ENERGY, CLIMATE AND THE ENVIRONMENT

Off-Grid Solar Electrification in Africa

A Critical Perspective

Edited by Nathanael Ojong

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Energy, Climate and the Environment

The aim of this series is to provide texts which lay out the technical, environmental and political issues relating to proposed policies for responding to climate change. The focus is not primarily on the science of climate change, or on the technological detail, although there will be accounts of this, to aid assessment of the viability of various options. However, the main focus is the policy conflicts over which strategy to pursue. The series adopts a critical approach and attempts to identify flaws in emerging policies, propositions and assertions. In particular, it seeks to illuminate counter-intuitive assessments, conclusions and new perspectives. The intention is not simply to map the debates, but to explore their structure, their underlying assumptions and their limitations. The books in this series are incisive and authoritative sources of critical analysis and commentary, clearly indicating the divergent views that have emerged whilst also identifying the shortcomings of such views. The series does not simply provide an overview, but also offers policy prescriptions.

Nathanael Ojong
Editor

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Acronyms

AECF	Africa Enterprise Challenge Fund
ANEV	Agence Nationale des Ecovillages
ASER	Agence Sénégalaise de l'Electrification Rurale
BoP	Bottom of the Pyramid
BRD	Development Bank of Rwanda
CERER	Center for Studies and Research on Renewable Energies
CIF	Climate Investment Funds
CRSE	Commission de Régulation du Secteur de l'Électricité
CSR	Corporate Social Responsibility
DANIDA	Danish International Development Agency
DFID	Department for International Development
DRE	Decentralized Renewable Energy
EAQIP	Rwanda Energy Access and Quality Improvement Project
EARF	Energy Access Relief Fund
ECOWAS	Economic Community of West African States
ECREEE	Regional Centre for Renewable Energy and Energy Efficiency
EDCL	Energy Development Corporation Limited
EDF	Électricité de France
EDPRS	Economic Development and Poverty Reduction Strategy
EnDev	Energizing Development

ERA	Energie Rurale Africaine
ERIL	Electrification Rurale d'Initiative Locale
ESMAP	Energy Sector Management Programme
EUCL	Energy Utility Corporation Limited
FAO	Food and Agriculture Organization
FCDO	Foreign, Commonwealth & Development Office
GDT	Gestionnaires Délégués Transitoires
GEDAP	Ghana's Energy and Development Access Project
GIZ	Gesellschaft für Internationale Zusammenarbeit
GOGLA	Global Off-Grid Lighting Association
GoM	Government of Malawi
GoR	Government of Rwanda
GSMA	Global System for Mobile Communications
IEA	International Energy Agency
IFC	International Finance Corporation
IRENA	International Renewable Energy Agency
JICA	Japanese International Cooperation Agency
KNES	Kenya National Electrification Strategy
KOSAP	Kenya Off-Grid Solar Access Project
LED	Light-Emitting Diode
MAREP	*Malawi Rural Electrification Programme*
MBS	Malawi Bureau of Standards
MCC	*Millennium Challenge Corporation*
MDGs	Millennium Development Goals
MERA	Malawi Energy Regulatory Authority
MoMo	Mobile Money
MRES	Malawi Renewable Energy Strategy
NEP	National Electrification Plan
NGO	Non-Governmental Organization
NREP	Nigerian Rural Electrification Programme
ONE	Office National de l'Electricité du Maroc
PASER	Plan d'Action Sénégalais d'Electrification Rurale
PAYG	Pay-As-You-Go
PNUER	Programme National d'Électrification Rurale
PREM	Programme Energétique Multisectoriel
PUER	Programme d'Urgence d'Électrification Rurale
PV	Photovoltaic
REA	Rural Electrification Agency
REBs	Rural Electrification Boards

REF	Rural Electrification Fund
REG	Rwanda Energy Group
REIAMA	Renewable Energy Association of Malawi
RESIP	Rural Electrification Strategy and Implementation Plan
RURA	Rwanda Utilities Regulatory Authority
SDGs	Sustainable Development Goals
SE4All	Sustainable Energy for All
SENELEC	Société Nationale d'Électricité du Sénégal
SHSs	Solar Home Systems
SIDA	Swedish International Development Cooperation Agency
SMEs	Small- and Medium-Sized Enterprises
SSA	Sub-Saharan Africa
TANESCO	Tanzania Electric Supply Company
TANGSEN	Tanzania Gender and Sustainability Energy Network
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
VAT	Value-Added Tax
WTP	Willingness to Pay

3

At the Margins of the Grid: The Politics of Off-Grid Electrification in Senegal

Pascale Trompette, Emilie Etienne, and Rhosnie Francius

3.1 Introduction

Access to energy is a major challenge in Sub-Saharan Africa, which is characterized by low electrification rates, unreliable grids and high-cost electricity. Since the late 1990s, the promise of off-grid solar solutions, such as mini-grids and solar home systems (SHS), has been promoted as

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a way to address the challenges of electrification for poor and dispersed rural areas ill-suited to the grid economy. International aid programmes to achieve UN Sustainable Development Goal (SDG) 7, related to energy, not only look to increase electrification rates, but also support the development of the (mini-)solar technology industry, organizing Sub-Saharan African markets of energy access. Senegal is an interesting area in which to analyze these electrification markets at the margins of the grid. On the one hand, the country has one of the largest mini-grid portfolios in Sub-Saharan Africa, to which can be added the thousands of (pico-) solar home systems[1] provided by public or private suppliers. On the other hand, it confirms the still very limited expansion of such small solar projects driven by public policies.[2] This modest public expansion contrasts with the dynamics of unregulated and informal markets for stand-alone power equipment, including small-scale, low-cost solar technologies.

This chapter examines the role of public policies in shaping these plural landscapes of rural, off-grid electrification in Senegal. It focuses on the last two decades (1998–2021), during which successive proactive policies of so-called 'rural electrification' have taken place. Rural electrification is understood as an administrative category corresponding to the provision of energy to areas not covered by the grid (Guillou, 2022). We analyse the way in which these policies and their regulations have shaped different market segments involving a diversity of actors (transnational and local Small and Medium Enterprises [SME]) alongside the national electricity leader, Senelec, making offers that combine or compete locally (Cholez & Trompette, 2016; Guillou, 2022; Jaglin, 2019). We examine how the politics of (market-based) electrification raises issues of energy justice in different ways: in the controversies and negotiations concerning the implementation of neo-liberal reforms; the power asymmetries between energy suppliers associated with market

[1] In this paper, we use the term 'solar home system' or SHS to refer generically to solar domestic installations. The term 'solar kit' refers to pre-packaged (plug and play) equipment, usually based on paygo (prepayment) systems, supplied by private or public service providers as a product-service (maintenance) or product only.

[2] The 2019 report of the Système d'Information Energétique du Sénégal (SIE) estimates the share of photovoltaics at 7.51% of the rural electrification rate in 2018.

regulations; and territorial and social disparities in terms of price and service quality for the off-grid population. Finally, we consider the way in which energy justice issues are put on the agenda of public authorities and give rise to new forms of regulation.

Energy policy has long been addressed from the perspective of enabling environments for private investment and scaling-up mechanisms (Williams et al., 2015). However, such a perspective relates to a technical–economic approach of disseminating socio-technical innovations and does not sufficiently take into account the intrinsically political dimension of market making and how this raises issues of energy justice.

Our analysis explores how policies are converted into the regulations, instruments, technologies and accounts (e.g., tariffs, business models) (Halpern et al., 2014) that configure socio-technical energy systems in practice and, as such, enact different forms of energy justice (Jenkins et al., 2016; Latour & Venn, 2002). These policy instruments configure the infrastructures connecting citizens to public services (Von Schnitzler, 2008) according to the way in which service provision has been defined as a public concern. We further conceptualize the politics of energy as a collective space not only conducted by governments or administrations but also involving a plurality of actors (Smith, 2016), including donors, NGOs, private actors and citizens who can, via trade unions or social movements, contribute to the debates and controversies surrounding the paths to electrification. Conceptualizing politics as a collective space of value confrontation puts energy justice at the core of policy design, rather than considering it a consequence. The political work undertaken by the various stakeholders involves competing aspects of energy justice; i.e., what it concerns (distribution justice), whom it affects (recognition justice) and how it is processed (procedural justice) (Jenkins et al., 2016).

The chapter is organized as follows: the first section goes back in time to trace the history of electrification in Senegal up to 1998, a period dominated by the grid expansion and interconnection, until the emergence of the first experimental off-grid solar initiatives. The second section focuses on the electricity reform of the early 1999s, introducing a partition between Senelec's electrified perimeter and a new area of rural electrification, which was opened up to private investment and actors. The negotiated implementation of this electrification has led to

the coexistence of policies and counter-policies, resulting in a territorial patchwork in the supply of electricity services. Taking a close look at how the diverse actors are trying to respond to the challenge of off-grid electrification, Sect. 3.3 delves into energy justice for the implementers of rural electrification. Section 3.4 turns to self-electrification markets based on stand-alone solar systems, which compensate for the absence or failures of (mini-)grids, while at the same time competing with public electrification programmes based on solar kits. The variety of electrification schemes is examined from the villagers' perspective in Sect. 3.5, which shows how rural customers experience exacerbated service discrimination at different scales. Finally, Sect. 6 reports on recent governmental efforts to coordinate, harmonize and regulate the various configurations of electrification.

3.2 A Political History of Off-Grid Electrification in Senegal

3.2.1 Before 1998: The Predominance of Senelec, the National Electricity Company, for Rural Electrification

Off-grid electrification, as small-scale decentralized electricity production (mini-grid or individual kit), is a relatively recent concept in the history of energy access policies in Senegal. The first, very experimental, projects appeared in the 1960s, led by scientific pioneers in solar energy (Caille & Badji, 2018; Minvielle, 1999). However, it was only at the turn of the century that off-grid solutions became part of public policy in the wake of a major reform in 1998, followed by a first rural electrification plan, Plan d'Action Sénégalais d'Electrification Rurale (PASER). This set up a specific institutional framework for rural electrification by integrating mini-grids (diesel, solar or hybrid) and SHS as possible technical options alongside the grid.[3] To understand the development of these two related

[3] Report of Japanese International Cooperation Agency (JICA by its initials in French), L'Étude du Plan d'Electrification Rurale par voie Photovoltaïque en République du Sénégal, 2001.

notions of 'off-grid' and 'rural electrification', this section looks at the background, revealing a history of electrification long dominated by the grid-model. The incompletion of the grid and the crisis in the energy sector prompted the creation of an alternative approach to the so-called 'sub-sector of rural electrification'. It is on the genesis of this partition that we will focus in this section, since this is what has conditioned off-grid governance and regulation.

Throughout the twentieth century, the development of the grid played a role in supporting economic development in the colonial context and subsequently in the national construction of Senegal, even though it failed to socially integrate the country's sub-regions (Ardurat, 2002; Coquery-Vidrovitch, 2002; Diedhiou, 2016; Robert, 2016; Saupique, 2002). The 'age of the grid' (Coutard & Rutherford, 2009) took off in the post-World War One world, with the concentration of several private concessionaires in a large electricity company: the West African Water and Electricity Company (EEOA in French) created in 1929 (Saupique, 2002). The combination of public and private capital favoured investment in electricity grid extension to foster the economic development of the colonies, previously confined to an economy of rent-seeking (Saupique, 2002). Alongside the interconnected network, secondary towns, such as Djourbel and Ziguinchor, were electrified from 1925 with decentralized power stations.[4] Upon its independence in 1960, Senegal inherited an embryonic system of electricity production and service distribution, which was nonetheless one of the most advanced in French-speaking West Africa (Saupique, 2002). For two decades, the post-colonial socialist government aimed to become economically independent through industrial development and growth, a strategy that heavily relied on the expansion of the electricity grid (Coquery-Vidrovitch, 2002; Robert, 2016). In this endeavour, the Senegalese government increased public investment and control over the electricity sector with the creation of Senelec in 1971 and its nationalization

[4] Rapport de Mission en Afrique Occidentale Française, Électricité de France, Service des Etudes d'Outre-Mer, 1948–1949. In the context of the Plan de Modernisation et d'Equipement des Territoires d'Outre-mer (Modernization and Equipment Plan for the Overseas Territories) initiated by the French government in 1946, the report reviews the existing infrastructure in Senegal and other countries of French-speaking West Africa (Togo, Guinea, Sudan, etc.).

in 1983. Electrification followed urban growth and remained focused on industrial development and public lighting, while also increasingly satisfying domestic needs (Minvielle, 1999; Robert, 2016).

Throughout this first century of infrastructure development, the rural world remained a no-man's land for electrification, limited to traditional energies, with a perceived limited energy demand (Robert, 2016). In the 1980s and 1990s, when the rural population's electricity needs were first considered a legitimate issue, the aim was above all to support the primary sector, although these merely economic objectives gradually gave way to a social project to improve the living conditions of the population. Nonetheless, the integration of rural areas into the political geography of electrification was inhibited by the crisis of the energy sector. At the turn of the 1990s, the sole maintenance of an ageing interconnected urban grid absorbed most of the electricity investment, while the quality of service deteriorated (Niang, 2011; Robert, 2016).[5] In his analysis of the electrification policies of this period, Robert (2016: 310) concludes: 'Rural electrification is thus the big loser of the energy policy of the 1980s. With the difficult economic context, Senelec does not have the capacity to invest in it'. Profitability constraints and the misconception that the rural population needed little electricity resulted in energy poverty.

The first tentative steps towards rural electrification remained modest, with only 5–8% of the rural population electrified by the end of the 1990s (Mawhood & Gross, 2014). Twenty-four secondary centres and just over 100 villages benefited from this first wave of electrification by Senelec in the mid-1990s. A few dozen more were electrified by non-governmental organizations (NGOs) and private actors (e.g., Isofoton) or international cooperation (notably the German Cooperation agency GIZ[6] and the Japanese government) (Ndiaye, 2011; Robert, 2016). It was in this context that the concept of 'off-grid' first appeared, referring to decentralized electricity production, with limited capacity (mini-grid or individual kit); it was based on mini diesel-power plants but with

[5] The ambition of grid expansion was hampered by sectorial difficulties as well as debt crises, combined with galloping urbanization linked to the rural exodus, oil shock and recurrent agricultural droughts.

[6] Gesellschaft für Internationale Zusammenarbeit (GIZ).

the idea of being combined with or, more importantly, substituted by renewable energy mini-grids, notably solar ones.

Senegal is described as one of the cradles of photovoltaic (PV) electrification, with research and innovations developed since the early 1960s (Caille & Badji, 2018; Minvielle, 1999). Pioneering technological research was initiated within the framework of collaboration between French and Senegalese researchers, resulting in the creation of the Center for Studies and Research on Renewable Energies (CERER). In addition, a large number of renewable energy projects were initiated by bi- or multilateral cooperation (Minvielle, 1999).[7] All these initiatives resulted in pilot pumping stations, irrigation systems and small solar power plants. Nevertheless, the off-grid PV concept was not yet mature; installation and operating costs were high with the result that off-grid solar energy remained limited to scattered, experimental initiatives.

Until the reforms of the 2000s, rural electrification stood out as the poor cousin of the grid story. Too far from urban centres, long ignored and then hard hit by austerity policies, rural citizens benefited at most from piecemeal interventions, mostly from international aid. Solar projects surfaced mostly as innovative experiments in the context of development aid, and despite the political interest of public authorities, they remained at the margin of electrification policies.

3.2.2 The 1998 Reform: The Fragmentation and Privatization of Rural Electrification, with the Emergence of New Actors and Regulations

At the end of the 1990s, against the background of the debt crisis, the Senegalese government came under strong pressure from international institutions, in particular the World Bank, to reform the electricity sector. The subsequent reforms aimed to increase private investment and performance through partial deregulation (Diouf & Miezan, 2021; Mawhood and Gross, 2014). The national electricity company, Senelec,

[7] 'Senegal is the country with the largest number of international interventions, bilateral or multilateral, in the field of renewable energy' (Minvielle, 1999: 63) [translated by the authors].

considered by international experts unable to overcome a chronic deficit and even less able to be reformed,[8] was marginalized in the electrification plans targeting off-grid areas, to the benefit of private investors. Law no. 98–29 of 14 April 1998 established a new legislative framework for the electricity sector in Senegal, limiting Senelec's prerogative to already electrified territories, which were overwhelmingly covered by the grid. Under the authority of the new Senegalese Rural Electrification Agency (Agence Sénégalaise de l'Electrification Rurale [ASER]), the areas to be electrified were open to public–private partnerships through concession contracts. Since the 1998 reform, the whole sector has been regulated by the Regulatory Commission for the Electricity Sector (Commission de Régulation du Secteur de l'Electricité, [CRSE]).

The first electrification plan, PASER,[9] was launched in 2002, dividing the country into concessions.[10] Concessions[11] are vast territories with a radius of approximately 100 km, covering hundreds of localities or villages in several departments and regions, with an estimated market potential of 10,000 to 30,000 connections each. Tenders have been offered to increase the share of private investment, with companies competing to connect the largest number of customers on the basis of a pre-agreed public subsidy. Enthusiastically supported by international donors, the reform initially fulfilled its promise by attracting substantial funds (De Gouvello & Kumar, 2007; Mawhood & Gross, 2014).[12] Total financial commitments were twice as high as initially required. Large national corporations from Morocco (ONE), Tunisia (STEG),

[8] Between 1996 and 2002, under pressure from the World Bank, Senelec underwent several privatization attempts, which gave rise to violent social conflicts with the important Sutelec union (one of the main Senegalese trade unions) (Ndiaye, 2017; Sene, 2013). The successive failures of private partnerships (e.g., Elyo and Hydro Quebec) led the State to take back a majority share in the company which, since the 1998 reform, had operated as a concessionaire (Sene, 2013).

[9] The PASER aimed to raise the electrification rate from 8% in 2005 to 30% by 2015, and 60% by 2022.

[10] See: Lettre de Politique de Développement du Secteur de l'Energie, 9 April 2003 (LPDSE), CRSE.

[11] The number and limits of these concessions were stabilized only in 2010.

[12] 'PASER has attracted offers of finance from donors in excess of $159 million (ASER, 2012) (…). The winning bids secured a contract of [USD] 52m in private finance, representing 49% of the total investment' (Mawhood & Gross, 2014).

and France (EDF), as well as the large Spanish solar company Isofoton, in partnership with Senegalese companies in the solar sector (LCS, Matforce, ENCO and LCL) bade for these concessions. Benefiting from an additional subsidy, off-grid solutions (mini-grid and SHS) based on renewable technologies have been a possible option for concessionaires, in addition to grid extension. For remote villages, cheap SHS or solar kits for areas far from the grid have been favoured at the expense of grid extension or mini-grids.

This planning approach has been complemented by a scheme supporting local initiatives for rural electrification, known as Electrification Rurale d'Initiative Locale (ERIL), in localities excluded from the priority plans of concessionaires, even those located within the geographical perimeter of the latter. ERIL has provided a policy frame for scattered small-scale projects of domestic electrification.[13] Such initiatives were designed for a maximum of 200 customers and could be carried out by partnerships between the state, local authorities, village community groups, NGOs, associations of consumers or migrants, or local private companies (Law no. 2006, dated 18 June 2006). ERIL projects have also been initiated by Senegalese small and medium companies in response to ASER's calls for tender. ERIL has become the go-to ground for off-grid solutions (diesel or solar powered mini-grid, SHS), and can be subsidized up to 80% by the Senegalese state or external donors.

The 1998 reform and the first rural electrification plans drew a political division between three areas with different governance of electricity service provision. Firstly, there was the interconnected urban grid (completed by secondary power plants), operated by a company (Senelec) still controlled by the state, with only a few mini-grids (diesel

[13] The same policy frame for multi-sectorial energy programme, called PREM in French (Programme Energétique Multisectoriel), applies to non-domestic applications. The PREM relates to off-grid micro-infrastructure for public institutions, social or community facilities and productive enterprises in certain villages awaiting an effective public electricity service. In 2008, the EcoVillage National Agency (ANEV) was launched. Attached to the Sustainable Development and Environment Ministry, ANEV promotes the creation of 'ecovillages', combining renewable energy with agroforestry and water management. In 2013, the National Agency for Renewable Energies (ANER) was also created. ANER is in charge of PREM-like projects, such as specific solutions for productive uses and solar streetlights.

or hybrid solar-diesel). Secondly, there was the rural electrification subsector, brought into being by a mosaic of private investment and using diversified technical solutions. These involved a third division, namely schemes based on large concessions and those entailing localized projects (ERIL). The next section examines the implementation of this grid and off-grid patchwork, highlighting the challenges of a system with multiple actors, complex public–private entrenchments and evolving regulatory environments.

3.2.3 The Bumpy Implementation of the Mosaic of (Off-)Grid Electrification

A Clunky Start for the Concession Model

The first electrification plan in the first decade of the new century sketched out this new political map of rural electrification by multiplying the mechanisms for activating private investment with 'à la carte' off-grid solutions. It nonetheless turned out to be more chaotic and laborious than suggested by initial funding successes. There were extensive delays[14] in starting up concessions, and as time passed, electricity connections remained far below initial projections, making it difficult for concessions to achieve profitability.[15] The enthusiasm for the concession model, which had made Senegal the 'darling' of donors, gave way to disillusion. Several studies have attempted to understand the failure of the concessions (Diouf & Miezan, 2021; Mawhood & Gross, 2014; Robert, 2016), from which we shall retain two key arguments.

The first encompasses the major political tensions within the government itself and with Senelec executives over the ousting of the national company. Senelec's resistance to the 1998 reform[16] does not only reflect a

[14] Contracts signed between 2008 and 2016, with inception phases of two to three years (Cour des Comptes Report, 2016).

[15] See: Document de consultation publique: Révision des conditions tarifaires de ERA (2019–2023) et Comasel (2021–2025), CRSE.

[16] Senelec, influenced by its powerful Sutelec union, defends a different conception of public service (Sene, 2013). Some actors, including the World Bank, suspected Senelec of delaying or even blocking private actors' integration into the electricity sector.

power struggle in the control of the sector vis-à-vis transnational private actors. It also brought to the fore a conflict of justice as to equality in electricity service, baring territorial disparities that disfavoured rural populations. The political controversy over the unequal public service provision put pressure on a government that was regularly exposed to the social rumblings of its population, particularly on energy issues (Caille & Badji, 2018; Sene, 2013). Popular protests are more likely to be led by urban youth, who contest power cuts and the cost of electricity in cities. Yet the need to provide rural electrification is also one of the issues raised by local elected officials and rural populations, particularly in pre-electoral periods. The second argument relates to the relative failure of the concession model as a market-based solution for rural areas suffering from economic precariousness.[17] It was not until 2013 that six out of the ten concessions open to tender were awarded, to ONE, ERA, STEG International Services and ENCO-Isofoton Maroc (CRSE, Avis 2018–03).[18] Failing to attract private investors, the remaining four were awarded to Senelec in 2018 (CRSE, Notice 2018/02). The medium-term requirement of profitability also weighs on technical and financial choices. It has led concessionaires to take advantage of the principle of technological neutrality to favour individual photovoltaic systems, considered less risky and less expensive than mini-grids.[19]

[17] The large companies in charge of concessions enter this challenging market with objectives that go beyond immediate profitability (Mawhood & Gross, 2014; Mostert, 2008; Robert, 2016). They hope to gain a strategic positioning within one of the most dynamic countries in West Africa or aspire to contribute to the company's social responsibility programme.

[18] All concessions associate international companies and Senegalese ones: Office National de l'Electricité du Maroc (ONE) from Morocco is associated with Comasel (Senegal); ERA (Energie Rurale Africaine) was created by EDF from France and Matforce (Senegal); Isofoton, a Spanish company, was associated with Enco from Senegal to create Kolda Energie and Electricité du Rip (EDR), while STEG International Services from Tunisia created the Senegalese company SCL Energie Solutions with the Senegalese companies Coselec and les Câbleries du Sénégal (LCS). (CRSE, Report 2015–2016); (CRSE, Notice 01–2013); (CRSE, Notice 2015–02); (CRSE, Decision 2019–13); (CRSE, Decision 2019–12).

[19] This minimalist option was criticized by the Cour des Comptes report (2016) on ASER's setbacks: 'The concessionaires consider that the connection of these villages would entail significant unprofitable investments. This is why the populations of these localities do not have access to electrical services, especially since the alternative solution taken by the concessionaires by installing photovoltaic systems in these distant localities is not viable' (p. 145).

The partial failure of the concessions has provided legitimate grounds for the Senegalese government to initiate 100% state-funded emergency programmes, thereby reducing its dependency on external donors. In 2008 and 2015, two emergency programmes[20] for rural electrification replaced the initial PASER plan with grid extension and off-grid projects, prioritizing the main districts within areas generally allocated to concessions. The plan was to connect nearly 6000 villages to the grid, as well as to construct mini-grids for 400 villages. The management of these programmes was put in the hands of 'transitional delegated managers' (Gestionnaires Délégués Transitoires [GDT]),[21] and was meant to be handed back to the concessionaires once the concession contract was in place. The GDTs include SSER, a subsidiary of Senelec created in 2004, along with three private Senegalese companies.[22] This emergency plan also envisaged small programmes from bilateral cooperation (i.e., India Phase 2 and Spanish Debt Cancellation). Electrification plans intensively carried out by the government have therefore reinstated local actors, especially Senelec, as key players in rural electrification. They have also restored the grid as the primary means of access to energy for villages (Table 3.1).

Small-Scale Initiatives and ERIL Projects: Innovative Solar Projects Within Unfinished Regulations

As a counterpoint to large rural electrification plans, targeted and small-scale off-grid projects burgeoned from various programmes and initiatives (Fig. 3.1). Pilot projects were initiated within bi- or multilateral cooperation programmes, in particular Spanish-Senegalese cooperation (Delta Saloum electrification), German-Senegalese cooperation

[20] These two programmes respectively are called Programme d'urgence d'électrification rurale (PUER) and Programme national d'électrification rurale (PNUER).

[21] The status of GDT was created by the Senegalese government in 2005 (CRSE, decision 2005–01), one year after Senelec set up its subsidiary SSER (Robert, 2016). This subsidiary enabled Senelec to participate in the state's calls for tender concerning rural electrification, from which it had been excluded, particularly for ERIL.

[22] The other GDT are the Société Sénégalaise pour l'Equipement et l'Energie (SS2E), the Groupement Sénégalais de Réalisation et de Maintenance (GSERM) and Equip Plus. The last withdrew from its concession in 2012 (CRSE, annual report 2015–2016).

Table 3.1 Operator contribution to rural energy supply

Operator	Number of clients	Percentage
Senelec*	239,425	73.4
Concessionaire	18,876	5.7
ERIL	9757	3
GDT	5404	1.7
Individual systems**	52,911	16.2
Total	326,173	100

*The number of Senelec urban and rural clients in 2016 was 952,018 clients
** Others than those provided by concessionaire.
Source MPE—Information system of energy, December 2017, in: Sénégal, Notes de Politique Économique et Sociale, Groupe de la Banque Mondiale, 2019, 43.
Note This table, part of a World Bank analysis of rural electrification policy, shows that Senelec still plays a central role in rural electrification (the number of customers mentioned includes customers already electrified before the successive plans), while the progress of the concessionaires remains very modest, especially compared to ERIL. The category 'Individual systems' refers to solar kits sold in the private stand-alone market. Most market surveys and data were produced by GOGLA—Lighting Global and World Bank (sec 4).

(PERACOD and PED programmes) and the EU PASES project[23] (Kébé, 2013). The ERIL concept was intended to provide a framework for bottom-up approaches started by village groups or local communities. But stimulated by international funding, the dynamics of these projects mostly relied on ad-hoc programmes targeting specific territories and supervised by the ASER.

Off-grid projects provide opportunities for Senegalese SMEs to develop their pool of mini-grids, spread over different areas. SMEs operate either in response to ASER's calls for tender or on their own initiative, seeking external funding by themselves. Coseer, Energie R,

[23] The Spanish-Senegalese programme has provided 10,000 households with SHS of 50 Wp and 10 village centres with solar power plants. The ERSEN project (Electrification Rurale au Sénégal) of the German-Senegalese cooperation is a component of the PERACOD programme (Promotion des énergie renouvelables, de l'électrification rurale et l'approvisionnement durable en combustibles domestiques), which was replaced in 2017 by the PED (Programme Energies Durables). ERSEN has been implemented by EnDev, a partnership created by Dutch and German cooperation agencies. The European Union funded a similar project called PASES-Programme 'Projet d'accès aux services électriques des localités de petite taille dans la région de Sédhiou' (Project for access to electrical services for small localities in the Sedhiou region) (Kébé, 2013). In total, the ERSEN and the PASES projects electrified 285 villages: 97 by mini-grids, 172 by SHS and 16 by grid extension (Niane, 2018).

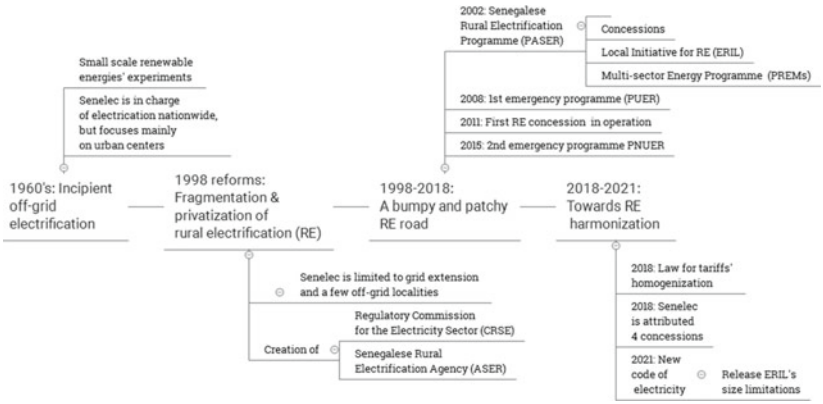

Fig. 3.1 Critical dates in Senegal's off-grid electrification

Faye Solaire, NS Resif, Sud Solar System and Salensol are among the Senegalese companies that have developed a growing expertise in the management of mini-grids, with varying degrees of success (see Sect. 3.4). 'There are many mayors who have contacted me to propose their villages. I have a database of villages asking for electrification and at the first opportunity, we try to go and search in these villages, and then it's our job to contact the mayors, the village chiefs…' (Chief Executive Office (CEO), SME2 with an ERIL portfolio, October 2016). Among ERIL operators, only one (Enersa) is a joint venture with a foreign company (Inensus) (Ulsrud et al., 2018a, 2018b). The contracting delays with the ASER[24] have placed SMEs in a kind of 'institutional void' or at least a grey area.

Although they are often considered marginal in rural electrification policies, targeted and small-scale projects open a space for alternative dynamics, bringing expertise in local governance and renewable energies, in particular solar technologies. While SHS remain a favoured option for ERIL, the share of mini-grids is greater than SHS in the concessions.

[24] As for concessions, the design of the institutional framework for ERIL experienced the same political tensions. According to our information, cross-referenced with administrative data (CRSE, 2019) and a recent report (Semis, 2020), only one company (Enersa) has been officially labelled ERIL, and that was due to privileged relationships. The others have started the procedure without being approved and are still waiting for regularization.

Small projects thus contribute to social and/or technical innovations, even if their viability is not totally secured (see Sect. 3.3) (Semis, 2020). However, as explained in Sect. 3.5, this also leads to price disparities that are barely acceptable to users, especially as mini-grids offer a limited and sometimes inferior service.

3.2.4 The Fragmented Landscapes of Rural Electrification

Although rural electrification is making progress, it is therefore in a dispersed order. Concessionaires entered gradually, hindered by governance conflicts and the risk of non-profitability, and these delays have provided legitimacy for public funding, emergency state plans and the return of Senelec. This policy also tends to re-establish the primacy of the grid electrification option (Guillou, 2022), while rural and remote villages are set up as secondary or experimental areas of solar off-grid electrification.

Rural electrification policies give way to multiple configurations of actors (Olivier de Sardan, 2011) and public service provision. Senelec, GDTs, concessionaires and ERILs all operate according to different rules while their respective geographical area of intervention may overlap over the course of successive electrification plans. Opportunities are driven by international aid-funded programmes and changes in public rules. All actors are faced with the challenge of very unlikely profitability, although Senelec benefits from a subsidized price per kWh along with the state's support in compensating for financial losses. Private operators, whether concessionaires or ERIL schemes, must ensure their economic viability by charging tariffs to at least cover their operating costs.

Turning to pricing, various problems are encountered. In addition to the above-mentioned difference in price per kWh, concessionaire and ERIL charge consumer tariffs according to a less user-friendly system of monthly flat-rate payments. This is based on levels of service (S1,

S2, S3, S4[25]) depending on the power scale,[26] regardless of effective consumption.[27] Tariffs also include the repayment of internal installations that were pre-financed by the concessionaire to facilitate household connections. Mini-grid and SHS options for remote villages add a further constraint to this tariff inequality by offering limited electricity time slots. Because of these differences in price and service, the population shows a certain reticence towards private actors, especially when their areas of intervention overlap with those of Senelec. In their reports, concessionaires mention the need to carry out awareness-raising campaigns and offer reduced-cost subscriptions for SHS to attract new customers. These strategies, however, sometimes prove unsuccessful in overcoming the drawbacks with shortened product lifetime and competition from other SHS private sellers.

The CRSE states that after installing 398 SHS in 128 localities between 2013 and 2017, i.e., 21% of its target, Comasel-Louga has resiliated all these contracts.

> According to the operator, the structuring of the offer had become unsuitable due to "*competition from suppliers who offered lower quality products within the concession area, fraud on the installations which led to deep discharges of the batteries before the end of the contract*". This situation, again, according to the operator, "*led to unpaid bills of 44 million CFA francs that subscribers refused to pay*" (CRSE, Révision des conditions tarifaires de Comasel-Louga 2021–2025).

As seen above, the implementation of state-led rural electrification in Senegal is dominated by three main actors: Senelec, large companies allied with foreign partners in charge of concessions, and Senegalese SMEs contracted to electrify specific villages through ERIL-like schemes.

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[25] In ERIL villages, the highest level of service (S4) corresponds to a monthly flat-rate payment, unlike in concession area, where payments for S4 depend on electricity consumption.

[26] Comasel services: S1 = 50w–50wc, S2 = 90w–75wc, S3 = 180w–150wc. The concessionaire tariff is the same whatever the mode of electrification (grid or solar kit).

[27] It is interesting to note that for these modest consumers, the concessionaires' tariffs were established by the CRSE with the hypothesis that grid-connected customers would use only 30% of what they are entitled to. This projection proved to be false, resulting in profitability losses for concessionaires.

This fragmentation of the governance of a public service raises issues of energy justice for implementers, as described in the next section.

3.3 Energy Justice for Rural Electrification Implementers: Highlighting Systemic Vulnerabilities for Small and Medium Senegalese Companies

The concept of energy justice has focused mainly on justice for final consumers (Sareen & Haarstad, 2018), while the position of the producers has not yet appeared as a priority research area (Sovacool et al., 2017). Opening up energy justice to the parties implementing rural electrification may shed light on inequalities in distribution, recognition and procedure (Jenkins et al., 2016). Indeed, while Senelec, concessionaires and Senegalese SMEs contracted under ERIL projects are entrusted with the same objective, namely connecting rural consumers to a reliable, affordable source of electricity, there are vast differences in their perimeter in terms of geography and clients, together with the regulation and delegation framework within which they operate. This inevitably affects their financial stability. In addition, the remoteness of the villages where the SMEs work tends to increase over time, while these companies also have to deal with ageing and at times undersized infrastructure, leading them to lose customers. This differentiation gives rise to equality issues, which are closely related to energy justice (Pellegrini-Masini et al., 2020).

According to rural electrification policies, distance from the grid and population density are the main criteria for deciding whether users will be electrified through the grid or decentralized solutions. Decentralized solutions are then targeted at villages that are the most distant from the grid, which often also means being far away from cities and paved roads. The remoteness of off-grid villages generates higher costs not only for maintenance, but also for collecting feeds. Pay-as-you-Go technologies are still incipient in Senegal, sometimes requiring companies to visit every village several times per month to distribute energy invoices

and collect payments (CEO, SME3 with an ERIL portfolio, September 2021).[28] Unlike Senelec and concessions companies, who work both on grid-extension and off-grid technologies, SMEs in charge of implementing the ERIL scheme work only in off-grid villages, increasing the average costs of operations and maintenance. Another source of inequality lies with the types of villages that each actor can electrify; until recently, ERIL projects were limited to 200 clients, capping the potential for economies of scale. It is therefore much harder for SMEs to break even cost balance in electrification activities,[29] partly because they work in smaller villages and also with their pool of clients being capped and relatively remote.

This profitability challenge is further aggravated by grid extension. When the grid reaches a village electrified through off-grid solutions, pre-existing operators are pushed to even more remote areas and also have to bear the costs of dislocation and transport of infrastructure. Operators can in theory receive compensation for the relocation costs but this does not seem to happen, as outlined by one of the operators interviewed: 'We are not compensated at all. We have to simply come and dismantle our equipment' (CEO, SME5 with an ERIL portfolio, October 2021). This is a consequence of their fuzzy legal status. Contrary to concession companies, Senegalese SMEs continue to evolve in a blurry legal framework, as only one of these companies, Enersa, has a full contract with the state (Semis, 2020). Lack of contracting results in difficulties accessing external funding, for example through loans (CEO, SME4 with an ERIL portfolio, September 2021) and also weakens incentive and sanction mechanisms. An expert from a cooperation agency summarized the reputational, financial and legal discrepancies between concessions and Senegalese SMEs:

> "Concessionnaires are players who are a little more solid. ERA is associated with EDF; Comasel is associated with ONE, and ONE with Morocco and SCL; it is STEG in Tunisia. These are players who have reputational issues behind them and who anyway have the funding to

[28] Some ERIL companies pay local villagers to collect electricity fees.

[29] Infrastructure costs are mostly covered by state-led programmes, but SMEs are expected to cover operations, maintenance and equipment replacement with customers' monthly payments.

> make it work …]. They also have real licence contracts, real contractual commitments, the State follows the achievements of these concessionaires. (Cooperation Agency Representative, June 2021)" (extracted from an interview)

Furthermore, many mini-grids run by SMEs are undersized. The largest Senegalese mini-grid projects, ERSEN I and II, installed infrastructure in some 100 villages without tailoring the capacity to economic activities and population size.[30] All the mini-grids have a capacity of roughly 5 kWc photovoltaic and 10 kVA from a genset. Enthusiastic new electricity clients often buy or receive equipment, such as TV and fridges, overloading a limited capacity mini-grid,[31] interrupting electricity services for the whole village and shortening the mini-grid's lifespan. Undersizing due to project design is the reason most commonly given by SMEs to explain the fast deterioration of technical systems. The founder of one of these SMEs explains:

> "When we met [with the cooperation programme], it was our worries, I was thinking that it would be better to have two big mini-grids than ten mini-grids that do not meet people's needs […]. But well, as we are not involved in the [feasibility] studies, we do not have a say. […] Batteries are often overused and every day that God makes, the diesel generator is turned on because batteries are empty. (CEO, SME5 with an ERIL portfolio, October 2021)" (extracted from an interview)

The interruption or fading of electricity leads consumers to refuse to pay, preventing companies from saving enough to replace expensive components such as batteries and inverters. In addition, poor services sometimes result in highly conflictive situations between villagers and companies, with physical or witchcraft threats towards SME technicians.

[30] These programmes were designed as pilots and expected to increase the capacity of mini-grids over time but, several years after their implementation, this has not yet happened. Most of these mini-grids were installed between 2010 and 2014.

[31] Each household is equipped with a power balancer to prevent the mini-grids from overloading, but it is not uncommon for rural customers to unplug these controlling devices.

The premature failure of off-grid systems is frequent worldwide and Senegal is no exception.[32] An extensive study in 2020 led by the Petroleum and Energy Ministry, GIZ and ASER found that half of the 98 hybrid mini-grids installed through the ERSEN I and II programmes are no longer working. Most ERSEN mini-grids started to operate between 2010 and 2014, and the average duration before breakdown is six years. Mini-grids which are still operational usually have a reduced service with an average of three hours of electricity per day instead of the initially-planned minimum of six hours (Semis, 2020). The Senegalese state, with support from funding agencies, is adopting a proactive approach with an ambitious rehabilitation programme (Sous-Commission Cadre Favorable à L'électrification Rurale Hors Réseau, 2021) for these inoperative mini-grids. In the meantime, rural consumers in the dark are going back to traditional devices or buying private systems when they can afford it. The pictures below illustrate the hybridization of a dysfunctional mini-grid connection and privately owned SHS systems to provide lighting and TVs in a Koranic school in a small village in Casamance, South Senegal (Figs. 3.2 and 3.3). This school accommodates around 150 young students and combines several electricity systems. The school was first connected to the village mini-grid (see the cable in the right-hand picture) but given reduced electricity time per day. SHS with a lease-and-own scheme as well as independent solar panels were added (SHS are visible in the left-hand picture, while individual solar panels can be seen in both). They provide the school with night lighting and TV so that children are less inclined to wander outside at night (Field Study in Southern Senegal, 2021).

[32] The figures, admittedly disparate, question the sustainability of decentralized access to electricity: 34% of off-grid systems are reported as inoperative in Peru (Feron & Cordero, 2018), almost 20% of tracked solar products are said to have ceased to function after 18 months in Kenya (Cross & Murray, 2018), 90% of the systems stopped functioning after ten years in Bolivia (Dávalos & Herrera, 2019). Analyzing a sample of 50 mini-grid projects, implemented worldwide between 1994 and 2017 and selected from the CoSMMA database, Berthélemy and Maurel (2021) estimate that about 50% of those mini-grids have failed. Disconnection rates of up to half the users of certain mini-grids in Madagascar are also reported (André-Bataille et al., 2020; Cholez & Trompette, 2019).

Fig. 3.2 Koranic school in a village in South Senegal is connected to the village mini-grid and has bought stand-alone solar panels (Field Study in Southern Senegal, 2021)

In this section, it has been seen how rural electrification stakeholders, particularly SMEs which do not have the support of private or public shareholders, are trapped in a vicious circle. Costs for collecting fees tend to rise as villages targeted for new mini-grids become increasingly remote due to grid expansion; tariffs fail to secure enough income to replace expensive equipment for mini-grids with a short remaining lifetime. Furthermore, SMEs suffer from a loss of consumers either because the mini-grids do have not enough capacity to connect new users, or because of unreliable or non-functional mini-grids. As for the concessionaire's SHS installations, dissatisfied villagers abandon the service provided under the ERIL scheme and turn to the private self-electrification market.

Fig. 3.3 The same school is also equipped with Baobab+ solar panels to cope with the mini-grid unreliability (Field Study in Southern Senegal, 2021)

3.3.1 Self-Electrification Through Stand-Alone Solar Systems: A Flourishing Market Weakening Energy Justice

The Market for Household Solar Systems: A Political Response for the Supply of 'Essential Goods and Services'

While public electrification programmes have been struggling to scale up access to energy for remote populations and grid deficiencies have persisted, the market of stand-alone solar systems offers an alternative, substitute or complementary solution to the grid. This self-electrification market is not radically new. Generator sets, (second-hand) car batteries or even simple electric torches have long been complementary solutions to traditional energy sources, such as wood and kerosene. However, being green technologies, household solar systems have received major political support as solutions to the challenge of electrification.

In the 1990s, NGOs first contributed to promoting and distributing lamps and solar panels by greatly subsidizing their installation. Ten years later, as seen in the PASER plan, they became a technical option for public electrification programmes. In Senegal, as in other Sub-Saharan countries, the formal market of stand-alone solar systems (SHS, solar kits, solar lamps) has been stimulated by the offensive of the 'solar off-grid industry',[33] in particular via the GOGLA federation and the support of the World Bank (Lighting Africa). Although these systems provide limited power, according to several surveys by the Energy Information Services in Senegal of WAEMU[34] (2013 and 2019), they have been promoted as a providential response to the challenge of universal access to 'essential goods and services' (Ndour & Boidin, 2012), mentioned in the UN Millennium Development Goals (MDGs) and Sustainable Development Goals (SDG). In 2017, Senegal's Petrol and Energy Ministry estimated that individual systems covered 16% of electrified rural consumers, without taking into account those installed by concessionaires.[35] More recently, the development policy letter (2019–2023) of Senegal energy sector mentioned the need to promote the deployment of SHS while the new electricity code designates SHS as an 'activity related to the electrical sector' (Article 53, Code de l'Energie). Despite this cautious wording, private SHS have been included in energy statistics after the 2013 population census showed the prevalence of these systems (Thiam Sow, 2021).

It is also interesting to observe that the dissemination of SHS or solar kits as a market-based solution intertwines the public and private sectors. The same technical option (SHS) can be provided in the framework of public electrification programmes by concessionaires or an ERIL project, as a public utility, or as a sale through the purely private segment of social business, as part of the Corporate Social Responsibility (CSR) programmes of start-ups or multinationals. Indeed, it is not

[33] In the area of aid development, market surveys also use the term 'off-grid' to refer to this market segment.

[34] West African Economic and Monetary Union.

[35] See Table 3.1 and its interpretation in Sect. 3.2.

Fig. 3.4 An example of a solar lamp with a lease-to-own scheme (*Note* Users pay for electricity as they can, and eventually become owners of the system [Field Study in Southern Senegal, 2021])

uncommon for equipment suppliers to sell through both channels. The following section will examine this private segment of self-electrification equipment (Figs. 3.4 and 3.5).

The Challenging Development of Off-Grid 'Bottom of the Pyramid' (BoP) Markets in Senegal

In Senegal, as in other West African countries, the uptake of small solar systems has taken longer than in East Africa. The entry of the first 'pico' (lamp) or small (kit) solar systems in Dakar took place in

Fig. 3.5 Branded and generic solar lanterns in a village of Casamance (Field Study in Senegal, 2016)

the mid-2000s, mostly following European SME initiatives (German, Spanish and French) seeking to position themselves in African markets with products sourced from China or Dubai. The director of a French SME, a pioneer in opening up these markets in Senegal, commented:

> I have done a lot of trade fairs, many in Asia, in Honk-Kong in Shanghai, in Canton, etc. It was in these shows that I really learned about all these little systems, these portable solar systems. […] In 2008, I was already importing my first small solar kits, on the plane leaving from Paris, maybe I had sourced them all over the world, but I brought them to Dakar or Ouagadougou to sell them. […] I am telling you about the situation until 2010 because afterwards I no longer recognized my market, because there are so many players who arrived on the market with these small systems, there has been an invasion of products, it's not complicated, an invasion of products and players. (CEO, French SME1, November 2014)

From 2010, these mainly European SMEs were joined by social business actors, which had previously targeted East Africa markets (Kenya, Tanzania, Ethiopia and Uganda). Their objective was to develop so-called 'bottom of the pyramid' (BoP) markets.

Among these, there are pioneering pico-solar start-ups, such as d.light or Greenlight, which are entering West African markets following activities in East Africa; subsidiaries of financial institutions like Baobab+ wishing to enter BoP market; and multinationals like Total operating within their CSR framework. They differ from the above-mentioned European SMEs in their much more intensive 'social impact' marketing. Social business narrative facilitates access to financial levers (responsible finance, donor subsidies), political levers (World Bank support via the Lighting Global programme) and economic levers (strategic partnerships between start-ups, microfinance institutions and major players in the telephone industry). These levers also offer an important institutional base with Lighting Global's marketing expertise, facilitating access to public programmes as well as NGO distribution networks (Trompette & Cholez, forthcoming).

In 2019, ECREEE[36] identified around 30 companies in this 'formal' segment in Senegal, established as importers, distributors or retailers, one-third of which are mature companies. Solar lanterns represent almost 90% of their branded products. Nonetheless, a few years after the launch of this market, sales volatility revealed the challenges of establishing BoP markets with branded products from the formal sector. The selling prices of branded products remain quite high for a basic lamp and phone charge (from €80 in its earliest days to approximately €30 nowadays). Most buyers have become owners of the systems through a lease-to-own scheme, even if the offer includes maintenance and after-sales services. Social businesses have to create their own distribution networks to reach remote and 'poor' customers, which may also result in a chain of indebtedness from the intermediary to the end user. Branded solar product dissemination is still dependent on public programmes and NGOs, which have become the main market intermediaries.

[36] ECREEE is the Regional Centre for Renewable Energy and Energy Efficiency of the Economic Community of West African States (ECOWAS).

3.3.2 Competition in Local Markets: When Senegalese Wholesalers Challenge Transnational Companies

At the same time, a more invisible but flourishing market of fairly similar products has developed in Senegalese urban marketplaces, namely non-labelled, low-cost solar products (lamps, kits, SHS), imported from China among the numerous 'chinoiseries' which have entered people's daily life over the last 20 years (Marfaing & Thiel, 2013). In Dakar, as in the major provincial cities such as St Louis, Kaolack and Ziguinchor, longstanding wholesalers in the local marketplaces have supplied solar systems since the early 2000s. They offer a myriad of products providing basic services (e.g., lamps and mobile charging) as well as more elaborate ones (solar kits plugged into appliances such as radios, TVs or fans), right up to SHS.

In Sandaga for example, one of the oldest marketplaces in Senegal providing for the sub-regional markets of Senegal and neighbouring countries, pico systems including a lamp with chargers or mini kits with several bulbs are sold from as little as €15 in hardware stores or specialized electrical shops, alongside solar kits. Prices vary according to quality and size. For SHS, the suppliers systematically connect customers to solar technicians who size and install more powerful systems in their home, leaving them free to combine components of different brands and even different quality/price ranges. In this informal solar market economy, criteria of brands and quality standards have been replaced by those of affordability and easy last-mile transport. Local wholesalers are better able to overcome entry barriers, such as customs taxes and other taxes related to commercial activity, and to control informal resale networks. This ability makes them more competitive than some European wholesalers that have attempted to enter this market.

Unlike SHS installed as part of public programmes, the self-electrification market based on solar kits and SHS was, until recently, unregulated. It was only in 2019 that ASER put the self-electrification market on the agenda. ASER intended to respond to complaints from formal companies regarding 'unfair' competition from the informal sector, which was accused of (at least partial) circumvention of taxes

and quality standards, and 'inundating' the market with poor quality products. This common criticism should be considered in the light of the competitive struggle between transnational and local companies. This study of Senegalese suppliers suggest instead that they are defending a broader offer with a low-cost entry level, admittedly of lower quality, while also selling quality products and providing after-sale services. The sellers interviewed reported that buyers tend to prefer low prices to quality (Field Study, 2016). However, according to some empirical works, even low-quality products may offer a more attractive price/performance ratio for the poorest (Bensch et al., 2018; Grimm & Peters, 2016) than solar kits in the formal market.

3.3.3 Villagers Claiming Energy Justice

Following the above description of the plurality of stakeholders and disparity of their services, the study will turn to the population's perception and negotiation of this diversity. A survey carried out in 2016 focuses on a rural commune of about 15,000 inhabitants, located in Basse-Casamance, a geographically isolated region in the south of Senegal. Said year was an interesting period as it revealed issues of energy justice rooted in the accumulation of public and private interventions before the Senegalese government drew up new regulations. As a result of public policies, the rate of rural electrification progressed significantly from 8% in 2000 to 33.2% in 2016 (UFC-MCA, 2017). The electrification of the above-mentioned commune provided the opportunity to empirically explore the complex configuration (Blundo, 2002; Olivier de Sardan, 2004) of public rural electrification services in a single commune.

The commune of Ouonck is composed of 24 small settlements (less than 500 inhabitants each) spanning approximately 30,000 ha, occupied by farmers, mainly from Diola groups. Ouonck is part of the Ziguinchor-Oussouye-Bignona-Sedhiou concession, one of the four that remained unallocated for several years due to their unattractiveness to investors. Faced with a lack of municipal resources and awaiting the implementation of state programmes, the mayor of Ouonck positioned himself as a 'development broker' (Bierschenk et al., 2000) on the market for external

donor projects. His objective was to accumulate projects to maximize the electricity coverage of the 24 villages:

> I have been received several times by ASER. The director of ASER knows me. The Minister of Energy knows me. We are even listed in a programme, apparently a programme of the state of Senegal […] I told [the NGO that installed the kits] that you have to compete [with the projects in the village] because if you don't, other concessionaires will come, they will propose programmes with much greater economic benefits, and so on. (Mayor of Ouonck, 2016)

Our research on Ouonck in 2016 revealed that five different operators were active in different hamlets of the commune:

- At the entrance to the commune, the main village has benefited from a connection to the grid operated by Senelec, as a result of the first Emergency Rural Electrification Programme (PUER) in 2010. These villagers are thus the only ones benefiting from a continuous service at the lower price, similar to the one applied by Senelec throughout its perimeter.
- Along the central road of the commune, in more remote hamlets, 190 households have benefited from SHS installed by a French NGO, which transferred the fully subsidized equipment to the commune, and its management to a community operator composed of villagers, including several elected municipal officials.
- A mini-grid was installed in a neighbouring hamlet by a Senegalese SME through the ERIL scheme. This SME operates more than ten off-grid photovoltaic electrification projects in the country. The 50 or so households in the village benefit from six hours of electricity per day, with the four levels of service, in line with the conventional ERIL framework.
- A few kilometres further on, a second small village of 230 inhabitants, on the edge of the forest, has had a kiosk solution installed as an ecovillage with an environmental focus. These kiosks have been promoted by the Agence Nationale des Ecovillages (ANEV), a government agency. They allow villagers to collectively access mobile phone

recharging, refrigerated space rental, lamp rental and recharge, along with cinema-video, paying a small fee for each of these services.
- Ten villages in the commune of Ouonck have been equipped with SHS managed by SSER, a subsidiary of Senelec considered a 'transitional delegated manager' (GDT), as part of the government's second emergency programme (PNUER). As SSER has not collected payments, subscribers have used this equipment free of charge but without maintenance (Table 3.2).

One commune has been home to five operators providing very different services (intermittent/continuous, individual/collective, a variable range of power within the S1 to S4 categorization of flat rates, different time slots), and tariffs that can vary by as much as 200% for the same quantity of energy (SSER/NGO). For these villagers, who are neighbours and often relatives, the inequalities are not explainable (Francius et al., 2017). Moreover, they are a source of tension in the interaction with the operators, who constantly face demands from users regarding the price of electricity, the quality of the supply or the power levels. In 2016, the community operator managing the SHS set up by the NGO Fondem, faced a major conflict with users who demanded the same free access as SSER clients in the neighbouring village. The mayor supported the community operator so as to maintain the attractiveness of his village to any future electrification project. Despite the intervention of elected officials, the conflict was settled in court, indicating a major crisis in a Diola society, which usually favours traditional forms of authority. This confrontation between the "sons of the village" (committee) and members of their families is symptomatic of a major political crisis. The tumultuous trajectory of electrification in this small Casamance commune reveals the extent to which this multiplication of service providers in deficient regulatory spaces weakens the social cohesion of a village.

Observing the electrical landscape of 'diffuse urbanization areas',[37] Guillou (2022) describes the same service fragmentation in Kaolack city and its peri-urban and rural periphery. Because they are part of

[37] Fieldwork carried out in 2019.

Table 3.2 Comparative service table (selection of the same range of power for the top three)

Operator	Service	Power (<=>)	Subscription price (FCFA/€)	Operating time	Tariff/month (FCFA/€)
NGO	SHS (S1 to S4)	(S3) 80 Wc/4 bulbs + 12 V outlet	50,000 (€70)	3 h/day	6800 (€10)
ERIL	Solar mini-grid (S1 to S4)	(S2) 50–90 Wc/ 7 bulbs + 12 V outlet	40,000 (€60)	8 h/day	6000 (€9)
SSER	Only service	65 Wc/ 7 bulbs + 12 V outlet	20,000 (€30)	3 h/day	2500 (€3.8)
Senelec	Average price per kWh: 117 FCFA (€0.18)				
Ecovillage	Phone charging: 50 FCFA (€0.076), refrigerated space = 200 FCFA (€0.30)/day, cinema: 50 FCFA (€0.76)				

the perimeter not electrified by Senelec, these areas are classified as 'rural' electrification zones, likely to benefit from limited offers. Certain communities are allocated to Senelec within a zone normally delegated to an inactive concessionaire, which implies a flat-rate payment for the basic services. Within the same area, several ERIL operators (Salensol, NSRESIF, Equip Plus+ and Sud Solar) provide electricity on the basis of mini-grids and SHS (limited-service slots), on a flat-rate payment basis.

Guillou (2022) and Jaglin (2019; Jaglin & Guillou, 2020) stress another aspect, that of hybridization with self-electrification solutions. While the promoters of solar electrification praise the savings made by the 'poor' thanks to the substitution of traditional energy sources, observation of practices shows that limited power, intermittency or power failures lead to the use of complementary solutions, as highlighted in Sect. 3.3 with the example of the Koranic school. As Guillou (2022: 199) explains: 'Hybridization is an adaptive response to the technical limitations of existing electricity supply systems or to a limited ability to pay for efficient services'. Hybridization consists of combining several sources of electricity within the household, with SHSs or generator sets, pooling some energy-consuming applications (community refrigerators), or obtaining electricity from an external source (e.g., recharging phones in neighbouring villages). In line with Jaglin and Guillou's work, other researchers analyzing off-grid electrification in areas both urban (Le Picard & Toulemont, 2022) and rural (Etienne, forthcoming; Cholez & Trompette, 2019; Ulsrud et al., 2018a, 2018b) show that hybridization, more than substitution, has become a common practice. These works also concur on the idea that service inequalities contribute to the perception of decentralized solutions as being downgraded in relation to the grid. The villagers are inclined to self-electrify while waiting for the arrival of the grid.

3.4 Towards Harmonization: The End of the Rural Electrification Patchwork?

Openness to private operators, claimed to be more efficient and able to accelerate electrification, has paved the way for an unequal electricity

geography with significant territorial disparities in both service provision and pricing. This has meant, at least temporarily, withdrawing from the model of national tariff uniformity and equal treatment of users (Colombier & Hourcade, 1989), even when addressing the most disadvantaged populations. The variety of electrification stakeholders and delivery patterns is summarized below (Table 3.3).

These inequalities have given rise to social and political controversies, with background confrontations from political and economic elites, regarding the neo-liberal Public–Private Partnerships scheme. On the one hand, critics[38] question the action of ASER (limited competences and means), the non-fulfilment of concessionaires' commitments in infrastructure implementation and their extensive use of minimal electrification solutions to avert financial risk, along with the lack of monitoring leading to many non-functioning installations, like mini-grids and kits.[39] On the other hand, ASER officials and private operators denounce the resistance of Senelec and the delays of the CRSE, as well as contracts based on over-optimistic projections, causing critical situations with concessionaires and ERIL exposed to heavy deficits. Nonetheless, all stakeholders concur on the issue of tariff inequalities.

The sensitive issue of electricity tariffs and equity of treatment between urban and rural areas called for a political response. The objective of tariff harmonization for rural areas has been announced in the context of the emergency plans from 2014 but its implementation is effective in 2018.[40] Concessionaires and SMEs in charge of ERIL projects should benefit from financial compensation for losses due to tariffs lower than

[38] The 2016 report by the Court of Auditors, which was motivated by malpractice within ASER (corruption, misappropriation of funds), is emblematic of these arguments.

[39] 'In all the localities visited in the centre, east and south of the country, solar installations over five years old have come to a complete standstill', mentioned the same report.

[40] Avis n°03/2018 concerning the modification of the rural electrification concessionaires' contracts.

Table 3.3 Summary table of electrification stakeholders and delivery patterns

	Senelec	Concessions	ERIL companies	GDT (transitional delegated managers)	Direct solar sellers
Characteristics	Historic national electrification company	Partnerships between international and Senegalese companies	Senegalese SME and one joint venture (Enersa)	Senegalese companies, subsidiaries of Senelec (SSER)	Transnational companies (branded products) or local SME (non-branded)
Names	N/A	ERA-EDF-Matforce Enco-Isofoton /Kolda Energy and EDR ONE-Comasel SCL Energie Solutions-STEG-LCS-Coselec	COSEER, Energie R, Enersa, Faye Energie, NS Resif, Salensol, Sud Solar, Sud Energie	Equip Plus GSERM SS2E SSER (In 2019 only GSERM and SS2E were still operating) (CRSE, 2019 annual report)	Baobab+ , PEG, Oulu Solar, Salensol, Sud Solar, Lagazel SN, among others
Main electrification solutions	* Grid extension * 7 off-grid hybrid centrals	Grid extension SHS	SHS Hybrid mini-grids (solar + diesel)	Grid extension Mini-grid Solar kits	SHS Kits with appliances (solar fridge, solar TV, etc.)

	Senelec	Concessions	ERIL companies	GDT (transitional delegated managers)	Direct solar sellers
Pricing (before tariff harmonization)	According to consumption, with bundles Off-grid and on-grid consumers pay the same tariff	* Low consumers (Services 1, 2 and 3) > Lump sum High consumers (service 4) > According to consumption	Lump sum for all consumers (Services 1, 2, 3, 4)	Low consumers (Services 1, 2 and 3) > Lump sum High consumers (service 4) > According to consumption	Various—not regulated
Subsidies	A 'maximum authorized revenue' is defined by CRSE. In case of deficit, Senelec can increase tariffs or receive state compensation	Benefit from a lower electricity price when buying electricity from Senelec	Most infrastructure costs are covered by cooperation programmes Operating costs are to be covered by tariffs	Infrastructure costs are covered by the state Operating costs are to be covered by tariffs and ASER's compensation	None
Geographical perimeter	Transport: nationwide Distribution: on Senelec perimeter	Concession perimeters	Nationwide, but project dependent	Concession perimeters (temporary solutions before selection of concessionaires)	Nationwide

(continued)

Table 3.3 (continued)

	Senelec	Concessions	ERIL companies	GDT (transitional delegated managers)	Direct solar sellers
Restriction of activities	NA	None: concessionaires can choose their favoured technical option	Capped to 200 consumers until 2021 Return exploitation to concessionaire when requested	Return exploitation to concessionaire when requested	NA

Notes Compilation of authors' observations and interviews, literature review, CRSE website, CRSE decisions and minutes

the initial business plan.[41] The ambition is to reduce tariffs by up to 50% of the prices currently paid by rural people. In the same year as tariff harmonization (2018), the government set up a consultation framework to coordinate the actions of stakeholders and organize the sector. Aid organizations (donors and NGOs), public and private operators (Senelec, concessionaires and ERIL projects) as well as transnational and Senegalese equipment companies, the federation of the renewable energy sector (Coperes) and consumer associations are all participating.

The normalization of the relationship between ASER, Senelec and the concessionaires provides a positive environment to sustain the scaling up of rural electrification projects. The UN Sustainable Development Goals are bringing a new impetus to off-grid electrification programmes, with a stronger trend towards renewable energy, while incentives to facilitate the development of ERIL projects have been put on the political agenda. State actors are well aware of the challenges faced by Senegalese SMEs in charge of ERIL. The new Code of Electricity, approved in 2021, has incorporated some of their demands: the limit of 200 clients per village has been removed, as has the mini-grids capacity limit, which was previously capped at 1 MW. These new rules should help companies to access larger villages and ease economies of scale. The harmonization of tariffs should also bring about a fall in client complaints even though, in the short term, it is unsure whether state compensation will improve companies' financial situation since it is known to be delayed. While large companies have enough working capital to wait several months for compensation, it might be more difficult for Senegalese SMEs.

These recent regulations are not only about restoring social justice in access to energy for rural populations. They aim to restore the population's trust in the operators, as well as the operators' trust in the future

[41] The funds come from an Energy Support Fund (FSE—Fonds spécial de soutien au secteur de l'énergie) supplied by the state budget allocation. Part of this fund should normally be collected by Senelec from its urban customers (tariff equalization) (decret n°02019–1884) (Ministère du Pétrole et des Energies, Prospectus d'Investissement, Accès Universel 2025, 2020).

of (off-)grid electrification. They also reflect a form of public–private compromise that reconciles the reform's liberal approach with the ideal of spatial solidarity enshrined in the public service.

3.5 Conclusion

The recent history of rural electrification policies in Senegal has paved the way for a collection of political instruments: a major but incomplete reform, a multitude of ad-hoc aid projects and eventually urgent state plans, each time justified by the electrification emergency. This history reflects a patchwork of projects targeting overlapping rural territories, leading to highly differentiated services in competition or complementarity with one another, or ignorant of each other. The link between a locality—a town, a village or even a hamlet—and a socio-technical system of access to energy has resulted from the political and institutional (micro-)trajectory that led to the inclusion of the place in one of the multiple interventions initiated over the successive strata of public policies, or due to their incompletion or failures. The problem is therefore not so much a territorial fragmentation but rather the lack of any rationale based on legitimate principles of energy justice behind such fragmentation.

Over the course of this story, off-grid solar solutions have become an essential part of energy access for rural Senegalese citizens, whether in the form of mini-grids, SHS, solar kits or lamps. They have been variously embedded in different political economies, as evidenced by a large range of suppliers (Senelec, concessionaires, GDT, SMEs, community operators, (semi-)informal suppliers) coexisting and indirectly competing. While off-grid solutions hold a new political relevance as a technical alternative to the grid, public policies tend to implement them as a 'second-rate' solution addressing remote 'second-class' citizens, deprived of the ideal of the grid (Guillou, 2022). More expensive electricity is

provided for an intermittent, low-power service, the sustainability of which depends on the involvement of local actors, such as dynamic SMEs or community representatives (Etienne, forthcoming). As fragile solutions, off-grid systems, on the contrary, need stronger and more coherent public support to increase their legitimacy in the energy landscape. In the meantime, users turn to the self-electrification market, opting for stand-alone equipment. Innovative solar kits, sold by transnational companies, struggle to find their place in competition with low-cost generic products, sold in informal markets with which Senegalese populations are familiar. These are now one of the major paths for stand-alone solar systems and SHS diffusion. They are inclusive markets in the sense that they are driven by local traders and resellers in the value chain. However, the lack of regulation gives way to a range that is variable in quality and includes low-cost degraded products, thus creating uncertainty among the buyers. These markets thus maintain individual solutions (generators, and more recently, lamps and SHS), with differing degrees of cost and efficiency, as an alternative way of accessing off-grid energy.

Annex 1

See Fig. 3.6.

Annex 2

See Fig. 3.7.

The graph shows the estimated costs per kWh considering an estimated average consumption for each service level and comparing them with the tariffs of Senelec and the highest level of service (S4) connected to the grid. The monthly packages can be up to seven times more expensive than the variable tariffs (compared to the kWh). Variable tariffs (per

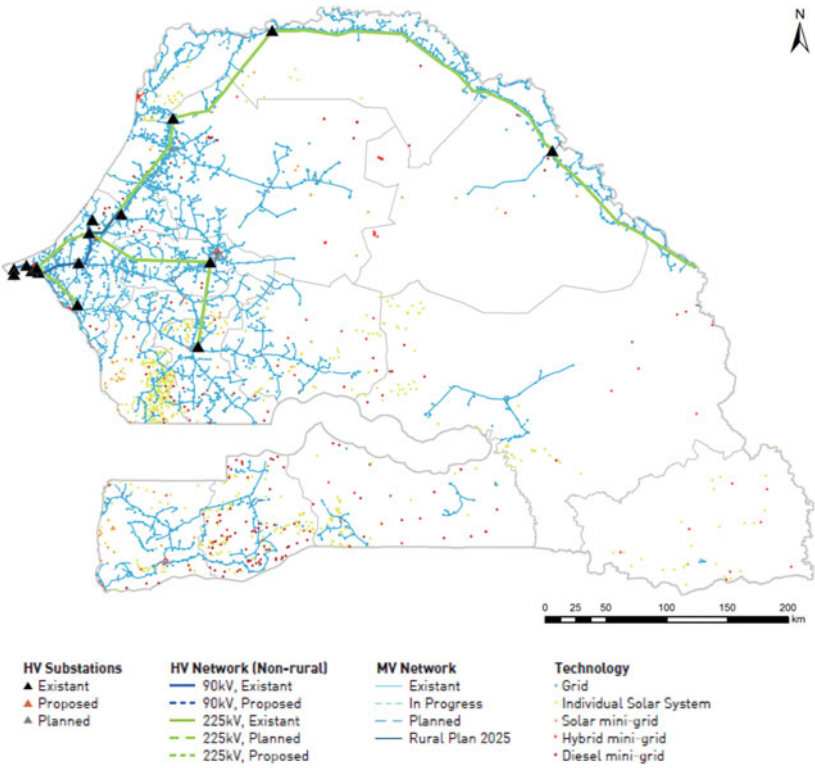

Fig. 3.6 Map of rural electrification options, including off-grid alternatives (diesel, hybrid or solar mini-grids, SHS) (*Source* Authors' GESTO Analysis based on data from ASER)

kWh) are also 20–30% higher in the concessions, however the difference is less significant (Rural Electrification of Senegal SE4All, Gesto Document Analysis, 2018, 51).

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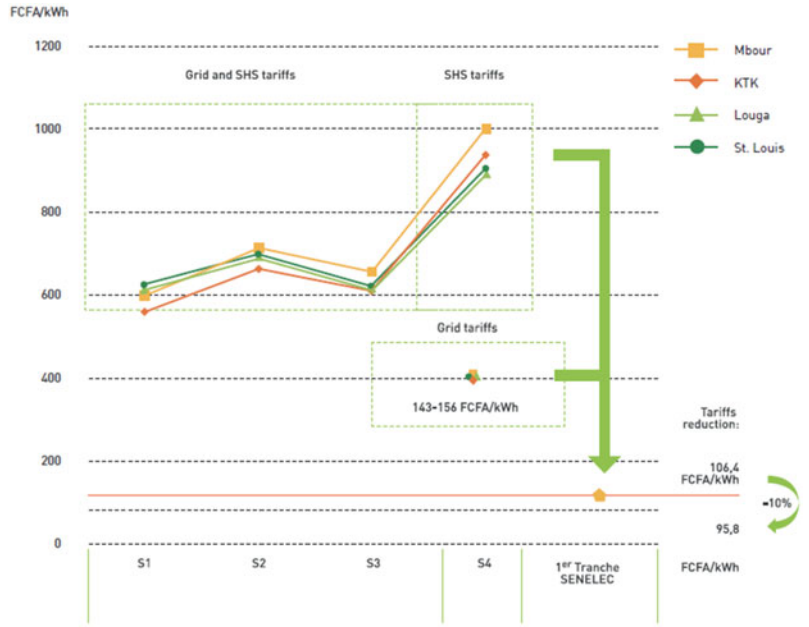

Fig. 3.7 Comparison of different tariffs in Senegal (Concessions and Senelec) (*Source* Authors GESTO analysis based on data from ASER, PLE and Senelec)

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