession, in South Africa, does not allow for meaningful extrapolation to other contexts and more analysis is necessary in order to determine the value of solar concessions.

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[73] Hosier, R. *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C., adapted from Kerf *et al.* (1998)

[74] Jacquot, G. *et al.* (2019), *Assessing the potential of electrification concessions for universal energy access: Towards Integrated Distribution Frameworks*, MIT Energy Initiative Working Paper, Cambridge.

[75] *Ibid*

[76] It is worth mentioning that the track-record of solar concessions outside of Sub-Saharan is more positive. Although developed in a comparatively more permissive environment (higher capacity to pay and larger pool for cross-subsidization), the solar concessions for energy access in Argentina and Peru have yielded very positive results and helped close the electrification gap in remote rural communities. A thorough analysis of past experiences in solar concessions in Latin America is available at:

Pérez-Arriaga, I. and Valdés, J.E. (2020), *Consultoría para la identificación y análisis de experiencias internacionales en la aplicación de modelos innovadores de acceso a la energía*, Consultancy Report for the InterAmerican Development Bank and the Colombian Ministry of Mines and Energy, Madrid.

Among all possible models, and as opposed to electrification mode-specific concessions, utility and territorial concessions offer a legal and financial security permissive to the idea of integrated distribution frameworks with the potential of encompassing within one single umbrella structure all possible electrification modes. These two concession models will be the focus of the next chapters.

Table 1. Overview of the four types of rural electrification concessions[77]

Concession type	*Typical Scale (number of connections)*	*Target zone*	*Power source*	*Electrification technology*
Utility concessions	100,000 or more	Urban and rural	Large, centralized power stations	All possible technologies
Mini-grid concessions	100–10,000 customers	Rural	Small integrated generation and distribution networks (in some instances operated as localized distribution utilities selling power from the national grid)	Mini-grids
Solar home system concessions	5,000–30,000 systems	Rural	Solar home system	Isolated solar home systems
Rural zonal concessions	5,000–30,000 to begin with, with the intent that they could grow beyond that size	Rural	Various: large, centralized power stations, small isolated generators, or solar home systems	All possible technologies

3.2. Territorial concessions: lessons learnt from the Senegalese experience[78]

Territorial concessions have experienced limited traction over the past years and Senegal remains the first and only well-documented case of application in sub-Saharan Africa. Despite being

[77] Adapted from Hosier, R. *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C.

[78] Sources:

Ibid.

Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: Senegal, Report to the World Bank*, Castalia Advisory Group, Paris.

Shanker, A. *et al.* (2012), *Accès à l'électricité en Afrique subsaharienne: Retours d'expérience et approches innovantes*, Agence Française de Développement, Paris.

considered as mixed at best[79], the seminal case of Senegal shows the potential of territorial concessions for energy access, provided that proper coordination arrangements are made between the national utility and actors responsible for mini-grids and solar home systems.

3.2.1. Review of Senegal's territorial concession program

The objective of the Senegalese concession program was to leverage private sector resources to electrify areas identified by the electrification agency ASER as poorly or not served by the national utility SENELEC. After the initial identification of the target zones in 2003, calls for bids were launched as of 2004, the first concessions were awarded in 2008 and became operational in 2011, almost a decade after the launch of the program. Out of the original 10 zones, six were still operational and three had already started connection programs as of 2015. Senegalese companies were prevented from bidding and all concessions were awarded to foreign utilities (Morocco's ONEE, Tunisia's STEG, or France's EDF) or producers of renewable energy equipment (such as ENCO/Isofoton).

Each concession was designed to be technology-neutral and to comprise 10,000-30,000 households in order to guarantee minimum economies of scale to contractors. Concessionaires were free to use any electrification strategy to meet pre-determined connection and service quality targets. The concessionaires had the obligation of charging cost-reflective tariffs based on their own costs of operation and maintenance for *each* technology deployed and special offtake prices were negotiated in order to purchase electricity from SENELEC whenever electrification would be grid-based. Subsidies were only allocated for initial investment, while operation and maintenance costs had to be entirely covered by the tariffs negotiated with the regulator. Hardware replacement would also be entirely covered by the concessionaire. The specifics of the Senegalese concession program are detailed in **Table 4**.

[79] Hosier, R. *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?* World Bank, Washington, D.C.

Table 4. Overview of the territorial concession model adopted in Senegal since 2003[80,81]

What is concessioned?	*25-year rights to provide electrical service within a defined area.*
General obligations on the concessionaire	Design and build the installations, maintain and renew the equipment. Perform electrical installation for new customers. Provide services for at least six hours per day (7 pm–1 am). Recover tariffs from users and be responsible for the operation of assets.
Specific obligations related to electrification	Concessions are awarded on the basis of the number of households that the private parties propose to electrify in the first three years of the concession. The winning bidders have contractual obligations of 7,500-27,000 connections each.
Main sources of finance for investment	The government provides significant up-front funding of capital costs. In Senegal, the share of private financing ranges from 22 to 68 percent of the total financing.
How costs are recovered	Concessionaires must recover their investment costs and the costs of ongoing operations and maintenance through their tariffs.
How tariffs are set	A tariff system is agreed with the regulator (CRSE). For small residential subscribers, the tariff is fixed depending on the number of lighting and power outlet points. For subscribers who require more power, billing is done according to measured consumption.
Type and extent of subsidy	The concessionaires receive a subsidy from the rural electrification agency (ASER) for a portion of their initial investment cost. They do not receive a subsidy of their ongoing operation and maintenance costs.
How the concessions are awarded	The concession contract is awarded following an international tender. The winner is the operator that proposes to connect the largest number of households during the concession's first three years, in return for a pre-determined output-based subsidy.
Why Senegal chose this model	Senegal has attempted several times to increase private sector participation in electricity so as to reduce the burden on the state of subsidizing the operations of the national utility, SENELEC.

3.2.2. Lessons learnt and application to IDF

The Senegalese concession program demonstrates that territorial concessions are unlikely to succeed without extensive and comprehensive planning, tight cooperation between public and private stakeholders, and the design of sustainable subsidization mechanisms tailored to each electrification mode.

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[80] From *Ibid*.

[81] Shanker, A. *et al.* (2012), *Accès à l'électricité en Afrique subsaharienne: Retours d'expérience et approches innovantes*, Agence Française de Développement, Paris

First of all, while successful in attracting private capital, the zonal concession program fell short of its electrification targets (c.f. **Table 5**). Unable to purchase electricity from the grid, facing limited economies of scale in remote rural areas, and given the limited viability of mini-grids at the time, concessionaires realized nearly 60% of their connections through solar home systems.

Several issues hampered the development and implementation of Senegal's concessions: the lack of least-cost planning tools; the absence of operational expenditure-based subsidies to ensure the affordability of costly off-grid solutions; the preparation stage lasted for almost a decade and concessionaires struggled to determine minimum-cost strategies within their areas of operation; tariffs were solely based on the technology used in a given household, preventing cross-subsidization schemes between urban and rural areas; moreover, SENELEC engaged reluctantly into the concession program and refused to sign offtake agreements, thereby limiting the ability of concessionaires to pursue grid extension programs.

Table 5. Status of currently operating territorial concessions in Senegal as of 2015[82,83]

Name	***Targeted number of connections***	***Actual number of connections***	***Total value of concession investment ($ million)***	***Private share of investment costs (percent)***
Dagana-Podor-St. Louis (COMASEL-ONEE)	19,574	2,367	18.36	67.8
Kaffrine-Tamba-Kedougou (ERA-EDF)	18,001	1,194	13.46	36.2
Louga-Linguere-Kebemer (COMASEL-ONEE)	11,826	165	15.64	22.5

The Senegalese territorial concession program yields several lessons on the design and implementation of large-scale and technology-neutral concessions:

(i) Cooperation between concessionaires and local utilities is key. The SENELEC proved unwilling to coordinate with contractors while extending its assets and did not sign off-take agreements to provide concessionaires with electricity, rendering grid extension-based projects unfeasible in most regions.

(ii) Planners should expect a lengthy concession design phase and dedicate extensive financial and human resources to the planning and implementation stages. Senegal was

[82] Adapted from Hosier, R. *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C.

[83] Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: Senegal, Report to the World Bank*, Castalia Advisory Group, Paris.

first in developing territorial concessions and the connections took place nearly ten years after the inception of the program without any least-cost plan.

Sustained political support is absolutely critical to ensure that electricity access remains at the top of the country's agenda during the entirety of this planning stage. In Senegal, informal negotiations between regulators, electrification agencies, and SENELEC limited the leverage of international companies in negotiating stable and favorable agreements.

(iii) Cross-subsidization mechanisms between electrification modes will be necessary to cover the viability gap and increase electricity services' affordability without impacting the profitability of the concessions themselves. In Senegal, mini-grid and solar operators proved unable to reach the expected number of households due to cost-reflective tariffs that were unaffordable to rural inhabitants.

With hindsight, by placing energy access at the center of concession agreements, territorial concessions could offer an interesting baseline for IDF, provided that the aforementioned stakeholder cooperation and subsidization mechanism hurdles are addressed. In practice, two decades after the onset of the Senegalese concession program, substantial changes in the energy access sphere may facilitate the implementation of territorial concessions for IDF. First of all, the advent of GIS-based geospatial planning tools facilitates the planning of territorial concessions by defining the optimal electrification mix and anticipating possible coordination issues between grid, mini-grid and solar operators. What is more, the solar sector has transitioned from a grant-based sector in the early 2000's to a venture-backed sector able to expand into remote rural areas unreachable by the grid or mini-grids, provided that adequate subsidization schemes are in place to cover higher O&M costs[84].

While territorial concessions do offer a promising baseline for the application of IDF, their energy access focus comes at the expense of a possible increase in the number of operators involved on the ground and increased coordination issues – as demonstrated by Senegal's case. The next section moves to a second model, utility concessions, and their potential application to IDF.

3.3. Utility concessions: A promising model yet to be opened to energy access

Utility concessions offer a possible and non-exclusive alternative to territorial concessions. By building on the experience and asset base of an incumbent DISCO to spearhead the electrification process — if needed, with the support of external partners and sub-concessionaires — utility concessions offer a possible solution to the coordination issues plaguing territorial concessions. Such concessions also offer an ideal platform for the implementation of IDF at scale, provided that they include explicit and binding energy access clauses.

[84] Debeugny, C. *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris.

In practice, while utility concessions do offer potential for scaling up private investment in distribution and improving the financing and operational performance of distribution companies[85], experiences in utility concessions in low-access countries remains very limited – mainly to the African context.

Tata Power DDL (TPDDL) is one of the few utility concessions implemented outside of sub-Saharan Africa[86]. Awarded a 25-year concession to supply around a third of India's national capital from 2001, TPDDL leveraged financially sustainable remuneration clauses in the concession agreement to engage into massive investments, which resulted in significant improvements in the quality of supply. Between 2001 and 2017, TPDDL committed nearly $1bn to upgrading its infrastructure, reducing distribution losses by 85%, increasing its network length by 128%, and reducing waiting times for new connections, meter replacement, and bill complaint resolutions[87,88]. The increasing quality of supply, along with a high population density in TPDDL's concession territory, allowed for the quick increase in the customer base, up from 700,000 in 2001 to 1.6 million customers in 2017[89]. Most importantly, these achievements came along with significant financial gains and the company has recorded financial profits since 2010[90].

In practice, while the Indian case does indicate the potential of utility concessions to revive ailing DISCOs, the purely urban scope of TPDDL's area of operation, the high population density of Delhi, the ability of the Indian government to guarantee stable and adequate subsidies to cover TPDDL's cost-reflective tariffs, and TPDDL's ability to negotiate financially comfortable remuneration terms all render the utility's experience in concessions unique and not directly transferable to more challenging contexts. The next sections review in more details the four ongoing utility concessions in sub-Saharan Africa and demonstrates the applicability of the utility concession model to IDF in challenging environments provided that adequate regulatory safeguards are implemented to enforce universal energy access clauses, along with adequate financial incentives.

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[85] Pérez-Arriaga, I., Stoner, R.J., Nagpal, D., Jacquot, G. (2019), *Inception Report of the Global Commission to End Energy Poverty*, Global Commission to End of Energy Poverty, MIT Energy Initiative, Cambridge.

[86] The utility concession model has been used in various Indian cities such as Agra, Ahmedabad, Jaipur, Kolkata and Mumbai. For more information for distribution franchises in India:

Mukherjee, M. (2014), *Private Participation in the Indian Power Sector, Lessons from Two Decades of Experience*, Directions in Development, World Bank, Washington D.C.

Brookings India (2019), *India's Power Distribution Sector: An assessment of financial and operational sustainability*, Brookings India, New Delhi.

[87] *Ibid*.

[88] TPDDL (2020), Annual Report (2019-2020), TPDDL, New Delhi.

[89] Pérez-Arriaga, I., Nagpal, D., Jacquot, G., Stoner, R.J. (2019), *Inception Report of the Global Commission to End Energy Poverty*, Global Commission to End of Energy Poverty, MIT Energy Initiative, Cambridge.

[90] *Ibid*.

3.3.1. Review of ongoing utility concessions in Sub-Saharan Africa

Four national utility-scale concession programs have been implemented in Sub-Saharan Africa and were still in operation in 2015 in Cameroon (ENEO), Côte-d'Ivoire (CIE), Gabon (SEEG), and Uganda (Umeme). All four were implemented with the idea of relieving the public sector from the burden of inefficient state-owned electricity utilities and to draw on private financial, technological, and financial resources and experience to revive ailing distribution sectors by improving sector performance and ensuring financial viability (c.f. **Table 6**). ENEO, CIE, and SEEG are all vertically-integrated utilities with substantial public ownership, while Umeme is exclusively involved in the distribution sector. Although the overall experience proved positive with regard to the revitalization of previously financially unsustainable utilities, none of these concessions was implemented to accelerate energy access, and their impact on electrification might be limited to date[91]. However, the resilience and flexibility of the utility concession model leaves ample room for adjustments and integrates energy access into well-designed concession agreements without compromising on financial sustainability.

Interestingly, Hosier *et al.* record that nine other sub-Saharan countries have attempted — although unsuccessfully — to implement electric utility concession programs and still have not abandoned the idea, which confirms the difficulty of implementing efficient and financially sustainable concessions. Most utility concession experiences remain undocumented. However, the limited amount of information available shows that most of these attempts failed at the inception stage during negotiations over tariff increases and the implementation of cost-reflective tariffs along with targeted subsidies.

[91] Hosier *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C.

Table 6. Overview of the typical structure of national utility concessions[92]

What is concessioned?	The right to operate an existing distribution grid to sell power to customers, collect revenue from customers, and extend the grid within the service area.
General obligations on the concessionaire	Providing electricity that meets specified power quality, reliability, and customer service standards. Maintaining assets and hand them back in good condition at the end of the concession. Employ staff of the state-owned utility.
Specific obligations related to electrification	Connecting everyone within a pre-defined distance from the grid There are often additional obligations related to extending the grid. These may be to connect a specified number of people in the service area (e.g., in Gabon) or to take over and operate grid extensions financed and built by a rural electrification program (e.g., in Cameroon).
Main sources of finance for investment	Predominately privately financed. The owners invest equity in the concessionaire, which is usually a special purpose vehicle. The concessionaire (that is, a company set up specifically to operate the concession) also brings in commercial finance in the form of long-term debt, both from commercial banks and international finance intermediaries.
How costs are recovered	Operating and maintenance costs, the cost of purchased power, and a return on capital invested are usually recovered fully through the tariff, with notable exceptions.
How tariffs are set	The concession contract establishes a tariff regime and allows for periodic revisions. Public entities involved in the determination of this tariff regime have limited discretionary power and disagreements about the tariff can usually be appealed to international arbitration.
Type and extent of subsidy	Tariffs are often uniform for a same customer type, leading to implicit subsidies. Additional cross-subsidies toward low-use residential consumers are common. Direct output-based payments from government to cover the costs of new connections for poor households are sometimes provided. Government may build lines into new areas and hand them over to the concessionaire for operation and in-fill electrification or densification. In some cases, governments absorb part of the cost of purchased energy or fuel costs in order to reduce tariffs for all customers.
How the concessions are awarded	Through international competitive bidding.
Why governments have chosen this model	The main motivation has been to solve finance and service problems with a state-owned utility. Often this has occurred when losses at the utility level have contributed to an unsustainable fiscal position due to periodic bailouts.

[92] Adapted from Hosier *et al.* (2017). This table builds on past experiences in utility concession to establish a "template" outlining the key features of utility concessions.

In Cameroon**,** the utility concession was awarded to the privately-owned consortium AES SONEL (ENEO since 2014) for 20 years in 2001[93]. The privatization of the Cameroonian power sector under a utility concession model has led to the revitalization of the distribution segment. Annual performance targets pertaining to operational efficiency, reduction of losses, and network extension have been met while the financial viability of the company has been consistently maintained over the past two decades[94]. Maintaining the concession in operation has required significant public involvement. ENEO's viability, guaranteed by cost-reflective tariffs that remain one of the highest in Sub-Saharan Africa, is further safeguarded by increasing public subsidies aiming at filling the gap between electricity tariffs and rising operational costs[95]. Significant tension has emerged over tariffs and the concession agreement was renegotiated three times in 2006, 2011, and 2015 at ENEO's request in order to update electricity tariffs and subsidy schemes[96].

Cameroon's approach to energy access has been singular. While the concession contract originally set mandatory annual connection targets — leading ENEO to focus on urban and peri-urban connections, regional energy access targets were later defined. In order to avoid affecting ENEO's financial viability, grid extension is financed by the rural electrification agency (AER in Cameroon) and assets are later returned to ENEO, which can then densify connections before AER proceeds to new extensions. The development of mini-grid concessions remains embryonic as high tariffs have remained politically unacceptable for the local regulatory agency to date[97].

Regarding Côte d'Ivoire, the concession was awarded to CIE (or *Compagnie Ivoirienne d'Electricité*) to operate the assets of the vertically integrated power utility for 15 years in 1990 and renewed for another 15 years in 2005[98]. As in Cameroon, energy access projects remain almost exclusively financed through public funding, thereby allowing CIE to focus on the operation, maintenance, and upgrade of its current asserts and safeguarding CIE's long-term financial stability[99].

As for Gabon, the concession contract was awarded to SEEG (or *Société d'Energie et d'Eau du Gabon)* for 20 years in 1997. A decade of preparation of the institutional, financial, and operational aspects of the concession agreement have allowed the country to operate on a single

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[93] Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: ENEO Concession Cameroon, Report to the World Bank*, Castalia Advisory Group, Paris.

[94] *Rapports annuels* (2013 to 2017), ENEO, Douala.

[95] Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: ENEO Concession Cameroon, Report to the World Bank*, Castalia Advisory Group, Paris.

[96] *Ibid.*

[97] *Ibid.*

[98] Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: ENEO Concession Cameroon, Report to the World Bank*, Castalia Advisory Group, Paris.

[99] Hosier *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C.

contract without major revision for nearly 20 years[100]. SEEG's financial sustainability is ensured by the company's ability to charge annual revised tariffs in most regions and to benefit from public subsidies for "social customers" — for which tariff increases are capped at 1%[101].

SEEG's electrification mandate is confined to its concession perimeter, which extends within 400 meters of the existing grid—a limited commitment that contributed to the good financial state of the utility[102]. Long-term investments in grid extension whose payback period exceeds the duration of the concession are the responsibility of the public sector, which then returns assets to the utility and reassesses the new extension of the concession perimeter. This strategy has allowed the utility to connect 98% of customers in urban areas where densification of the existing grid within the concession area is cheapest and to increase the overall electrification rate from 74% to 89% between 2000 and 2012, against a mere 45% access rate in rural areas. The remaining 3,000 villages unserved by the grid are considered as outside of the utility's perimeter of action.

Uganda's concession was awarded to Umeme Limited — a special purpose vehicle spearheaded by Eskom, Globeleq, and Actis — for 20 years in 2004 with the support of the World Bank and the Multilateral Investment Guarantee Agency[103]. Umeme accounts for 95% of the country's distribution network, while small-size grid and mini-grid concessions account for the remaining 37,000 customers[104]. Uganda's case differs from the previous three in the sense that the national utility operates in a fully unbundled power sector and in a common law country (as opposed to French law in Cameroon, Côte d'Ivoire, and Gabon).

The main objective of the concession was to relieve public finances by revitalizing the distribution sector through loss reduction and increased bill recovery rates. Umeme's case is traditionally considered as a successful concession experience in Sub-Saharan Africa with regard to the transformation of an ailing State-owned utility into a profitable business able to meet service stringent quality requirements.System losses fell from 38% in 2005 to 16% in 2019 and bill collection rates increased from 80% to 99.7% over the same period[105]. While access to financing and good practices explain this success, the absence of an electrification requirement in the concession agreement may have helped in Umeme's development by setting a focus on the

[100] International Finance Corporation (2010), *Gabon: Société d'Energie et d'Eau*, Public-Private Partnership Stories, IFC, Washington, D.C.

[101] Tremolet, Sophie (2002), *Multi-Utilities and Access*, Public Policy for the Private Sector, World Bank, Washington, D.C.

[102] World Bank (2015), *Gabon: Access to Basic Services in Rural Areas and Capacity Building Project*, World Bank, Washington, D.C.

[103] Hosier *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C.

[104] Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: Uganda, Report to the World bank*, Castalia Advisory Group, Paris.

[105] Umeme (2019), *Annual Report 2019*, Umeme, Kampala.

upgrade of pre-existing infrastructure rather than on cash-intensive and low-margin rural electrification.

Umeme's responsibility in energy access is limited to its concession zone, which extends within 1km of the existing grid[106]. The extension of the grid into rural areas is currently financed by public entities—mainly the Ugandan Rural Electrification Agency (REA) —and assets are later transferred to local concessionaires[107].

In Cameroon and Côte d'Ivoire, public investments are later transferred to the utility and the fragmenting of the distribution sector resulting from the large number of concessionaires has led to duplication of efforts and limits the potential for economies of scale.

Uganda's electrification rate followed a slow but steady upward trend, up from 9% in 2000 to 43% in 2018[108]. Around a third of Umeme's new connections have been made in rural areas[109].

3.3.2. Lessons learnt and application to IDF

Utility concessions offer a very promising baseline for the implementation of IDF by placing distribution assets under a single umbrella structure and a clear, long-term contract, ensuring the financial viability of the DISCO's operations. While such financial stability has always been achieved at the expense of electrification so far, past experiences show that concessionaires in Cameroon, Cote d'Ivoire, Gabon, and Uganda have proved willing to engage in energy access provided that adequate financial frameworks were implemented.

Four key lessons[110] could be derived from their experience and prove helpful in the design of future concessions for universal energy access:

(i) Utility-scale concessions were not designed to address the challenge of energy access but could prove resilient and flexible enough to accommodate IDF requirements – universal access in particular — and serve as an umbrella coalescing all electrification means under one leading vehicle. The experience of the four aforementioned countries shows that utilities were both willing and able to expand their concession area and engage into well-defined electrification programs within their area of action provided that adequate financing mechanisms were implemented.

(ii) Successful utility concession agreements should integrate the universal energy access mandate without compromising on the financial health and increased performance of

[106] *Ibid.*

[107] Hosier *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?* World Bank, Washington, D.C.

[108] World Bank World Development Indicators (accessed on March 11th 2021)

[109] Hosier *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?* World Bank, Washington, D.C.

[110] As determined by Hosier *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C.

the concessionaire and on macroeconomic stability and public debt. Energy access targets should be defined in a holistic manner entailing both connections and quality of service. Electrification should then be pursued concurrently with pre-defined profitability requirements and minimal financial sustainability levels. New blended finance models will be needed in order to provide concessionaires and public agencies with the right types and amounts of grants, debt, and equity best able to support cash-intensive electrification programs on the basis of pre-agreed electrification clauses attached to the concession agreements.

(iii) Utility concessions are compatible and complement territorial concessions. Territorial concessions allow for a greater focus of public and private investments into a well-defined territory at the expense of possibly more challenging coordination issues among a variety of stakeholders. On the other hand, utility concessions trade energy access for greater financial viability and greater coordination of all energy access efforts under the leadership of one single authority. Therefore, a key lesson from past experiences is that a territorial utility concession could, at least from a theoretical standpoint, strike a middle ground between the two options and leverage a DISCO's resources and asset base to expand energy access into target territories under stringent public-private partnership contracts.

(iv) Echoing the lesson derived from the Senegalese experience, political support plays a key role in the design and implementation of resilient concessions. Such support will prove all the more important if energy access becomes part of concession agreements and fosters further institutional, financial, and operational cooperation between public and private stakeholders. The major advantage of national utilities over smaller-scale concessions is their negotiation power over public institutions and ability to set up more favorable conditions best able to support financially sustainable frameworks for action.

Overall, territorial and utility concessions have the potential to revitalize distribution by both reviving ailing distribution companies and empowering utilities to implement IDF. However, both concession models assume that the operator(s) would be able to leverage all possible electrification modes to achieve universal energy access. In practice, while grid extension has long remained the natural focus of concession programs, the concrete avenues to integrate off-grid solutions (mini-grids and solar systems) into concessions remain unclear. This thesis briefly reviews mini-grid concessions next (chapter 4) and paves the ground for future research on the application of mini-grid concessions to IDF. It then focuses on a much more thorough analysis of the most dynamic segment of the off-grid sector, namely solar, and the design of solar concessions as part of IDF (chapter 5).

4. Mini-grid concessions: the way toward IDF?

Mini-grids are now recognized as an important pillar of an integrated approach to reach universal electricity access by 2030. [111] They strike a middle ground between the two other electrification modes, extending grid services to remote rural areas unlikely to be electrified by the national grid in the medium term while providing a comparatively higher capacity and cheaper supply than off-grid solar systems.[112] The role of mini-grids in energy access has been extensively studied, including their cost structure, possible business models, policy and regulatory challenges, and financing needs.[113,114,115,116]

In practice, while past experiences have shown that mini-grids do need a supportive regulatory environment to thrive and achieve financial sustainability, the current minimalistic regulatory approach to mini-grids is unlikely to support long-term universal energy access goals. Subject to light-handed regulation (if any), the deployment of mini-grids under this kind of arrangement have proven both flexible and timely, with obvious advantages for the yet unserved population[117]. However, with a limited track record, concerns may arise about the coordination with DISCOs and the long-term inclusiveness and permanence of most mini-grid programs – provided that they already achieved initial financial viability in the first place.[118]

Tight regulatory frameworks such as concessions seem well suited to bringing mini-grids into a long-term planned and coordinated approach to energy access such as IDF. A mini-grid concession would aim at providing service to settlements where demand is limited and the costs of extending the national grid to the area either are prohibitively high or cannot be financed in a timely manner. Most mini-grids remain small and operate in remote areas, where they generate and distribute power for sale to local consumers.[119]

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[111] Nagpal, D. and Pérez-Arriaga, I. (2020), *Integrating isolated mini-grids with an IDF-compliant regulated distribution sector: A long-term perspective towards universal electricity access*, Global Commission to End Energy poverty, MIT Energy Initiative, Cambridge.

[112] *Ibid.*

[113] *Ibid*.

[114] World Bank (2019), *Mini-grids for Half a Billion People: Market Outlook and Handbook for Decision Makers*, World Bank, Washington, D.C.

[115] IRENA (2018), *Policies and regulations for renewable energy mini-grids*, IRENA, Abu Dhabi.

[116] IRENA (2019), *Innovation landscape brief: Renewable mini-grids*, IRENA, Abu Dhabi.

[117] Nagpal, D. and Pérez-Arriaga, I. (2020), *Integrating isolated mini-grids with an IDF-compliant regulated distribution sector: A long-term perspective towards universal electricity access*, Global Commission to End Energy poverty, MIT Energy Initiative, Cambridge.

[118] IRENA (2018), *Policies and regulations for renewable energy mini-grids*, IRENA, Abu Dhabi.

[119] Hosier *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C.

Two types of concessions have been experimented for mini-grids: bottom-up concessions where governments and rural electrification agencies call for proposals to electrify unspecified areas at a certain service standard offering some financial support – for instance on a per-connection basis – and top-down concessions in which governments and agencies involved in energy access planning pre-define the concession areas and invite proposals under prescribed conditions.

While bottom-up approaches have led to a scattered and uncoordinated development of mini-grids, their success at the pilot scale demonstrates the potential of mini-grids under well-defined top-down electrification planning frameworks, provided that adequate regulatory and institutional arrangements are made to balance universal coverage within a territory and financial viability, while anticipating the terms and conditions of a later connection to the national grid.

4.1. Mini-grid concessions: a bottom-up approach

The development of most mini-grid concessions has long followed an informal, or "bottom-up" model[120]. Once adequate frameworks and subsidy models have been established by public agencies such as a consortium of ministries and the local rural electrification agency, projects are proposed, evaluated, and approved by public authorities. Interestingly, no national plans mention targeted areas as areas of specific interest for mini-grids and feasibility studies have exclusively remained at the charge of the local communities — or any form of local contractor.[121]

Tenenbaum *et al.*[122] has shown that while a few African countries actively encouraged private mini-grids, adequate regulatory frameworks were still absent at the time, creating confusion and uncertainty, especially with regard to subsidy regimes and the regime of connection to the grid. More recently, several countries have introduced dedicated policies and regulations to address issues related to mini-grid development, including licensing, tariff setting, main grid arrival, and financial support. Their effectiveness has been limited to date, but efforts are being made and continue in countries like Nigeria.[123] New business models like "mini-grids under the grid" are also emerging, aiming to complement insufficient supply from the main grid.[124]

Despite the proclaimed objective of several African countries to actively support mini-grid concessions, adequate regulations and institutional frameworks remain elusive. An average 4-6

[120] *Ibid*.

[121] *Ibid*.

[122] Tenenbaum, B., Greacen, C., Siyambalapitiya, T., and Knuckles, J. (2014), *From the Bottom Up: How Small power Producers ad Mini-Grids Can Deliver Electrification and Renewable Energy in Africa.* World Bank, Washington, D.C.

[123] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_mini-grid_policies_2018.pdf

[124] Nagpal, D. (2020), *Towards Actionable Electrification Frameworks: Mini-Grids under the Grid*, GCEEP Working paper Series, Global Commission to End Energy Poverty, MIT Energy Initiative.

years elapsed between the development of national laws for mini-grid concessions and the award of the first concessions in Mali, Uganda, and Madagascar[125,126,127].

In practice, these small-scale mini-grid concessions have proven successful in attracting *local* private capital and skills. Most projects entailed private funding accounting for 10 to 60% of the total investment costs (c.f. **Table 7**).

Table 7. Overview of the financial status of existing mini-grid concessions in Sub-Saharan Africa[128]

Country	*Private investment in concession*	*Public investment in concession*	*Financial sustainability of concession*
Burkina Faso	—	—	Concessions are unlikely to meet long-run marginal costs of operation
Guinea	$0.4 million	$1.737 million	No evidence available on financial sustainability of concessions
Madagascar	$5.95 million	$13 million	When government stopped subsidizing diesel, 17 of 47 mini-grids closed down. Long-term term financial viability unclear
Mali	$13 million	$39 million	Ability of concessions to cover long-run marginal costs and achieve full sustainability not yet clear.
Senegal	—	—	ERIL mini-grids were meant to be bottom-up mini-grids largely funded by development partners. Insufficient evidence available on financial sustainability.
Uganda	$12.3 million	Initial grant of $14.75 million from REA using World Bank funds	After initial financial difficulties, tariff rise and restructuring, WENRECo appears on target to achieve 15 percent return on equity. Insufficient information to judge the situation of three of the five concessionaires.

Mini-grid concessions have demonstrated positive local impact despite their limited geographic scope. Most importantly, field studies in the countries mentioned in **Table 2** have shown a dramatic involvement of local entrepreneurs and communities in the financing, installation, and maintenance of installations, unleashing local businesses and productive businesses best suited to local contexts. The decentralized nature of mini-grids has proved well suited to local entrepreneurship and the involvement of communities[129].

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[125] Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: Madagascar, Report to the World Bank*, Castalia Advisory Group, Paris.

[126] Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: Uganda, Report to the World Bank*, Castalia Advisory Group, Paris.

[127] Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: Mali, Report to the World Bank*, Castalia Advisory Group, Paris.

[128] Adapted from Hosier, R. *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?* World Bank, Washington, D.C.

[129] Hosier, R. *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C.

4.2. The limitations of bottom-up approaches

Several key challenges now hamper the large-scale development of mini-grids. In terms of financial viability, mini-grid concessions have demonstrated mixed results to date. Past experiences show that while most concessionaires usually raise adequate equity and debt to establish mini-grids and manage to recover their operation, current bottom-up models have limited the financial viability of these projects and their ability to maintain and expand their asset base[130]. First, the small size of most mini-grids prevents concessionaires from benefiting from economies of scale (c.f. **Table 8**). Second, the bottom-up nature of mini-grid projects limits the ability of concessionaires to negotiate adequate cost-reflective tariffs and well-targeted subsidy schemes. Lastly, local populations are often unwilling to pay higher prices compared to grid-based services. In Mali, for example, most mini-grids located within a close distance from the grid had to be purchased by the national utility and apply grid tariffs in order to avoid local unrests[131].

Table 8. Overview of existing mini-grid concessions in Sub-Saharan countries[132]

Country	*Mini-grid program name*	*First year of operation*	*Number of mini-grid concessionaires and mini-grids in operation*	*Total number of connections*	*Average number of connections per mini-grid*
Burkina Faso	Coopératives d'électricité (Coopels)	2003	Concessionaires = 92 Mini-grids = 92	14,250	155
Guinea	Decentralized Rural Electrification (PERD) Project	2006	Concessionaires = 26 Mini-grids = 26	8,248	317
Madagascar	Mini-grid concessions	2005	Concessionaires= 30 Mini-grids = 30	7,100	237
Mali	Projets de Candidatures Spontanées de l'énergie Domestique et de l'Electrification Rurale	2003	Concessionaires = 68 Mini-grids = 250	78,000	312
Senegal	Projets d'Electrification Rurale d'Initiative Locale (ERIL)	2003	Concessionaries = 4 Mini-grids = 4	500	125
Uganda	West Nile Rural Electrification Project	2003	Concessionaire = 1 Mini-grids = 1	6,800	6,800
	Small grid extension concessions	2006	Concessionaire=5 Mini-grids = 5	31,600	6,320

130 Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: Mali, Report to the World Bank*, Castalia Advisory Group, Paris.

131 *Ibid.*

132 As of 2017. Adapted from Hosier, R. *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C.

From a planning perspective, current bottom-up models suffer from the lack of coordination with larger-scale electrification projects and a structural inability to tap international funding sources. Most importantly, mini-grids are developed independently from each other on an individual basis following local requests[133,134]. In the absence of detailed pre-feasibility studies, common management and ownership, and large-scale integrated planning—for example, through geospatial planning tools — mini-grids are unlikely to benefit from economies of scale and adequate subsidy schemes.[135,136]

Mini-grids also generally develop without grid connection clauses, thereby threatening the viability of the projects while the grid arrives.[137] In the absence of such clauses, the interaction between the mini-grids and distribution companies remains very limited – if not actively avoided on purpose — and reduced to ensuring that the area to be electrified does not overlap with the zones to be electrified by grid extension in the short to medium term, creating a buffer zone with little to no electrification options until the later connection to the grid (if any).[138]

What is more, the local nature of mini-grids usually prevents developers from directly tapping into international equity and debt financing, being mostly limited to public funding through ministries or eventually rural electrification agencies. Bottom-up mini-grid initiatives rarely qualify for DFI-backed financing packages for top-down electrification programs and remain limited to raising capital from smaller financing pools through local authorities. [139]

4.3. The way forward and application to IDF

Despite these obstacles, the positive impact of mini-grids warrants focused attention to supporting their deployment in areas likely to remain unserved by the grid in the short or medium term. This includes improving access to international funding and private capital, developing well-targeted customer cross-subsidization schemes within the mini-grids, ensuring cost-recovery for developers and operators for long-term sustainability of supply via adequate subsidies, adopting transparent licensing, permitting and grid arrival clauses, and encouraging shared management and ownership.

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[133] *Ibid.*

[134] Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: Madagascar, Report to the World Bank*, Castalia Advisory Group, Paris.

[135] Pérez-Arriaga, I., Stoner, R.J., Nagpal, D., Jacquot, G. (2020), *2020 Report: Energy Access*, Global Commission to End Energy poverty, MIT Energy Initiative, Cambridge.

[136] Nagpal, D. and Pérez-Arriaga, I. (2020), *Integrating isolated mini-grids with an IDF-compliant regulated distribution sector: A long-term perspective towards universal electricity access*, Global Commission to End Energy poverty, MIT Energy Initiative, Cambridge.

[137] *Ibid*.

[138] *Ibid.*

[139] Hosier, R. *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C.

Nagpal (2020)[140] provides a comprehensive overview of the key actions necessary to bring current and future mini-grid concessions into IDF-like approaches depending on local contexts and the remuneration regime of the mini-grid (i.e., willing-buyer/willing-seller tariff supported by connection-based RBF, regulator-approved tariffs supported by subsidies, uniform national tariff supported by subsidies). Nagpal (2020) highlights the importance of cost-reflective tariffs supported by direct and cross-subsidies between electrification modes and/or between mini-grid users; of grid connection clauses and grid-compatible mini-grid standards built into mini-grid programs; and of building local regulators' capabilities in mini-grid business and financing models[141]. Last but not least, mini-grid concession programs should incorporate explicit timed and quantified universal energy access clauses.

In conclusion, while mini-grid concessions have not had the success of utility or territorial concessions, the lessons derived from bottom-up projects suggest that mini-grid projects have a large untapped potential best harnessed through IDF. Placing mini-grid projects into integrated initiatives leveraging all possible electrification modes would allow planners to leverage the economies of scale offered by mini-grid compared to off-solar while building on cross-subsidization mechanisms to ensure mini-grids' viability and outreach into underserved areas.

The lessons learnt from past experiences and possible improvements of existing mini-grid concessions have been explored in depth by the existing literature. However, while the concessions developed and most improvements proposed to date have so far focused on enabling the development of mini-grids that could not exist without supportive regulatory environments and public subsidies, additional measures will be necessary in order to go beyond the mere financial viability of mini-grids. Dedicated universal energy access clauses, defining the terms and conditions of a later connection to the national grid in coordination with the national DISCO under comprehensive national plans, and ensuring the development of adequate cost-reflective tariffs and associated direct and cross-subsidies will be critical in order to integrate mini-grid concessions into integrated distribution frameworks.

5. The next frontier: integrating off-grid solar into concession programs

One of the four pillars of IDF is the integration of all three electrification modes into one single national electrification plan. Integrated frameworks have been defined at a high level[142] and practical guidance is necessary to overcome the hurdles that a naïve interpretation or adoption of integrated distribution models may encounter as countries move to the implementation stage.

[140] Nagpal, D. and Pérez-Arriaga, I. (2020), *Integrating isolated mini-grids with an IDF-compliant regulated distribution sector: A long-term perspective towards universal electricity access*, Global Commission to End Energy poverty, MIT Energy Initiative, Cambridge.

[141] *Ibid.*

[142] Pérez-Arriaga, I., Stoner, R.J., Nagpal, D., Jacquot, G. (2020), *2020 Report: Energy Access*, Global Commission to End Energy poverty, MIT Energy Initiative.

More specifically, among all three electrification modes, solar systems appear to be the least covered by the existing literature and little to no guidance has been written on the institutional frameworks – such as utility and/or territorial concession programs — for the deployment of solar technologies within integrated frameworks.[143] Since the late 2000's, solar companies have precisely perceived their independence from top-down electrification initiatives and regulatory regimes as two critical factors of success.

Building on past experiences, this chapter shows that integrating solar companies into national electrification programs and structuring solar concessions will likely prove challenging. It argues that these companies have less incentives to join IDF than utilities and mini-grids and are unlikely to engage into integrated frameworks and concession programs without legal guarantees and financial incentives. It concludes that, although solar remains the only segment of distribution able to thrive independently of any form of public support – as opposed to grid and mini-grid operators, public-private partnerships such as concessions will be necessary in order to harness the full potential of solar in energy access.

5.1. Obstacles to the integration of solar within concession programs

The majority share of the research on integrated frameworks remains focused on the restructuring of grid operators and regulatory regimes for supporting mini-grids, leaving aside the issue of the integration of solar into IDF[144]. In practice, such integration remains unlikely to take place without ad-hoc policies and proper incentives[145].

The privately-driven structure of the solar sector does not lend itself to the integration of off-grid solar into tight regulatory regimes. First of all, and as opposed to national utilities and mini-grid developers, off-grid solar companies do not have any obvious financial and operational incentives to join regulated regimes typical of integrated electrification programs[146]. Second, solar companies are currently unable to fill the electrification gap left by the national grid and

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[143] An early experience in applying Integrated Distribution Frameworks to solar-driven electrification is presented in the following report:

Pérez-Arriaga, I and Valdés, J.E. (2020), *Consultoría para la identificación y análisis de experiencias internacionales en la aplicación de modelos innovadores de acceso a la energía*, Consultancy Report for the InterAmerican Development Bank and the Colombian Ministry of Mines and Energy, Madrid.

[144] *Ibid*.

[145] The role of these incentives is detailed in two reports on reforms of the distribution sector for universal energy access in Colombia and Uganda:

Pérez-Arriaga, I and Valdés, J.E. (2020), *Consultoría para la identificación y análisis de experiencias internacionales en la aplicación de modelos innovadores de acceso a la energía*, Consultancy Report for the InterAmerican Development Bank and the Colombian Ministry of Mines and Energy, Madrid.

Pérez-Arriaga, I. (2021), *Stocktaking in the Energy Sector, Electricity Distribution*, The European Union Global Technical Assistance Facility on Sustainable Energy, European Commission, Brussels.

[146] Jacquot, G., Pérez-Arriaga, I., Stoner, R.J., Nagpal, D., (2020), *Reaching universal energy access in Sub-Saharan Africa: The promises of pay-as-you-go business models under comprehensive electrification planning*, Global Commission to End Energy Poverty, MIT Energy Initiative, Cambridge.

mini-grids while maintaining minimum profitability standards imposed by private investors. Third, the fast-changing structure of the distribution sector with the ongoing unbundling of solar companies into specialized entities[147] and the diversification of pay-as-you-go solar companies into new services (e.g. clean cooking) opens several challenges left unanswered by integrated approaches, further complicating the tentative integration of solar into IDF-like concession programs.

Balancing benefits and obligations will therefore be key to involve solar companies in meaningful integrated universal electrification schemes, i.e., in attractive business models and regulatory approaches that provide political, operational, and financial guarantees to solar companies. This thesis focuses on solar concessions and sub-concessions. The next section reviews two emblematic solar concession programs and derives key lessons informing the possible integration of solar into IDF.

5.2. Toward solar concessions: review, analysis, and limitations of past experiences

Concessions appear to be a promising institutional framework for the implementation of IDF and safeguarding the concurrent pursuit of its four pillars. However, while concessions in various forms have been undertaken for grid and mini-grids and valuable lessons have been derived from past experiences, solar concessions are less common. In Africa, solar concessions have not been implemented until the 1990's and 2000's before the onset of today's pay-as-you-go business models [148,149], with mixed results.

Solar concessions have been more common and yielded more positive results in Latin America. In Peru, nine public and private solar concessions have led to the electrification of 5,000 rural households — including in some of the country's most remote communities. Solar was deployed outside of any integrated planning as a default option where the national grid and mini-grids would not expand in the medium term[150]. The three private concessions[151] created since 2012 as part of the concession programs for solar electrification are still operating, demonstrating the long-term resilience of the energy-as-a-service business model adopted by the concessionaires

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[147] Current proposals include unbundling PAYG solar companies into different entities specialized in technology development and manufacturing, logistics of product delivery and installation, financing, and retailing activities plus facilitation of appliances and services to the end customers. The main objective is to increase efficiency, to segment risks and ultimately channel investments into more targeted financial vehicles specialized in well-defined parts of the energy access business. See https://www.pv-magazine.com/2019/11/23/the-weekend-read-offgrid-goes-global/

[148] Debeugny, C. *et al.* (2017), *L'électrification complète de l'Afrique d'ici 2030 est-elle possible ?*, Afrique contemporaine, vol. 261-262, no. 1, 2017, pp. 139-153.

[149] Hosier, R. *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?*, World Bank, Washington, D.C.

[150] Pérez-Arriaga, I. and Valdés, J. E. (2020), *Consultoría para la identificación y análisis de experiencias internacionales en la aplicación de modelos innovadores de acceso a la energía*, Consultancy Report for the InterAmerican Development Bank and the Colombian Ministry of Mines and Energy, Madrid.

[151] Under the leadership of Acciona Microenergía Perú, Entelin and Ergon.

that did not suffer from any subsequent grid or mini-grid deployment since the beginning of the concessions[152,153].

The case of Argentina, where 5,500 solar home systems were installed and maintained in remote rural areas, mirrors Peru's success at a similar pilot scale[154]. The 55-year concession, launched in 1996, is still operational and was originally designed to serve the regions of lowest population density – with an average number of connection/sq.km. of 0.16[155]. Similarly to Peru, standalone solar was deployed as a default option whenever the national grid, mini-grids or micro-grids could not be offered cost-reflectively to local communities, outside of any integrated plan.

Building on the positive experiences in Latin America, the rest of this chapter examines past African experiences[156] and shows that concessions could play a major role in advancing the diffusion of solar in complex environments with limited ability to pay and a comparatively lower potential for cross-subsidies. Most importantly, successful solar concessions will require extensive long-term regulatory backstops balancing universal energy access obligations for solar companies and financial incentives to expand into remote rural territories.

5.2.1. The South Africa territorial solar concession: an early and unsuccessful attempt [157,158]

The South African experience illustrates the risk of inadequate institutional frameworks and concessions for solar-based electrification. Two decades after its inception, the concession program's scope and ambition has been largely scaled down due to insufficient preliminary planning, poor stakeholder coordination, and financial viability issues. With dinsight, the emergence of pay-as-you-go business models and integrated distribution frameworks could mitigate if not solve these issues and make similar concessions more feasible in the future.

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152 Pérez-Arriaga, I. and Valdés, J. E. (2020), *Consultoría para la identificación y análisis de experiencias internacionales en la aplicación de modelos innovadores de acceso a la energía*, Consultancy Report for the InterAmerican Development Bank and the Colombian Ministry of Mines and Energy, Madrid.

153 WBCSD (2013), *ACCIONA: Enabling access to electricity in rural Peru, World Business Council for Sustainable Development*, Geneva.

154 Pérez-Arriaga, I. and Valdés, J. E. (2020), *Consultoría para la identificación y análisis de experiencias internacionales en la aplicación de modelos innovadores de acceso a la energía*, Consultancy Report for the InterAmerican Development Bank and the Colombian Ministry of Mines and Energy, Madrid.

155 *Ibid.*

156 For a more thorough analysis of Latin American solar concessions and their application to IDF, see:

Pérez-Arriaga, I. and Valdés, J. E. (2020), *Consultoría para la identificación y análisis de experiencias internacionales en la aplicación de modelos innovadores de acceso a la energía*, Consultancy Report for the InterAmerican Development Bank and the Colombian Ministry of Mines and Energy, Madrid.

157 Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: The South African Solar Home System (SHS) Concessions, Report to the World Bank,* Castalia Advisory Group, Paris.

158 Hosier, R. *et al.* (2017), *Rural Electrification Concessions in Africa: What Does Experience Tell Us?* Washington, DC: World Bank.

5.2.1.1. The South African concession program

The South African government introduced territorial solar home concessions as of 1999 in order to accelerate the electrification of areas unreachable by grid extension. After a competitive process, concessions were awarded to six companies with the objective of installing 50,000 solar home systems in each territorial concession. Concessionaires were tasked with the installation, operation and maintenance of the systems over a 20-year period.

In order to support their activities, the government of South Africa provided concessionaires with a 5-year exclusive access right to a subsidy covering 80% of installation costs in the concession area. In addition, concessionaires were remunerated on monthly user's fees. Lower-class users qualified for direct end-user government subsidies covering a portion of the monthly fees[159].

Twenty years after the concessions' onset, results seem mixed at best. Less than 100,000 solar home systems have been installed, less than a third of the 300,000 systems initially planned by government authorities. Among the 100,000 solar systems installed, only around 60,000 were still operational in 2015. What is more, only three of the concessions set up in 1999 are still operational in the same format as they were at the outset.

These results led the government to officially abandon the concession model and opt instead for more flexible approaches whereby the public sector contracts with private providers for installations and with user cooperatives for maintenance.

5.2.1.2. Factors of failure and lessons learnt

A number of institutional, financial, and technological factors can be traced to as the cause for the disappointing performance of the South African concession model.

First of all, the concession program suffered from a lack of initial planning from the public sector side. Contracts stipulating the rights and obligations and the concessionaires had not been designed at the time the tender was advertised and operations were delayed, thereby leading to a major scaling back of the original deployment plans once the terms of the concessions were released.

Second, solar developers faced early competition from the grid and unwillingness of local populations to pay for what they perceived as a costly and permanent alternative to the main grid. Without sufficient planning and coordination between solar companies and grid operators, many municipalities were connected to the grid shortly after being electrified by solar systems, affecting the economic viability of the solar concessions.

Third, the lack of a transparent and binding regulatory framework rendered the concession financially unviable. At the national level, most concessionaires were declined public subsidies

[159] Castalia (2015), *Evaluation of Rural Electrification Concessions in sub-Saharan Africa, Detailed Case Study: The South African Solar Home System (SHS) Concessions, Report to the World Bank*, Castalia Advisory Group, Paris.

by regulatory agencies, which affected the very viability of the concessionaires' business model and led to the collapse of the national concession program. At the local level, few municipalities managed to find the funds for end-user subsidies and to disburse in a timely fashion the agreed monthly subsidies to populations, thereby creating affordability issues among solar users.

Lastly, lower than expected bill recovery rates prevented the program from scaling up into remote areas. In the absence of modern-days connected pay-as-you-go business models, solar operators resorted to costly and inefficient physical bill collection, with limited success.

5.2.2. The Moroccan experience in solar territorial concessions

Thirty years after the inception of its universal energy access program, Morocco has become a textbook example of integrated planning for energy access. Rural electrification rates in the kingdom increased from 18% in 1990 to nearly 100% presently[160]. Around 10% of the country's population, or 200,000 households living in remote rural areas, were electrified through solar home systems[161].

Three key factors have underpinned the dramatic success of the Moroccan experience with solar. First, a strong political support in favor of solar systems, which translated into ambitious agendas and adequate public resources to achieve government objectives. Second, the ability of local stakeholders to design and implement solar concessions and attract capable international solar developers on the basis of extensive pre-feasibility analyses that matched demand estimates with all possible electrification modes. Third, the ability of the national utility and solar concessionaires to leverage all possible sources of funding available for energy access around a transparent and financially sustainable private sector-driven model, from cross-subsidies to direct public subsidies and international debt[162,163].

5.2.2.1. General context

Back in 1990, rural electrification rates hardly reached 14% in Morocco against 70% to 84% Tunisia, Algeria, and Egypt[164]. After a couple of pilot-scale electrification programs, the Moroccan government launched in 1996 the Global Rural Electrification Program (*Programme d'Electrification Rurale Globale*, or "PERG"), with the objective of reaching universal energy

[160] ONE, *Rapports d'Activités* 1998-2017, Office Nationale de l'Electricité (ONE).

[161] ONE (2007), *Programme d'Electrification Rurale PERG,* Power point presentation by Office Nationale de l'Electricité (ONE).

[162] I. Nygaard and T. Dafrallah (2016), *Utility led rural electrification in Morocco: combining grid extension, mini-grids, and solar home systems,* Energy and Environment.

[163] Debeugny, C. *et al.* (2017), *L'électrification complète de l'Afrique d'ici 2030 est-elle possible ?,* Afrique contemporaine, vol. 261-262, no. 1, 2017, pp. 139-153.

[164] *Ibid.*

access within 15 years[165]. Building on the lesson from previous pilots, the PERG relied on a series of technical, financial, and organizational innovations paving the way for the first "integrated" electrification program. The most innovative feature of the program was its ability to leverage all possible electrification strategies existing at the time, with a strong emphasis on decentralized renewable options, on the basis of carefully designed operational, technical, and financial planning established for the entire country.

Morocco has followed a purely utility-driven approach, in which the national utility—the ONE, or *Office National de l'Électricité* (National Electricity Company) — has responsibility over the *entire* energy access program in the kingdom. Most importantly, and in a very unusual move compared to the model adopted in most African countries, the ONE was also responsible for providing electricity to remote communities (10% of the villages, 5% of the country's population[166]), either through diesel- or renewable-powered mini-grids or through photovoltaic kits via a fee-for-service model coordinated by the ONE but operated by private companies under ten-year concession agreements[167].

5.2.2.2. Institutional framework for electrification

Universal energy access was the number one social policy of the Moroccan government in the 1990s and 2000s and gained very strong traction due to unconditional political support from the monarchy. Although the main outcome of the power sector reforms in Morocco was the privatization of national power production and distribution in the major cities, the reforms of the Moroccan power sector did not lead to the creation of a rural electrification agency. Instead, full responsibility for implementing the PERG was left with the state-owned utility, the ONE. This "utility model" mostly stems from the limited success of early rural electrification programs of the 1970s and 1980s[168], during which the local authorities were fully responsible for financing rural electrification.

The ONE spearheaded the PERG as an integrated power company, a national transmission and system operator, a distribution company and a "single buyer" of electricity, owning 51% of the market share in final power supply, while local and smaller-scale municipal and private distribution companies supply the rest[169]. To coordinate the PERG, the ONE set up a new,

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[165] ONE, *Rapports d'Activités* 1998-2017, Office Nationale de l'Electricité (ONE).

[166] *Ibid.*

[167] Massé, R. and Watchueng, S. (2010), *La coordination multisectorielle et l'électrification rurale en Afrique*, Club des agences et structures Africaines en charge de l'Électrification Rurale, Club ER, 2010.

[168] The PERG was predated by the PPER, or *Programme de Pré-électrification Rurale*, which was the first African electrification program to integrate solar PV at scale. Results were limited due to lack of meaningful funding from local communities.

[169] Nygaard, I. and Dafrallah, T. (2016), *Utility led rural electrification in Morocco: combining grid extension, mini-grids, and solar home systems*, Energy and Environment.

specially dedicated rural electrification department responsible for overall electricity planning, identifying villages, mobilizing local populations, supervising, quality control, and leveraging GIS as part of the planning and implementation stages[170].

One of the key innovations of the PERG was to integrate off-grid electrification right from the outset as a systematic alternative to grid extension projects in remote and/or sparsely populated areas. After field surveys, solar home systems were the main option considered for the PERG on grounds of technical and economic feasibility, convenience in use, and the high levels of solar penetration across the country.

5.2.2.3. Overview of Morocco's solar territorial concessions

Solar electrification was carried out using an integrated approach, weighting the pros and cons of grid and off-grid options under a single global program, the PERG, to ensure fairness in terms of advantages for the beneficiary and coherence in the electrification process. First, rural demand was assessed throughout national field survey campaign covering all 36,000 villages. Utility technicians visited each village to enquire about their geographical locations and delineations, populations, number of households and businesses, electricity needs, existing and necessary infrastructures, and existing social amenities in order to later establish least-cost electrification strategies at national scale.

Second, GIS systems were leveraged in order to manage the large amount of collected information on rural households and villages, as well as existing economic, social, and electricity infrastructures. The geospatial planning tool was used for rural electrification planning and cost evaluation, the spatial positioning of the villages throughout the country, and to evaluate the progress of solar electrification. Grid extensions were planned first based on the principle of spatial optimization, with the objective to maximize village connections within the overall budget. Solar was then deployed wherever the grid could not go.

The master plan developed by the ONE relied on the assumption that the limiting factor in energy access remained last-mile connection, with the hypothesis that grid reliability and power supply would not be an issue — a hypothesis largely validated today.[171]

In practice, the PERG was planned in five different stages (PERG 1 to 5). Each of the five main stages consisted of the connection of households for which connection costs in the least-cost model would remain below a pre-defined threshold. According to an agreement between the ONE and solar companies, the ONE would be responsible for the connection of all households with connection costs below 27,000 Dh (around USD2,000) while off-grid PV solar would be offered as a default alternative to all remaining households. Given the success of the program and the fact that the 80% electrification objective had been reached six years ahead of schedule,

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[170] AFD (2012), *Le programme d'électrification rurale global au Maroc*, working paper, AFD, Paris.

[171] *Ibid.*

the maximum threshold for grid connection was later increased to 50,000 Dh (around USD5,000) as part of the fifth and last stage of the PERG (c.f. **Table 9** below).[172]

From a planning perspective, construction, operation, and management of infrastructures depend on the electrification mode: (i) for all grid-based projects, the ONE remains both prime/general contractor and is responsible for the exploitation of all assets; and (ii) for off-grid projects, the ONE organizes and controls the implementation of all electrification projects but delegates the execution and exploitation to private operators that are granted 10-year territorial concessions (*Délégation de Service Public* scheme, widespread throughout francophone Africa).[173,174]

Investment cost (Dh[175])			**Grid connection**		**Off-grid solar**		**Final rural electrification rate**
			Maximum connection cost per hh (Dh)	*Average connection cost per hh (Dh)*	*Connection cost per household (Dh)*	*Average cost per household (Dh)*	
PERG 1 & 2		1996-2001	10,000	6,500	N/A	N/A	18 => 55%
PERG 3		2002-2004	14,000	8,500	6,000 to 15,000	7,000	55% => 72%
PERG 4	**4-1**	2004-2005	20,000	12,000			72% => 87%
	4-2	2006-2006	27,000	17,000			87% => 96.8%
PERG 5		2009-Present	50,000	29,900	8,000 to 35,000	18,000	96.8% => 99.95%

Table 9. Overview of the key parameters underlying the planning of the PERG (source: ONE[176])

5.2.2.4. Technical terms of the concession program

Developing and implementing off-grid PV solar electrification programs at scale proved to be a daunting challenge for the ONE, a state-owned utility without experience in off-grid systems. Based on the key lessons derived from previous electrification programs implemented in the late 1980s and early 1990s, and in order to speed up the electrification process, to ensure a

172 Nygaard, I. and Dafrallah, T. (2016), *Utility led rural electrification in Morocco: combining grid extension, mini-grids, and solar home systems*, Energy and Environment.

173 Massé, R. and Watchueng, S. (2010), *La coordination multisectorielle et l'électrification rurale en Afrique*, Club des agences et structures Africaines en charge de l'Électrification Rurale, Club ER, Paris.

174 Nygaard, I. and Dafrallah, T. (2016), *Utility led rural electrification in Morocco: combining grid extension, mini-grids, and solar home systems*, Energy and Environment.

175 1 Dh ≈ 10 USD.

176 ONE (2009), *Programme d'Electrification Rurale PERG*, Power point presentation by Office Nationale de l'Electricité (ONE).

sustainable electricity service, and to integrate existing technical and organizational knowledge, the ONE decided to outsource the off-grid component to private-sector actors.[177,178]

An international bidding process was established to select enterprises for public-private partnerships under 10-year concession contracts, and a first contract to supply 16,000 households with electricity was signed between Temasol (a consortium formed by Total and EDF) and ONE in 2002. A total of around 105,000 solar home systems has been contracted to date.[179]

The concession contract set up the conditions for a fee-for-service model. Temasol was responsible for installation and maintenance over a 10-year period on a territorial concession. The company was remunerated on a one-off connection as well as a monthly fee depending on the size and the year of installation.

In the Moroccan public-private partnership model, the concessionaire was in charge of: (i) marketing: identifying potential clients and generating demand; (ii) contracting: signing subscription contracts with the consumer on behalf of ONE; (iii) installation: buying and installing all PV system components; (iv) maintenance: delivering free of charge after-sale service and renewals during the 10-year warranty period; (v) revenue collection: collection of the connection fee and the monthly fee during the 10-year concession period; (vi) environmental control: maintenance includes changing batteries and recycling used batteries. Interestingly, the ONE remained the owner of all installations, and consumers were thus a customer of the *utility* itself and not of Temasol. These technical arrangements have ensured technical sustainability of the projects to date.[180]

Upon the launch of the PERG in 1996, around 150,000 households, or 10% of rural households, were identified as having high costs for on-grid electrification and suited for off-grid solutions under a concession model.

5.2.2.5. Financial terms of the concession program

Morocco's national electrification plan required customers to pay for about 25% of the overall investment and electrification costs, while the remaining 75% were paid by the public sector. However, the terms and conditions for solar electrification slightly departed from national

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177 Massé, R. and Watchueng, S. (2010), *La coordination multisectorielle et l'électrification rurale en Afrique*, Club des agences et structures Africaines en charge de l'Électrification Rurale, Club ER, 2010.

178 SCET-Maroc and GERERE (2005), *Small scale project design document. Photovoltaic kits to light up rural households in Morocco. 101,500 PV solar home systems for rural electrification in Morocco,* Working Paper, GRET, Paris.

179 *Ibid*.

180 I. Nygaard and T. Dafrallah (2016), *Utility led rural electrification in Morocco: combining grid extension, mini-grids, and solar home systems*, Energy and Environment.

averages and household contributions typically varied from 13% to 85% of the upfront and monthly costs[181], depending on the system size (as detailed in **Table 10** and **Table 11** below).[182]

System	**Household contribution**		**ONE contribution**
	Upfront payment	*Monthly payment*	
50 W_p	700	60	5,400
75 W_p	1,800	96	5,400
100 W_p	5,000	129	5,400

Table 10. Overview of the pricing scheme for Temasol's first solar project (16,000 kits; in Dh) (source: ONE[183])

System	**Household contribution**		**ONE contribution**
	Upfront payment	*Monthly payment*	
50 W_p	700	60	3,600 to 6,400
75 W_p	1,800	96	4,850 to 5,600
200 W_p	5,000	230	10,000 to 14,000

Table 11. Overview of the pricing scheme for Sun Light Power's current projects (12,000 kits; in Dh) (source: ONE[184])

In total, 51,559 systems were actually installed by 2013—achieving only about 32% of what was first planned and about 50% of the targets in the concessions, due to unexpected grid extension initiatives under local population pressure (they perceived solar as a second-tier solution and an exclusive alternative that would prevent them from being ultimately connected to the grid). New solar projects signed in 2015 and 2016 with Temasol and Isofoton have brought this number to nearly 105,000 by raising the number of subsidies offered to households for high-capacity systems.[185]

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[181] Nygaard, I. and Dafrallah, T. (2016), *Utility led rural electrification in Morocco: combining grid extension, mini-grids, and solar home systems*, Energy and Environment.

[182] Massé, R. and Watchueng, S. (2010), *Public-private partnerships in rural electrification programs in Africa*, Group of African Agencies and Structures in charge of Rural Electrification (Club-ER).

[183] ONE (2009), *Programme d'Electrification Rurale PERG*, Power point presentation by Office Nationale de l'Electricité (ONE).

[184] *Ibid.*

[185] Nygaard, I. and Dafrallah, T. (2016), *Utility led rural electrification in Morocco: combining grid extension, mini-grids, and solar home systems*, Energy and Environment.

As solar projects extended further from urban and peri-urban regions and costs increased, subsidies were scaled up in order to ensure complete accessibility to the entire population.

5.2.2.6. Economic structure of the PERG

One of the most important features of the PERG was to rely on long-term financing models to ensure sound sharing of responsibilities between end consumers, local municipalities, and the State-owned utility ONE. Twenty years after the inception of the program, the PERG still appears as a textbook case study for financially sustainable electrification programs that first leveraged all possible sources of funding, both locally and internationally, while preserving local sovereignty over energy access policy.[186]

By 2019, consumers had provided about 25% of the total investment and ONE the remaining 75% for solar. The financial resources of the municipalities came from their value added tax allocation, as well as support from the ministry budget and the Municipal Development Fund. On the other hand, ONE drew most of its resources from a solidarity tax (2.25% of on-grid sales[187]), concessionary loans, and equity. It is worth mentioning that customer and municipality contributions remained at their 1996 level throughout the entire PERG, thereby increasing the financial pressure on the ONE as grid connection costs gradually rose from 10,000 Dh/household to 14,000 Dh in 2002; 27,000 Dh in 2006; and 50,000 Dh in 2009. In addition, solar electrification costs experienced a 150% increase over the same period as distribution costs ramped up in increasingly remote areas.[188]

The total cost of the PERG has been estimated at nearly USD2,5bn as of 2017, and its solar component at around USD350m over the same time frame.[189]

While most financial resources were eventually available locally and provided at 75% by customers or ONE as equity, the PERG also relied on a fundraising campaign among international donors (c.f. **Figure 1** below). Concessional debt and targeted subsidies, mainly aimed at achieving prefeasibility studies and setting up electrification planning programs, allowed the State to safeguard the financial viability of the project without endangering public finances. The figure below shows the breakdown of the different sources of funding of the ONE, which itself contributed to an average of 55% of the overall cost of the program.

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[186] Debeugny *et al.* (2017), *L'électrification complète de l'Afrique d'ici 2030 est-elle possible ?*, Afrique contemporaine, vol. 261-262, no. 1, pp. 139-153.

[187] ONE, *Rapports d'Activités* 1998-2017, Office Nationale de l'Electricité (ONE).

[188] Massé, R. and Watchueng, S. (2010), *La coordination multisectorielle et l'électrification rurale en Afrique*, Club des agences et structures Africaines en charge de l'Électrification Rurale, Club ER.

[189] AFD (2012), *Le programme d'électrification rurale global au Maroc*, Working paper, Paris.

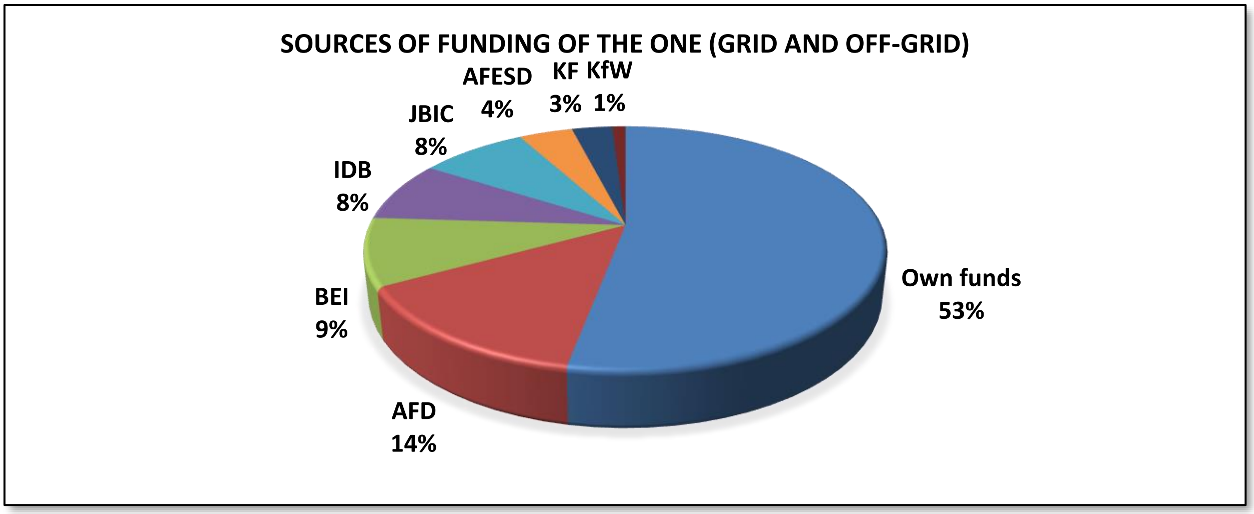

Figure 1. Main sources of funding of the ONE over the entire duration of the PERG (source: AFD)[190]

5.2.2.7. PERG's outcome

More than twenty years after its inception, the PERG has led to a near 100% electrification rate (c.f. **Figure 2**). As of 2018, more than 40,500 villages were electrified (37,100 through grid and mini-grid connection, 3,400 through solar systems) accounting for a total of around 2,078,679 households (grid connection: 2,027,120; solar: 51,559). The rural electrification rate increased by an average of 6% per year for more than a decade, up from 18% in 1995 to 95.4% in 2008 and 99.64% in 2018, for a grand total cost of around €2,5bn.[191,192]

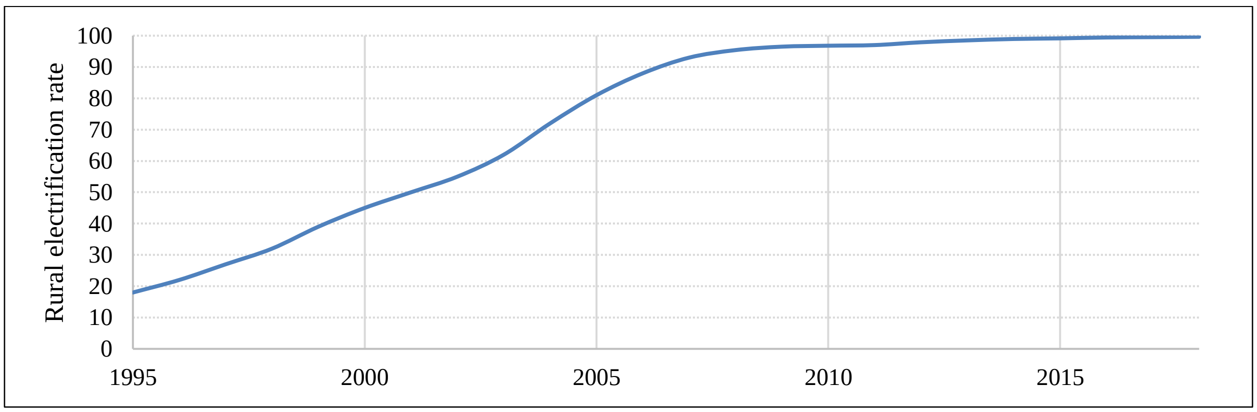

Figure 2. The electrification of Morocco: Reaching universal energy access in a decade (source: ONE[193])

[190] **Acronyms:** AFD – French Development Agency; BEI – European Investment Bank; JBIC – Japan Bank for International Cooperation; IDB – Islamic Development Bank; AFESD – Arab Fund for Economic and Social Development; KF – Kuwait Fund; KfW – German Development Bank

[191] ONE, *Rapports d'Activités* 1998-2017, Office Nationale de l'Electricité (ONE).

[192] Nygaard, I. and Dafrallah, T. (2016), *Utility led rural electrification in Morocco: combining grid extension, mini-grids, and solar home systems*, Energy and Environment.

[193] ONE, *Rapports d'Activités* 1998-2017, Office Nationale de l'Electricité (ONE).

However, Morocco's positive long-term outcomes in terms of electrification rates hide a bleaker picture for solar concessionaires whose service could hardly compete with the fast-expanding national grid.[194] As grid extension accelerated under the government's pressure, households proved decreasingly willing to sign up for solar systems that they considered to be more expansive than the national grid for services of lesser quality.[195] The reluctance from the public to adhere to the solar electrification program and the accelerated expansion of the national grid into the concessionaires' territories led several solar companies to not renew their concession agreement.

5.2.2.8. Key lessons learned

Morocco's success shows the potential of solar territorial concessions to complement a broader and well-structured utility-driven approach in remote areas unreachable by the national grid or mini-grids.

First, a key success factors of the PERG was to rely on an integrated planning approach leveraging all possible electrification strategies without dismissing solar as a credible electrification solution acceptable by local households. While traditional electrification programs had quasi-exclusively relied on grid extension, the PERG integrated grid extension and the diffusion of solar home systems into a grand national strategy aimed at harnessing the potential of all existing technologies to reach universal energy access on financially viable terms.

Second, assessing connection costs and the demand estimation and forecast proved critical in Morocco's national electrification plan. By conditioning the deployment of each electrification strategy to clear indicators relative to electrification costs and levels of demand, the PERG maintained a coherence between the various technical options for electrification (e.g., grid versus solar home systems) and the local demand and ability to pay, thereby ensuring a balance between *profitability* for power suppliers and *affordability* for local populations.

The success of the solar concessions stemmed from the integration of these demand analysis and cost estimates into tariffs and the design of adequate subsidies aiming to remunerate private operators on the basis of transparent revenue requirements.

Third, the gradual approach adopted in the PERG, and the division of the program into five stages, has played a key role in the monitoring of the solar program. It allowed the ONE to monitor progress via quantitative pre-defined targets and to leverage its increasing experience in electrification to further optimize electrification plans (demand forecast, ability to pay and pricing, concession contracts) with the support of international donors as the PERG unfolded.

[194] Debeugny, C. *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris.

[195] Pérez-Arriaga, I and Valdés, J.E. (2020), *Consultoría para la identificación y análisis de experiencias internacionales en la aplicación de modelos innovadores de acceso a la energía*, Consultancy Report for the InterAmerican Development Bank and the Colombian Ministry of Mines and Energy, Madrid.

Significant efficiency gains and periodic updates of the electrification plan led ONE to electrify most of the last 10% of unelectrified households within the predefined public budget.

Last but not least, Morocco's experience also demonstrates the potential of innovative financial schemes leveraging a range of instruments to finance integrated energy access policy. The controlled recourse to a range of bilateral and multilateral development finance institutions allowed the country to accelerate electrification and to retain sovereignty over its energy access policy while limiting the financial burden falling on public finances. As a matter of fact, the utility's ability to finance an average of 75% of the overall cost of the solar project (the remaining 25% being paid by consumers) allowed for the establishment of balanced and structured relations between public and private actors under the overall supervision of the national State-owned utility.

However, several issues prevented the solar concession program from reaching its anticipated scope and ambition. First of all, the reluctance of local populations to subscribe to monthly payment plans for solar home systems, that they perceived as a costly and limited alternative to a grid that was expanding at a quick pace in neighboring municipalities. This led the ONE to impose a buffer zone of several kilometers between the national grid and solar concessions in order to support the diffusion solar without hampering grid extension efforts.

Second, the primary target of Morocco's solar electrification plan were households and productive uses of electricity remained left aside. The rigid nature of concessions did not allow for a swift integration of larger-size systems into the solar PERG. The later adoption of a dedicated electrification program for productive uses, or PVER – for *Programme de Valorisation de l'Electrification Rurale* – faced limited funding and political support[196].

Third, technical, operational and financial issues typical of pre-pay-as-you-go business models for solar have imposed relatively high amount of subsidy per service offered. Costs of operation, maintenance and bill recovery increased sharply in remote areas, leading to high public subsidies requirements in order to balance affordability and profitability.

Lastly, the ONE did not coordinate with solar concessionaires and proceeded to grid connections in remote rural areas much faster than initially planned, competing with solar concessionaires in areas that were initially thought to be "reserved" for solar. This acceleration of grid extension efforts questioned the very financial viability of solar concessions and quality of service in areas unlikely to be electrified by the grid.

At the end of the day, the Moroccan experience not only confirms the potential of solar concessions backed by a national utility, but also provides interesting insights into the broader potential of solar concessions in energy access. It further confirms the synergies between national utility-driven approaches and more local solar territorial concessions. In the case of Morocco, the use of solar territorial concessions in regions identified as suited for solar by GIS

[196] ONE, *Rapports d'Activités* 1998-2017, Office Nationale de l'Electricité (ONE).

tools allowed for the targeted, timely, and financially viable electrification of remote rural areas unreachable by grid extension. The leadership of the ONE leadership in PERG guaranteed that solar concessionaires had one single clearly identified partner company to work and coordinate with. However, solar-driven electrification suffered from the lack of dialogue and cooperation between the ONE and solar concessionaires. Clear coordination and compensation rules between the national utility and solar concessionaires seem absolutely critical in order to ensure the long-term viability of solar concessions as the national grid expands I to solar concessions.

One should be careful in drawing parallels between country experiences and adapting Morocco's experience to other low access rate countries. The development of a financially viable universal electrification plan was facilitated by the structure of the Moroccan market and the development level of the country. The program benefited from (i) a large potential for cross-subsidization between a large base of urban consumers and rural users whose usage of electricity would remain comparatively limited[197]; (ii) a limited need for cross-subsidies, due to the relatively high ability to pay of rural households compared to Sub-Saharan Africa economies; (iii) the DISCO's good financial health and ability to offer direct subsidies for solar, since the distribution company was able to charge cost-reflective tariffs from end-users since the PERG's inception; and (iv) the financial health of the State, which eventually contributed to 75% of the overall cost of the solar project.

The South African and Moroccan experience illustrate the range of outcomes resulting from past and current solar-driven electrification projects tasked with reaching bottom-of-the-pyramid populations unreachable by grid extension or mini-grids. While South Africa's program may well show the financial, technical and operational risks posed by ill-prepared concessions and their outcome, arguably worse than a laissez-faire policy leaving markets drive the diffusion of solar, Morocco's experience has proved that territorial solar concessions could help planners close the electrification gap under adequate conditions, confirming the lessons from Latin American experiences in Peru and Argentina.

Both the Moroccan and Senegalese experiences provide planners with valuable lessons pertaining to the design and implementation of successful solar-driven electrification projects and their integration within IDF. The next chapter takes stock of these lessons and recent development in the solar sector and aims to provide a structured proposal of guidelines for future solar electrification programs.

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[197] The ratio "urban population"/"rural population" may not, in itself, be a reliable indicator of the potential for cross-subsidization. While the literature on the topic remains completely non-existent, one might prefer a more volumetric approach comparing loads; i.e., the power consumed (in MWh) by urban and rural populations to assess the effective potential for subsidization of electrification programs and power distribution in rural areas by urban and peri-urban consumers.

6. Guiding principles for solar electrification

Widely perceived as a means to close the electrification gap wherever the grid and mini-grids could not expand under sensible financial terms, the solar sector must be given the means to fulfill its full potential and effectively complement other electrification modes. Among all possible institutional frameworks - from laissez-faire to pure nationalization, this thesis argues that territorial concessions appear to be the most promising avenue to not only accelerate but *make possible* the diffusion of solar in the most challenging areas yet to be electrified. This framework could also be expanded into areas closer to the grid or mini-grids, or already electrified with poor level of reliability. This chapter details technical, operational and financial guidelines for the development and implementation of territorial solar concessions within integrated distribution frameworks.

6.1. Objective of solar electrification

Integrated distribution frameworks list universal energy access, integrated planning, economic and financial viability, and socio-economic development as key pillars of any successful electrification program.

In practice, transposing these objectives to solar is particularly challenging. As opposed to the grid and mini-grids whose expansion and expected scope will expand over time, solar is considered under IDF as a default electrification solution to fill *any gap left by other electrification means* – from a couple percent of a country's population in some Latin American countries such as Colombia[198] to a substantial portion of the population in most Sub-Saharan economies.

Therefore, and in more operational terms, the role of solar could be segmented into two complementary missions:

(i) To *make possible* the electrification of regions unlikely to be electrified by grid extension or mini-grids in the medium term – e.g., a couple of years, though the specifics depend on each territory – by providing a solution likely to remain in the medium or long term.

(ii) To *accelerate* the electrification of zones either already connected by the grid or mini-grid with poor level of reliability, or currently unelectrified and likely to be electrified in the medium term – e.g, within a couple of years – by providing a temporary solution likely to be replaced by another electrification means in the medium term.

Harnessing the potential of solar on both fronts will prove all the more challenging given the current situation of the solar sector mentioned above, characterized by dynamic and financially attractive business models thriving in free-market environments and used to operating on private sector-driven expectations outside local regulatory frameworks.

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[198] World Bank, World Development Indicators database, accessed on February 11th 2021.

More specifically, institutional frameworks for solar electrification should address two major challenges. First of all, these frameworks should find a way to harness the full potential of solar in the long term in areas where it has the most value compared to the grid and mini-grids. Planners should provide necessary incentives to solar companies to act as default electricity providers and get involved in a long-term regulated service to provide sufficient and reliable energy access in the most challenging contexts. In other words, a central mission of any framework for solar electrification would be to define appropriate regulatory measures balancing profitability and affordability, incentivizing solar companies to move from cherry-picking the most profitable customers in urban and peri-urban areas to engaging in rural electrification and serving bottom-of-the-pyramid populations at scale until reaching full electrification.

Second, institutional frameworks for solar electrification should aim to not impede but rather support the later electrification by the national grid or mini-grids.

Territorial solar concessions are one possible avenue to offer solar companies adequate financial and legal incentives in exchange of binding long-term commitments to universal energy access and a minimum quality of service. The next sections outline regulatory, financial, technical and institutional guidelines for solar concessions.

6.2. Geographical scope of solar territorial concessions

A key aspect of solar concessions is the determination of their geographic scope, likely to evolve as other electrification modes expand into rural areas.

Territories could be segmented into at least two types, each calling for a different approach to electrification. The first type of territories are zones where solar is likely to remain the only possible electrification means for the foreseeable future – provided that proper incentives make solar electrification possible in the first place. Territorial solar concessions seem best suited to these remote areas unreachable by grid extension or mini-grids under financially viable terms, or by solar companies under current free-market rules.

The geographic scope of solar concessions in such territories should be defined based on transparent and simple criteria pertaining to electrification costs and the level of demand, which must be tailored to the local contexts. To this end, geospatial planning tools could prove useful if used with caution. These tools typically provide planners with a long-term least-cost electrification mix, where grid extension and mini-grids cover the largest maximal financially viable territory, limiting solar to the most challenging rural markets. However, the role of solar is likely to evolve over time as the coverage of grid and mini-grids expands. “Intermediate” least-cost electrification mix simulations would therefore be better suited to the design of solar concessions. The scope of territorial concessions could for example be based on simulations of the reach of solar systems at a given deadline – for example 1 to 3 years. By setting this reference year, planners have an opportunity to offer visibility to solar providers that are guaranteed to have their market "secured" against other electrification modes[199] of sufficient size (the scope of solar is likely to shrink as other electrification modes expand) while also limiting territorial concessions and associated market distortions to challenging rural areas where solar companies hardly operate on financially viable terms[200]. The reference year will also determine the level of market distortion in remote rural areas where the diffusion of solar remains limited comparatively to urban and peri-urban areas.

The second type of territory warranting solar electrification are areas either already electrified by the grid or mini-grids but with poor levels of reliability, or likely to electrified by grid expansion or mini-grids in the medium term and left aside by the previous concessions. Territorial concessions could expand into such territories in order to *accelerate* electrification by providing a temporary means of access to electricity to households left unserved by solar providers under the current free-market rules. The relevance of solar concessions in such territories will depend on the local context and governments' willingness to accelerate electrification at the cost of significant market distortions.

In practice, planners could consider several scenarios giving different weights to solar in national electrification programs. A first option would be to limit solar concessions to the first case and the most challenging territories where solar is likely to remain the only possible electrification means in the foreseeable future – at a deadline to be defined by local authorities. This case has the advantage of giving solar providers more security against other electrification modes in the medium term and limiting the needs of public subsidies for solar electrification, at the cost of a slower electrification of the territories poorly covered by the grid or mini-grids or likely to be connected in the foreseeable future. This solution has remained the default option in the few countries that experience solar concessions and remains the fastest option to implement solar concessions in remote areas at the cost of a slower pace of electrification of bottom-of-the-pyramid populations in the rest of the country.

A second case would be the creation of solar concessions covering both territories. This option has the advantage of providing accelerated pathways for the electrification of populations left aside by the DISCO or mini-grids at the expense of significant coordination challenges between electrification modes (and therefore a longer planning stage), a necessary promotion of solar as a comparatively more expensive but temporary electrification solution until the later connection by another mode, and higher public subsidies for solar. Significant backlash is to be expected by existing solar providers operating outside of the concession framework and without public subsidies. Providing the concessionaire with a different set of financial incentives in the two territories could partially mitigate market distortion if deemed necessary.

[199] The compensation model for early connection by the grid or mini-grids will be detailed in a subsequent chapter.

[200] The coexistence of a solar concession and other non-regulated solar operators will be addressed in a subsequent chapter.

A third option could be to separate the two territories into different territorial solar concessions with their own rules. This option, although heavier administratively and raising important coordination issues between the solar concessionaires in the two territories, would give planners more room to mitigate market distortions in areas already covered by solar providers while also segmenting the risk associated with solar concessions into two different concessions with different risk profiles and opportunities[201].

The adoption of any of these three models, or possible coexistence of these different models in different parts of a same country, will likely depend on local contexts, political willingness to accelerate electrification at the cost of increased institutional and financial risks, and effective ability of stakeholders to coordinate the joint expansion of all electrification modes as per IDF guidelines.

6.3. Size of territorial solar concessions

Recent developments in the solar sector and the emergence of pay-as-you-go business models have modified the financial fundamentals of the sector. While the geographical scope of solar should primarily be based on least-cost electrification models, the possible division of territorial solar concessions between different solar providers should balance the exposure risk to a few concessionaires unable to achieve the desired results in a timely fashion and the need to guarantee sufficient economies of scale to solar providers.

The issue of concession sizing remain important as geospatial planning tools typically rely on outdated models, and do not account for the specific cost structure of pay-as-you-go business models and associated high upfront costs facing newcomers in the sector. While past territorial concessions typically included 5,000 to 15,000 systems, pay-as-you-go solar companies may require a different treatment and a concession possibly greater than previous concessions in order to achieve break-even and financially viable operations. The exact size of the solar system should therefore be determined by planners after extensive consultation of solar developers and assessment of the required economies to achieve the desired cost structure while checking for the effective ability of solar providers to deliver services at scale in remote rural areas.

6.4. Obligations of the solar concessionaire

The primary objective of territorial concessions remains to fill the electrification gap left in the allocation to solar systems in the least cost plan that is not covered under free-market rules. End-users remain free to opt for other solar home systems - at their own expense. Concession contracts should enforce a binding universal electrification mandate placing solar as ultimate default electrification mode at the country scale and require solar companies to commit to a long-

[201] The first concession, covering remote areas, who benefist from a relative isolation from other electrification modes at the cost of an increased reliance on public subsidies in currently untapped markets. The second concession would provide a more easily reachable set of customers at the expense of a higher exposure to coordination issues with the national grid and mini-grids. While the issues facing concessionaires in these two territories could and should be expected and addressed explicitly in the concession agreement, planners and solar companies may prefer to segment risks into separate entities with its own contractual terms and financial risk profiles.

term role as default service provider — a sharp departure from the short-term approach dictated by financial incentives and currently prevailing in the sector.

To this end, territorial concession contracts could include a set of obligations ensuring universal energy access and the delivery of a minimum quality of service. Obligations should include:

(i) customer acquisition and contracting;
(ii) the installation of the solar systems following the technical standards defined by the concession contract;
(iii) the maintenance of the solar systems for a pre-defined period of time tailored to the specifics of each system;
(iv) the periodic renewal of the solar system with predefined criteria and financial terms;
(v) revenue collection;
(vi) environmental control, such as the collection and recycling of used parts and batteries;
(vii) maintaining a clear ownership structure for the systems, that remain the property of a public authority (in the *affermage* model), the DISCO (as was the case in Morocco), of the solar company, or of the consumer after a given period (if operating in a rent-to-own model).

What is more, and most importantly, the solar concessionaire will be responsible for ensuring that its products follow the technical standards determined in the concession agreement. The term of the concession should define the technical specifications of the solar systems to be sold (e.g., services offered, maximum power of the system) and the concessionaire should meet the demand with one single system or a range of systems with well-defined features. In the latter case, the concession agreement should define a minimum level of service to be offered within the concession.

The concession contract could also regulate the type of pay-as-you-go business model used within the concession. While most solar companies operate on a rent-to-own (RTO) model in order to maximize short-term profitability, regulators wishing to establish a long-term concession may want to enforce the use of an energy-as-a-service (EAAS) model whereby customers prepay indefinitely for the use of a system that remains the property of the concessionaire (or of the State/DISCO in the case of an *affermage*). Trading short-term profitability for financial visibility and longer-term income, the energy-as-a-service approach also allows for lower monthly user's fees, increasing the affordability of the solar systems among underprivileged rural communities, decreasing default rates, and ultimately lowering the need for public subsidies. More detail on the tradeoffs between RTO and EAAS models and the role of EAAS in the specific context of long-term energy access programs is presented in the **Annex**.

6.5. Remuneration of the concessionaire and subsidy mechanisms

The solar concessions should balance profitability and affordability, providing solar companies with enough financial incentives to engage them into tight regulatory regimes. The remuneration of the concessionaire and associate subsidy framework to cover any gap between costs and revenue requirements will likely determine the success of the concession and effective ability of local authorities to leverage the dynamism of the solar sector to electrify populations left aside by other electrification modes.

The financial viability of the solar concession will likely require remunerating the concessionaire at the cost of service at a single tariff per concession per type of solar system. The concessionaire should be remunerated by tariffs as well as public subsidies compensating for the difference between the tariffs charged to end consumers and the concessionaire's cost of service.

This remuneration model, well suited to attracting private actors into difficult rural markets, raises two major challenges. First of the all, reaching universal access in remote rural areas will require the expansion of solar companies' activities into untapped markets where these companies have little to no experience compared to urban and peri-urban centers. Assessing distribution costs in such geographies may therefore prove challenging, all the more for private actors obeying stringent profitability expectations, and will require substantial time as well as financial assistance from public stakeholders.

Second, costs are likely to vary in each region, increasing with the distance to distribution hubs and urban centers. The viability gap between costs and revenues is therefore likely to vary over space and time, warranting the design of flexible subsidy regimes accounting for such variability across regions – either providing an averaged subsidy for the entire concession, or subsidies tailored to the company's cost structure in a given territory. This subsidy will also depend on the number of systems sold, and several subsidy regimes should be established for each type of system required from the concessionaire in the concession agreement.

In order to compensate for the gap between tariffs and the company's agreed revenue per system, planners should leverage all possible subsidization mechanisms available. These traditionally include direct subsidies as well as cross-subsidies (or similar to a "solidarity tax" or "rural electrification tax") from grid and possibly mini-grid consumers. The role of cross-subsidies is likely to represent a small share of the amount of subsidy needed initially and to progressively increase as the pool of grid and mini-grid consumers increases with time.

6.6. Coordination with other electrification modes

The concept of integrated distribution frameworks places integration and coordination among all electrification modes as a key success factor of electrification programs. Solar concessions should define "connection rules" serving two objectives. First, provide solar companies with financial and legal incentives to engage into long-term electrification efforts with a guaranteed income over a minimum period of time. Second, allow for a possible acceleration of the national electrification plan and prepare for the connection to the grid or a mini-grid of households served by solar companies, and compensate the affected parties while safeguarding the financial viability of each electrification mode.

Concession agreements should therefore anticipate and prepare the connection of households served by solar companies under mutually agreed financial terms. To this end, planners could provide financial visibility to solar company by offering the concessionaire a minimum guaranteed revenue per customer.

This guaranteed income could be defined in several ways. First, by giving the solar provider "exclusivity right" over a defined period of time (for example three to five years) and compensate the concessionaire with a predefined "connection fee" in the eventuality of the early connection to the grid or to a mini-grid before the expiration of the concessionaire's "exclusivity right" and paid directly by the grid operator or the mini-grid developer to the concessionaire. The "connection fee" would depend on the system sold by the solar concessionaire and would be independent of time, provided that the connection takes place before the expiration of the "exclusivity right". This approach would provide financial visibility to solar developers and full "protection" from early connections while also allowing for a possible acceleration of the national electrification plan, whereby public authorities could for example subsidize the payment of the connection fee in order to accelerate the extension of the grid or the deployment of mini-grids ahead of schedule without affecting the financial viability of the DISCO or mini-grid developer.

A possible variation of this model would be to define the connection fee as a function decreasing with time. This connection fee would be set initially to the expected revenue per consumer, later decreasing to zero at the end of the "exclusivity right' of the solar company. This variation on the previous model would incentivize the solar provider to increase its revenue per user in the early years of the concession (through additional services) and lower the cost of an acceleration of the grid/mini-grid electrification plan.

The concession contract could also include post-connection clauses offering solar providers the opportunity to provide services to newly connected grid/mini-grid customers within the territorial solar concession, such as productive systems, appliances, or insurance policies.

The duration of the "exclusivity right" is independent from and shorter than the duration of the concession. While the solar provider is offered the opportunity to generate revenues from its users during the entirety of the duration of the concession, and will likely do so in part of its concession, the "exclusivity right" aims to provide the concessionaire with the guaranty of a minimum revenue per user over the duration of the concession.

Planners should also recognize that the importance of this "connection fee" and "exclusivity right' will likely vary with the geographic scope of the territorial solar concession. While concessionaires operating in remote rural areas with limited to no interactions with the national grid and mini-grids in the medium term may not see the adoption of such mechanisms as critical to their success, the timely and adequate design of the "connection fee" and "exclusivity right" will likely be critical in de-risking concessions closer to the grid and mini-grids and making these viable and attractive to solar companies. The success of territorial solar concessions in areas close to other electrification means is therefore likely to be conditional upon the completion of negotiations on mutually agreed "connection fees" and "exclusivity rights" between solar developers and public authorities.

6.7. Attribution of the territorial solar concession

The awarding process could proceed in various ways, ranging from direct awarding to competitive bidding. While direct attribution remains the fastest way to initiate the concession, competitive bidding would provide the State with more choice over the concessionaire while ensuring the transparency of the selection process.

A direct attribution of a territorial solar concession to a solar operator would allow public authorities to kickstart their rural electrification plans on a timely basis. This option should be pursued in a transparent fashion, place the possible concessionaire as *one* favored option whose approval remains conditional on the success of the negotiation with the State, and explicitly mention the option of opening the concession to competitive bidding in case of failure of the discussions. A major risk to be anticipated by planners remains the lack of transparency in this direct negotiation process and the large bargaining power of the possible concessionaire against public authorities, that may not be informed about opportunities arising from other market players.

In practice, the implementation of territorial solar concessions will likely face initial skepticism from pay-as-you-go operators until results from early field pilots are successful and few solar companies might be both willing and able to pursue territorial solar concessions at scale. Direct attribution might therefore allow for the timely development of a "proof of concept" that would, if successful, attract more companies within regulated solar electrification strategies.

A second and somewhat more traditional option is the attribution of a territorial solar concession through competitive bidding, privileging transparency and free markets at the expense of a possibly longer negotiation phase. One key issue in this case would be the design of the bidding process itself. While planners could consider several possible bidding strategies, one possibility is to make potential concessionaires bid on the one-off and annual public subsidies that would be needed to meet the concession agreement's requirements of universal energy access and quality of service over the entire duration of the concession. The "connection fee" and "exclusivity right" would be set by public authorities ahead of the bidding process. This approach, based on a cost strategy, aims at maximizing the number of households electrified per public dollar invested while limiting the intervention of the concessionaire defined to the requirements of the concession.

In order to incentivize innovation from the private sector and promote the development of new services to customers within the territorial solar concession, public authorities could also add to the aforementioned bidding process a second element. With this second model, the public sector would require prospective concessionaires to bid on the additional services (e.g., productive uses, clean cooking, health insurance) that they could provide to customers in exchange for pre-defined public funding (e.g., subsidies, loans) - in addition to fulfilling the concession's universal energy access and quality of service requirements. Such strategy would foster the development of additional services in rural electrification, de-risk private sector innovation by subsidizing field pilots on risky projects with high socio-economic impact, while leaving the private sector in charge of proposing the technological, operational and financial innovations to be implemented on the ground. A major drawback of this approach might be the scattered impact of the resulting projects – an issue that could be addressed through periodic reviews of the projects and conditioning the disbursement of public subsidies to the structuring of services as stakeholders gather field experience.

Solar concessions therefore appear as a promising regulatory vehicle to provide electricity access in remote areas unlikely to be electrified by other electrification modes in the short to medium term. Building on past experiences, planners are in a position to harness the full potential of solar and make it fulfill its dual role of *enabling* access in remote areas, and *accelerating* access in regions closer to the national grid or mini-grids without impeding their later expansion.

The success of territorial solar concessions will be conditioned to the planners' ability to balance stringent universal energy access and quality of service requirements with medium to long-term financial and legal incentives.

7. Conclusion

There is a trend in the energy sector to move away from siloed approaches to energy access. Holistic approaches to energy access have the potential to break the current status-quo and to not only accelerate electrification, but also make universal energy access *possible* at the earliest possible deadline through tight coordination among electrification modes and adequate allocation of technical, human, and financial resources among the national grid, mini-grids, and standalone solar. Realizing these benefits requires careful identification of the key bottlenecks in energy access and the design of adequate frameworks based on an integrated approach that includes institutional, regulatory, economic, financial, technical, and operational analysis of the distribution sector in its present and likely future form. However, although acknowledged by the international community, this integrated approach has not yet been widely analyzed or applied in the design of distribution sector reforms and the structuring of energy access policy in developing countries, where investment requirements, financing capabilities, and institutional capacities can vary widely compared to power sectors in industrialized countries. As a result, energy access has not experienced any significant breakthrough and prospects for improvement remain limited. This dissertation demonstrates how integrated approaches could be applied in practice to advance the universal energy access agenda through a detailed analysis of the IDF[202] and possible regulatory vehicles allowing for its implementation.

[202] As defined in Pérez-Arriaga, I., Nagpal, D., Jacquot, G., Stoner, R.J. (2020), *Integrated Distribution Framework: Guiding Principles for universal Energy Access*, Global Commission to End Energy Poverty, MIT Energy Initiative, Cambridge. https://www.endenergypoverty.org

7.1. Contributions

From a study of past and ongoing African experiences in energy access, this dissertation demonstrates that the Integrated Distribution Framework[203] is a prime avenue to address key bottlenecks in distribution sector reforms for universal energy access. To explore how IDF can be applied in developing countries, this thesis focuses on the potential of concessions as a possible regulatory vehicle for the implementation of IDF. After a high-level presentation of the concession model, it examines the potential of utility concessions, briefly mentions the role of mini-grid concessions, and concludes with a much more thorough analysis of solar concessions as a possible way to integrate off-grid solar into regulated mechanisms for universal energy access such as IDF.

The primary contributions from this work include establishing a solid grounding of the concept of integrated approaches to energy access into past and ongoing experiences in Sub-Saharan Africa (Chapter 1); the identification of the key high-level institutional, regulatory, economic, and financial challenges facing the implementation of the IDF (Chapter 2); a review of the potential of territorial utility concessions for the implementation of IDF and outlining possible guidelines to design IDF-like utility concessions for universal energy access (Chapter 3); a brief analysis of the limitations of current mini-grid concessions in energy access and the need for further reforms to bring mini-grid concession into the realm of IDF (Chapter 4); an assessment of the role of solar concessions in harnessing the full potential of solar in universal energy access, and the challenges facing planners in the integration of off-grid solar into IDF (Chapter 5); a framework for the design and implementation of solar concessions (Chapter 6).

This thesis relies on a detailed study of past and ongoing African experiences and, to a lesser extent, some Latin American and Asian experiences in energy access. The specific recommendations developed as part of this analysis can be generalized and applied to similar contexts.

7.2. Future work

This dissertation aims to pave the ground for more analysis on the implementation of integrated approaches to energy access in developing countries, with a strong emphasis on the role of the Integrated Distribution Framework. While the topic of integrated energy access planning could be approached in a wide range of different ways and raise innumerable questions, this thesis gives rise to opportunities for further research in several key areas.

First of all, the analysis of IDF could be improved with a more thorough analysis of the key high-level institutional, regulatory, economic, and financial challenges facing planners that is mentioned in Chapter 2. While this thesis deliberately focuses on the specific issue of possible regulatory vehicles and more specifically on the role of concessions as a means to implement IDF, more research will be needed on several fronts: a rethink of the structure of the three

[203] *C.f. supra.*

segments of distribution – namely the national grid, mini-grids, and standalone solar – to turn them into dynamic and financially viable sectors harnessing the full potential for cooperation among electrification modes to drive universal energy access efforts; a more thorough analysis of the role of mini-grid concessions in IDF and actionable guidelines for planners in this field, similarly to the work done in this thesis for solar concessions; the assessment of the financing requirements of IDF and the design of associated financing instruments; an assessment of the macroeconomic limitations to the implementation of IDF and possible strategies to circumvent sovereign debt issues; the development of joint energy access and industrial policies linking distribution sector reforms to the targeted development of priorities in industries with a high socio-economic impact.

Second, more research is needed on the governance of energy access and possible governance arrangements allowing for the implementation of IDF. The distribution and energy access sectors have long been paralyzed by a status-quo stemming from four compounding challenges: (i) the lack of a clear political commitment toward universal energy access; (ii) the need for an actionable strategy to reach universal energy access (such as the Integrated Distribution Framework); (iii) the necessity to identify stakeholders best placed to spearhead the design and implementation of this strategy on the ground; (iv) the practical implication of articulating all possible financing mechanisms, and creating new mechanisms as needed, in national universal energy access programs. Establishing a clear hierarchy and a logical flow among each of these four challenges will likely prove key in unlocking the full potential of integrated approaches, such as IDF, for universal energy access.

Finally, further research could also examine the validity of the key lessons learnt to various other contexts, not only in Africa where most of the examples are drawn from and are therefore likely to transpose "easily" to, but also in the specific contexts of Latin America and Asia.

8. Annex

Business models for solar: the role of energy-as-a-service in long-term energy access planning

One of the critical success factors for the development of PAYG solar has been the flexible payment terms offered by solar companies. PAYG solar companies now offer customers the opportunity to prepay the use of their systems on flexible terms with the possibility of putting their repayments on pause for a number of “grace days” reducing the burden on cash-strapped households.

PAYG solar companies typically operate on two possible models, with very different objectives and results: (i) energy-as-a-service (EAAS) and (ii) rent-to-own (RTO). Driven by high short-term profitability expectations, RTO remains poorly suited to long-term electrification programs aiming for universal electrification. EAAS seems better positioned to provide reliable and affordable services at scale at the cost of a longer-term profitability.

The energy-as-a-service model

The “energy-as-a-service” (EAAS) model builds on a traditional approach of electric services. Customers prepay the use of the solar system on a daily, monthly or yearly basis and enjoy their SHS for a predefined time depending on the amount prepaid, until the system automatically locks down. Under this model, the SHS remains the property of the solar company and represents a slow and steady source of cash to the PAYG solar company. Solar companies operating in Sub-Saharan contexts typically provide aftersales services and technical warranty for a predefined time.

In practice, financial limitations have led solar companies to question the viability of the EAAS approach. The relatively small prepayment fees, and growing maintenance costs over time led solar companies to transition to a more transparent and profitable lease-buy model.

Transitioning to the lease-buy (or “rent-to-own”) model

The transition to the lease-buy model has been driven by financial, operational and technical objectives aiming to increase solar companies’ short-term profitability:

(i) provide limited technical warranty on solar products for a predefined time, thereby limiting maintenance costs, passing on technical, operational, and financial risks to end customers;

(ii) transfer the ownership of the SHS to the customer itself, thus incentivizing households to take care of their devices and further reducing maintenance costs during the warranty period;

(iii) increase short-term revenues, which mechanically increases the IRR and facilitates raising debt and venture capital in a sector that investors used to perceive as extremely risky and not trustworthy;

(iv) develop additional revenue streams by selling separate insurance packages once the initial warranty is over – this package is usually sold after the system has been entirely repaid, which makes it much easier for the company to sell its services and explain that even though the system is now the customer's property, the PAYG solar company can still provide insurance, but at an additional cost;

The RTO business model has become within a couple of years the new norm in the solar sector in sub-Saharan Africa. Customers prepay daily fees typically 30-50% higher than in the EAAS model and acquire the system over a 12-36-month timeframe.

Limitations of the RTO model in long-term electrification planning

The RTO approach has nevertheless several caveats, typical of private-sector driven strategies. First of all, RTO approaches value short-term profitability at the expense of long-term service delivery. Once the system has been sold to customers and entirely repaid, this consumer is "lost" and new sources of revenues are then needed to satisfy high profitability expectations. This forces PAYG solar companies to develop aggressive growth models that eventually proved unsustainable and led to the restructuring of the PAYG solar sector in 2017 and 2018.

Second, and as a corollary to this short-term mindset, PAYG solar companies offer a high-quality service that isn't guaranteed past the initial technical warranty on the system. Therefore, they typically do not offer the "permanence" of grid-based electrification solutions without additional mechanisms ensuring technical warranty and active customer engagement past the initial repayment.

Third, the idea of increasing the revenue per user through diversification is theoretically appealing but hard to implement in practice. This high-risk diversification is rendered particularly complicated by the high cost of capital faced by solar developers and the unbundling movement that started a couple of years ago, favoring highly specialized companies.

Fourth, the higher prepayment fees for RTO make PAYG SHS unaffordable to nearly 50% of the base-of-the-pyramid populations in sub-Saharan Africa[204] and prevent solar from filling the gap in regions where the grid or mini-grids could not be deployed.

The RTO model proved well suited to fast-growing start-ups subject to high short-term profitability expectations. Nevertheless, this model remains less suited to challenging environments where the market base is limited, access to capital is easier, and profitability is evaluated on a longer-term basis – such as in concessions. Planners should consider the EAAS as a credible alternative for solar concessions for universal energy access.

[204] Lepicard, F. *et al.* (2017), *Reaching Scale in Access to Energy: Lessons from Practitioners*, Hystra, Paris.