Success factors in off-grid energy auctions: A comparative analysis of selected cases from low- and middle-income countries

Backer, Martijn; Keles, Dogan; Bergaentzlé, Claire

Published in:
Renewable and Sustainable Energy Reviews

Link to article, DOI:
10.1016/j.rser.2023.113350

Publication date:
2023

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Success factors in off-grid energy auctions: A comparative analysis of selected cases from low- and middle-income countries

Martijn Backer*, Dogan Keles, Claire Bergaentzlé
Technical University of Denmark (DTU), Department of Technology, Management and Economics, Kgs. Lyngby, Denmark

ABSTRACT

Renewable energies are a key to reducing carbon emissions and enabling access to affordable energy for rural populations in many low- and middle-income countries. For this reason, many governments have started to introduce auctions for off-grid renewable energy. Despite their relevance for clean, accessible energy, the factors for successful or failed off-grid renewable energy tenders have not been broadly studied yet. This paper investigates the success factors for the successful implementation of off-grid energy auctions to enhance rural energy access in low- and middle-income countries. For the scope of this research, the off-grid energy tenders are considered successful if they lead to cost-efficient outcomes, have a high implementation rate and improve the equality of access to energy. Using success measures and success factors from the state of knowledge on energy auctions, three real-world cases from Peru, Uganda and Senegal are analysed and compared. The investigations show that auctioneers should strike a balance between 1) economies of scale and streamlining administrative procedures, 2) allowing adequate product designs for a diverse group of beneficiaries and 3) attracting enough bidders in this relatively young sector. Moreover, this paper confirms that balancing the developers’ risks and public risks is essential in designing off-grid energy tenders and that there are several ways to do this. Furthermore, the advantages and limitations of different support payment types are illustrated. Finally, regarding governance, the real-world cases in this research underscore the importance of clarity about responsibilities and procedures, without which significant delays can be incurred.

1. Introduction

The share of the global population without access to electricity declined from 29% to 10% in the period from 1990 to 2018 [2,3]. For low- and middle-income countries in particular, the increased access rate coincided with the (partial) adoption of a comprehensive power-sector reform model that has been diffused by the World Bank and other international financial institutions since the 1990s [4]. This reform model uses market forces to attract private investors and thus generating capacity into the energy sector, resulting in more access to electricity. Major elements in the reform model are the unbundling and liberalization of the power sector and the privatization of incumbent utilities.

Although success rates vary strongly between countries that have adopted (elements of) the power-sector reform model, it was generally observed that increased private-sector participation has positively affected both generating capacity and electrification rates [4]. Due to radical reductions in costs in recent years, renewable energy technologies – mainly photovoltaic (PV) and wind energy – have contributed to reducing the energy access gap in many low- and middle-income countries. The World Bank’s definition of “low-income” (GNI per capita < $1,085 in 2021) and “middle-income” (GNI per capita < $13,205 in 2021) economies is used in this paper.

Yet, if current policies and population trends continue, an estimated 674 million people will have no access to electricity by 2030 [5]. An important part of this can be explained by the fact that the market forces in the power-sector reform model are less effective in providing the right incentives for delivering electricity to less profitable customers [4]. In many cases, it is not economically attractive to expand the electricity grid to settlements that have low energy-consumption levels or that are located in remote areas [6].

Off-grid energy infrastructures have provided a solution for this, most notably solar home systems (SHS) and mini-grids.1 Slow grid

---

* Corresponding author.
E-mail address: backer.martijn@gmail.com (M. Backer).

1 Throughout this report, solar home systems are defined as completely autonomous PV-based micro-power plants that provide electricity to households or buildings and that usually include some low-consumption devices such as light bulbs and phone-chargers. Mini-grids are defined as a group of interconnected distributed energy resources (DERs) plus loads or a single DER plus load(s) within clearly-defined boundaries. The main feature of mini-grids is their ability to operate independently, enabling them to be set up in remote locations not reached by the main grid [1].

https://doi.org/10.1016/j.rser.2023.113350
Received 9 June 2022; Received in revised form 28 January 2023; Accepted 29 January 2023
Available online 11 July 2023
1364-0321/© 2023 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).
expansion, combined with the rapid fall of costs for renewable energy (R.E.) generation technologies, have allowed SHSs and solar- and wind-based mini-grids to become the cheapest electrification solution for many places in the world [7–9]. The cost-efficiency of off-grid energy technologies is particularly apparent for topographically isolated settlements where electricity consumption is low [10]. Several studies have confirmed this. For example, Moner-Girona et al. [8] estimate that the cost-optimal rural electrification strategy for Kenya is to cover 90% of the rural population with PV mini-grids. Hubble and Ustun [9] state that, under favourable conditions, the cost break-even distance for mini-grids as opposed to grid expansion can be as short as 138 m away from the existing grid. The Energy Sector Management Assistance Program (ESMAP) [7] estimate that by 2030, mini-grids could be the cheapest electrification solution for 490 million people globally.

However, developing off-grid energy solutions comes with its own set of risks. These risks include but are not limited to: scarcity of proven business models (due to the newness of the sector); potential inability to charge cost-reflective tariffs (due to government regulations); uncertain local demand; social risks (e.g. lengthy processes to gain trust of the beneficiary communities); and the possible arrival of the main grid (which would undermine the economic viability of the off-grid energy solutions) [11,12].

Low- and middle-income countries have used different policy mechanisms to offset these risks, chief among them auctions for subsidies for renewable electricity [10]. Some of the auctions have been implemented quite successfully, while others more or less failed to achieve the set targets. The underlying factors for the success and the reasons for failed renewable electrification measures need to be investigated to design better future policies in the low- and middle-income countries. However, unlike utility-scale energy auctions, which have become a much-discussed topic in the academic literature (see for example [13–16]), the challenges for off-grid energy auctions are scarcely described.

Existing literature on this topic mainly consists of theory formation and individual case studies (e.g. [6,12,14,17,18]): a comparative analysis between real-world cases does not exist yet to the best of the authors’ knowledge.

This study therefore aims to gather knowledge about the successful implementation of off-grid energy auctions to enhance rural energy access in low- and middle-income countries. Two research questions are central to this study:

- What are the success factors in the design of off-grid energy auctions?
- What are the indicators of good governance in off-grid energy auction programmes?

For this purpose, the existing conceptual analyses on the topic are assembled to create a conceptual framework for energy auction design and governance, allowing a focused assessment of off-grid energy auctions. By comparing three real-world cases, this study investigates how the success factors of energy auctions that can be derived from the academic literature apply to each of these cases.

The lessons from the comparative study will provide insights for regulators and stakeholders in low- and middle-income countries when organizing or participating in similar off-grid electrification tenders based on renewable energy. It will also form a basis for further academic analyses that are urgently needed to address the social challenge of green energy-based electrification in low- and middle-income countries.

This paper is structured as follows. Section 2 describes the approach and conceptual framework used for the analysis, and Section 3 the methodology. In Section 4, the policy contexts and designs of the real-world case auctions are discussed. Section 5 provides a descriptive overview of the outcomes of the real-world cases. In Section 6, the conceptual framework is applied to the real-world cases to identify patterns regarding auction design and governance. The paper ends with a summary of the most important conclusions (Section 7).

2 As rural electricity access in high-income countries is already at 99.9% [3], these countries have been excluded from the scope of this study.
The different elements of Fig. 1 are further elaborated upon in the following sections. In Section 2.1, the success measures, i.e. the measures used in this study to determine the success rate of the auctions, are presented. The most important success factors for off-grid energy auctions are summarized in Section 2.2. Auction design is considered to concern the arrangement of the auction's parameters, whereas governance refers to a process through all stages from development to implementation and follow-up of the energy auction. Empirical studies create new knowledge by providing observations and matching the validity of theoretical studies in real-world cases. The academic literature and theory formation about on-grid energy auctions in high-income countries is rather extensive. However, their applicability to off-grid energy auctions in low- and middle-income countries has not yet been discussed as much in the academic literature. This empirical comparative analysis gives a first attempt to enrich existing literature. Moreover, the chosen research design allows us to compare cases from non-harmonized data sources. The selection of real-world cases shows a variety of country contexts. Gathering observations from different contexts could make the results more interesting for multiple contexts.

2.1. Success measures

Defining the "success" of auctions is no trivial matter. The three success measures used in this paper are an adaptation from those put forward by Lucas et al. [19], Del Río et al. [20] and Gephart et al. [21].

The first measure is cost-efficiency (Section 5.1). An auction is considered cost-efficient if the auction target is reached at the lowest possible system costs. The fact that the real-world cases in this study were launched relatively recently made it difficult to analyse their dynamic efficiency in a meaningful way (e.g. long-term technology effects such as the impact on innovation). Therefore, only static efficiency falls within the scope of this paper.

The second measure is effectiveness (Section 5.2) consisting of a priori effectiveness, or the degree to which the offered volume is contracted and ex-post effectiveness, or the degree to which the contracted volumes are actually delivered [22].

Finally, given the focus of this paper on low- and middle-income countries, equality of access is taken into account (Section 5.3). Equality of access is defined as the degree to which the auction outcome reduces energy access disparities between regions and income groups.

2.2. Success factors

2.2.1. Auction design

Auction designs can significantly affect the outcomes and must be carefully arranged together. By affecting the costs, risks and benefits to participants, the design affects the number and type of bidders [23, 24], the resulting tariff / subsidy level [13], the type and scale of technologies that will be deployed [23], public acceptance of R.E. technologies [23] and the realization rates of winning bids [13]. As policy goals might inhibit one another, designing auctions is a balancing act [16].

Policymakers have many degrees of freedom in designing R.E. auctions.³ In this paper, these degrees of freedom are called auction design elements. Inspired by a list of twelve such design elements [14], Table 1 presents a selection of six energy auction design elements that are central to this study. The elements that are considered specifically relevant for off-grid energy auctions (based on, among other sources, the conclusions of Lucas [6]), are selected for investigation in this study.

Table 1

<table>
<thead>
<tr>
<th>Design element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target volume</td>
<td>Target of the auction. Typically a capacity, generation volume, budget or number of connections.</td>
</tr>
<tr>
<td>Product diversity</td>
<td>Degree of technological requirements to the auctioned product</td>
</tr>
<tr>
<td>Support conditions</td>
<td>Remuneration conditions. Can be capacity-based (e.g. fixed subsidy), generation-based (e.g. feed-in tariff, feed-in premium), service-based (e.g. number of connections)</td>
</tr>
<tr>
<td>Financial guarantees</td>
<td>Security payments and penalties to ensure that winning bidders actually deliver the agreed products</td>
</tr>
<tr>
<td>Price ceiling</td>
<td>Maximum support level</td>
</tr>
<tr>
<td>Risk allocation</td>
<td>Distribution of risks between public and private stakeholders</td>
</tr>
</tbody>
</table>

³ For off-grid energy auctions, the policymakers are usually the Ministry of Energy or affiliated agencies such as a rural electrification agency.
must be designed in such a way as to limit the risks to private investors.

In addition to the target type, the target volume must be set. Setting the right volume is important as auctioned volumes that are too large may reduce competition by deterring smaller participants [25], or if the market is not ready to take up the auctioned volumes [26]. On the other hand, volumes that are too small may lead to excessively aggressive bidding (thereby affecting the implementation rate) and less R.E. deployment than could potentially have been deployed [22].

**Product diversity**

Auctioneers must decide on the technological restrictions of the auctioned products. Central here is the discussion between technology-specific and technology-neutral R.E. auctions. In technology-specific auctions, the contributions of individual R.E. technologies are set beforehand. Kitzing et al. [13] explain that auctions with this constraint may lead to higher generating costs than technology-neutral auctions, where those technologies that have the lowest generating costs are awarded first. However, determining the technology beforehand may reduce the system integration costs and benefit the development of new industries. The choice between technology-specificity and technology-neutrality therefore depends on elements such as the differences in generation and system integration costs between technologies, available market potential and maturity of the technologies [13].

**Support conditions**

Auction designers must make choices regarding the characteristics and conditions of the financial support given to R.E. generation. Remunerations can be set for newly installed capacity (e.g. fixed subsidy) per unit of electricity generation (e.g. feed-in tariffs and feed-in premiums) or, especially for off-grid energy systems, for provided services (e.g. the number of installations). Although generation-based support brings more incentives for efficient plant operation, capacity-based support may provide greater certainty on support costs [14]. Additional choices are whether to couple the remuneration level to performance or not, and which responsibilities to charge the winning bidder with.

**Financial guarantees and penalties**

In order to ensure timely project realization, bidders may be obliged to pay financial guarantees beforehand or pay penalties in case of non-delivery. Financial guarantees and penalties can form a security measure against winning bidders not delivering the agreed installation. Again, there is a balance to strike in deciding upon the proper penalty and the level of financial guarantee. Whereas levels that are too low may attract speculators, penalties that are too stringent may form a barrier to smaller parties in particular to participate, which would reduce competition [13]. Due to the novelty of the off-grid energy markets and the limited examples of proven business models related to that, this auction design element is particularly interesting to consider when analysing off-grid energy auctions [10].

**Price ceiling**

Policymakers have the option to set a maximum support level or price ceiling in order to control support costs. Generally, Kitzing et al. [13] recommend price ceilings for R.E. auctions, although some important notes are made regarding setting the right level for the ceiling price. If policymakers set the ceiling price at a level much higher than the technology cost and there is limited competition, bidders may adjust their bids towards the ceiling price. Moreover, the mere existence of a ceiling price may give bidders the idea that the auctioneer anticipates low levels of competition, thereby inducing strategic bidding behaviour. On the other hand, setting the price ceiling below the technology costs reduces competition and may even make it difficult to reach the R.E. target.

**Risk allocation**

To stimulate off-grid R.E. project development effectively, auctions must be designed in such a way as to limit the risks to private investors while not causing excessive risk for public parties. Based on a large number of interviews with stakeholders within the R.E. mini-grid sector in Africa, the UK Department for International Development [11], Phillips et al. [10] and Antonanzas-Torres et al. [27] provide overviews of the additional risks of developing R.E. off-grid energy projects compared to utility-scale R.E. plants (for which a set of common risks can be found in [28]). The first of these specific risks is the lack of proven business models, technical capacity and streamlined procedures due to the novelty of the market [10].

Secondly, developers may not be allowed to charge cost-reflective tariffs. In only 2 out of 17 developing countries studied by Foster & Rana [4] were the electricity tariffs charged sufficiently high to cover the total cost of power delivery. Providing electricity to rural areas is usually more costly than electricity provision in urban areas, and often rural incomes are below urban ones [19]. Therefore, politicians may be reluctant to allow higher tariffs than in the rest of the country based on the principle of spatial justice [27]. Such restrictions can make it impossible to charge cost-reflective tariffs and mount a challenge for public authorities to offer additional sources of income (subsidies, premiums) to the developer that make the development of mini-grids attractive [11].

Thirdly, mini-grid developers face demand risk. The economic viability of mini-grids depends on local demand more than utility-scale plants that inject their generated electricity into the main (national) grid. Fourthly, off-grid projects face social risks, as the process of gaining trust and acceptance from the end-user communities can be lengthy and costly [12,27]. Finally, a factor unique to off-grid energy solutions is the risk of grid expansion. As electricity from off-grid energy solutions is usually more expensive than electricity from the main grid, expansion of the main grid into the area where the mini-grid operates can threaten the competitiveness of the off-grid energy solutions [11].

2.2.2. Indicators for good governance of energy access projects

“Good governance” is a success factor that goes beyond designing an energy auction. It is important at all stages from development to implementation and evaluation of the energy auction. Governance can be defined as the traditions and institutions by which authority is exercised [29], “by a government, market, or network” [30]. Multiple scholars describe the effects of good governance environments on public–private partnerships’ success within the energy sector and across different sectors [31–33]. For example, using data from over 4,500 public–private partnership projects from 138 developing countries, Wang et al. [29] found evidence that a good governance environment makes private investors willing to assume more risk for their investments in the energy sector.

Following Stritzke et al. [34], this study splits up “good governance” into six success factors related to energy access projects. Many of these serve as necessary pre-conditions for each other.

The first success factor, rule of law, is defined as the “existence and consistent application of a clear legal framework for the private sector to invest and operate in energy access projects” [34]. This includes reliable licensing and permission processes because a track record of sudden and unannounced changes in the applicable regulations in a country increases the risks for private investors. This point is confirmed by the statistical research of [29].

Secondly, good governance is characterized by transparency. Maurer and Barroso [35] confirm this, stating that the off-grid energy sector, nascent and highly dynamic as it is, demands predictability and clarity about procedures and responsibilities [35]. Making information accessible to all stakeholders who are directly or indirectly affected by the energy projects, before, during and after the auction, can help obtaining predictability and clarity [34,35]. Moreover, timely dissemination of information about the auction’s objectives, rules and operations can help auction participants prepare and provide inputs [35].
Thirdly, in Stritzke et al. [34] inclusiveness is seen as an important indicator of good governance. Inclusiveness means that all affected stakeholders are included in the decision-making process. Also, this involves auction organizers displaying clear efforts to balance interests between beneficiaries, the public sector and the private sector. Although Wang et al. [29] find no evidence for any positive relation between “public voice” and private investment, inclusiveness can be an important success factor for the long-term operation of energy projects in developing countries. Stritzke et al. [34] illustrate the relevance of inclusiveness. Without inviting local decision-makers to the table, programmes that are entirely designed by foreign donors run the risk of favouring foreign companies and thereby excluding local participants. Also Wlokas et al. [36] highlight the importance of quality relationships between industry, government and local communities if energy projects in low-income countries are to be developed successfully.

Fourth comes efficacy of the auction rules. Efficacy means that the rules are harmonized and coherent and leave no space for loopholes [34,35]. Also, it involves a focus on economically efficient solutions that show no technological bias (for example, towards grid expansion rather than off-grid solutions, as seen in [34]). Wang et al. [29] find that the quality of policy formulation and implementation and a government’s commitment to their policies increases the willingness of private parties to invest in the energy sector in developing countries. Specifically, sectors with fragmented administrative structures and low technical and managerial capacity on the part of the government increase the risk to the success of projects.

The fifth good governance indicator is accountability. In general, this is the possibility to investigate policies critically. In relation to energy access, it involves providing beneficiaries with enough knowledge to trace the outcomes of a policy to the responsible actor. Unclear mandates between different actors form a common threat to accountability. For example, Maurer and Barroso [35] notice that the role of the auctioneer is often confused with that of the government. Another risk to accountability is the influence of foreign donors and companies in designing energy access policies, especially in contexts where governments are not in a position to reject foreign involvement easily [34]. On the other hand, ex-post audits that verify whether all the rules were correctly followed and whether participants have abused market power contribute to accountability [35].

Finally, responsiveness, or the “capability to understand, institutionalize and ultimately meet the needs of the sectoral stakeholders involved in a reasonable time frame”, also makes for good governance [34]. For this, there must be multiple channels of communication between beneficiaries, governments and other stakeholders [34].

3. Methodology and data collection

As Flyvbjerg [37] argues, sometimes real-world cases can show more depth and completeness than a cross-unit analysis because they focus on the development of the cases over time and in relation to their environment. For this research, real-world cases are used to shed light on how auction design and the governance of energy access projects influence the process from tender publication to project implementation.

The following off-grid energy tender programmes are selected for the real-world cases: an SHS auction in Peru called Proyecto Masivo (2014), the Pro Mini-Grids programme in Uganda (2015) and the Programme Prioritaire d’Electrification Rurale in Senegal (2004).

Peru, Uganda and Senegal all have experimented with liberalizing their electricity sectors by following the World Bank’s power-sector reform model over the past twenty years [4]. Although each country adopted the reform model to a different degree, the described energy access programmes all form a new step in these long-term pursuits of private-sector participation in the energy sector. Furthermore, all three countries enjoy abundant solar resources but suffer from limited electrification rates in rural areas. These reasons form part of the rationale for selecting these real-world cases for the analysis.

The scope of this research did not allow a large set of interviews to be conducted throughout the case-study areas. The remoteness of the beneficiary areas of the real-world cases made such an effort time-consuming and costly. At the same time, conducting a smaller set of interviews may have resulted in a bias in favour of the experiences of those stakeholders that are the most easily accessible, and against those who are more remotely located. Therefore, the choice has been made to base this study primarily on peer-reviewed academic literature. As the academic literature on off-grid energy auctions in low- and middle-income countries is limited, it is complemented by government documents and documents from respected international institutions.
Renewable and Sustainable Energy Reviews 183 (2023) 113350

(such as the World Bank, the UN, or ECOWAS). A small number of mainstream media sources are used for some minor updates on these programmes. All sources used in this paper are categorized in Table 6 in Appendix.

The internal validity of this study is ensured by basing it on highly credible sources, and the reliability of the academic sources is ensured by the fact that they are peer-reviewed. Based on the fact that there is a broad use of data from international institutions in the scientific literature (see, for example, [38–41]) and that sometimes this data is the only source for low- and middle-income countries, the authors believe that the international institutions that were used as sources for this paper (i.e. the World Bank, the United Nations, IRENA, GIZ, the UK Department for International Development, ECOWAS) have high levels of credibility. Regarding the government agency sources, these sources were mainly used for “neutral” and easily verifiable observations, such as auction conditions, auction winners and prices. In the few situations where a government source was used for the evaluation of the auctions, the statement is backed up by a non-government source to ensure that the information from the government source is reliable.

4. Real-world cases: Evidence from Peru, Uganda and Senegal

This section presents the real-world cases. Table 2 provides an overview of the auction parameters in the three real-world cases.

4.1. Peru: SHS concession zones

Peru presents an unbundled electricity sector with clear separations between generation, transmission and distribution. Private actors own the majority of the generating capacity (78%) and transmission grid (88%), but the distribution grid has mainly remained state-owned (81%) [4]. A large share of electricity is traded on the wholesale market, and an independent regulator, Osinergmin, is responsible for monitoring the market. Auctions for R.E. projects have existed since 2006 [42].

The sector restructuring stimulated electrification, which increased from 67% in 1995 to 93% in 2014 [3,4]. However, a closer look at the electricity grid expansion shows significant discrepancies between urban and rural areas [4,43], with an average electrification rate of 99% in urban centres against only 73% in remote rural areas (data from 2014, see Fig. 2) [3].

Off-grid solutions such as SHSs have formed a part of the Peruvian authorities’ strategy to narrow the energy access gap in rural areas [6], as outlined in the Rural Electrification Plans [43]. The plans have given rise to two Rural Electrification Improvement Projects (FONER 1 and 2) conducted between 2006 and 2013, of which auctions for 9,000 to 20,000 SHS connections formed a part [43]. In 2014, these programmes were followed up by the Proyecto Masivo, a larger, nation-wide tender for 150,000 SHSs [5,43,46].

The product auctioned in the Proyecto Masivo was a concession to install and maintain SHSs for a minimum of 149,000 households, 630 medical centres and 2,260 schools against a fixed subsidy per end-user [6]. The auction was set up for three concession zones (north, central and south), with the minimum number of installations shared approximately equally between the zones. The auctions specifically targeted sites in remote areas with high poverty rates that are not connected to the main grid and are most unlikely to be connected to the main grid in the next ten years. The technical requirements and sizes of the installations were prescribed in detail under the rationale that this would allow for economies of scale and hence lower bids [6,47].

The winning bidders receive 15 years of remuneration in monthly instalments from a fund. The money in this fund originates from end-users (20%) and from subsidies (80%) [48]. The instalments are indexed for global inflation and paid out in US$ to limit inflation and currency risks for international investors [49]. Moreover, the level of remuneration is corrected yearly based on the developer’s response to failures in the installations [49], in response to Osinergmin’s findings that up to 34% of installed SHSs in previous programmes were not in operation [43].

The task of collecting payments was assigned to incumbent distribution companies in the regions [48], so as to shield developers from this expensive task. However, the developer is responsible for maintaining the installations and disconnecting the SHSs when end-users do not fulfill their payments (and reconnecting once payments are resumed). These can become costly tasks due to the rough terrain that many end-users live in. The fee that the developer is allowed to charge the users for these services is defined by Osinergmin [49].

The only selection criterion for the auction was the price. Other selection criteria, such as fulfilling social goals or stimulating the local economy, were assumed to be covered by the site-selection process and product choice. A non-disclosed ceiling price formed a safeguard against very high costs if the auction is non-competitive. A sealed-bid, single-item auction set-up was used [6].

Regarding the bidders, several requirements were put in place. First, the bidders had to be registered in Peru with a minimum social capital of 10 million US$. Second, the bidders had to provide financial guarantees: 1 million US$ bid guarantee, 10 million US$ construction guarantee and 2 million US$ contract guarantee. As the off-grid market in Peru was small at that time, no technical requirements were defined concerning the bidder’s previous experiences in the field [6].

4.2. Uganda: Pro mini-grids

Uganda’s electricity sector is fully unbundled, and the country has an independent Electricity Regulatory Authority (ERA), which is in

Fig. 2. Electrification rates per department and transmission grid in Peru, 2018. Most cities are situated at the coast. Source: Author’s creation, data from [44,45].
Renewable and Sustainable Energy Reviews 183 (2023) 113350

M. Backer et al.

Fig. 3. Electrification rates per district in Uganda, 2014. The concession zones of the Pro Mini-Grids are Lamwo in the north and Isingoro/Rakai in the south [50].

charge of planning and setting cost-reflective tariffs [4]. Nevertheless, Uganda never fully liberalized its power sector. Electricity is traded using a single-buyer model, where the TSO Uganda Electricity Transmission Company Limited (UETCL) is the only authorized trading intermediary between the generating and distribution companies [51]. Moreover, although allowed in generating and retail activities [52], private-sector participation remains limited, partly due to a 2010 law establishing the state’s involvement in all energy projects over 25 MW [4].

Although Uganda’s largest distribution company, Umeme Limited, ranks as one of the better-performing utilities in sub-Saharan Africa regarding progress with operational efficiency and cost recovery, energy access rates have remained low (Fig. 3) [4]. As access-related investments were thought to drive up electricity tariffs, the ERA often did not allow them [4]. However, the second Rural Electrification Strategy Plan (RESP, 2013–2022), which spells out a master plan for each of Uganda’s thirteen regions, has assigned more importance to off-grid energy solutions and to mini-grids in particular [4,52]. In line with this, the Ministry of Energy and Mineral Development, Uganda’s Rural Electrification Agency (REA) and the ERA initiated a programme for the large-scale deployment of mini-grids in 2015. This programme received financial support and technical assistance from the German Corporation for International Cooperation (GIZ) and the European Union (EU) [17].

Central to this so-called “Pro Mini-Grids” programme was a pilot tender for mini-grid deployment in 40 villages, with the objective of attracting international mini-grid developers [17]. Multiple mini-grid locations were bundled into single contracts to allow economies of scale [17]. Two auctions were held: one in the country’s north (for 25 mini-grid locations) and one in the south (15 mini-grids). Each of the auctions provides the successful bidder with the right to build, own, and operate mini-grids in the pre-selected sites for ten years, after which the ownership and operation are transferred to REA [17].

The Pro Mini-Grids auction consists of two stages. In the pre-selection stage, the bidders are shortlisted based on their perceived technical experience (based on their track record) and financial strength (based on their financial performance over the previous five years, among other things) [1]. The winning bidder is selected mainly based on the lowest tariff offer in the next stage. However, here the proposed time frame of implementation, quality of materials and incorporation of plans for productive use are weighted as well. Productive use here means commercial and industrial electricity use (e.g. mills, welding machines, fridges, a processing facility). The productive use element was added because the Pro Mini-Grids programme is specifically aimed at rural industrialization and because its (daytime) energy consumption can increase the profitability for the mini-grid developer [17].

The auction designers have tried to mitigate the developers’ risks through several regulations. First, grid arrival risk is minimized through site selection, by situating the mini-grids in areas into which the grid will most likely not be extended in the near future. Should grid arrival occur, however, developers are offered the possibility to continue operations or to transfer their assets to the REA (or be financially compensated) [17]. Other financial risks are reduced through the government’s commitment, even for force majeure [17]. The aforementioned productive-use element may ensure a stable energy demand for the developer. Finally, risks related to land acquisition are mitigated through government purchases of the land, after which the developers lease the land from the government [17].

4.3. Senegal: Technology-neutral concession zones

Senegal’s electricity sector contrasts starkly with those of Uganda and Peru. A public company, Senelec, owns most of the country’s generation, transmission and distribution activities. The electricity tariffs are regulated by an independent regulatory body, Commision Régulatoire du Secteur de l’Electricité (CRSE).

Furthermore, the rural electrification agency – Agence Sénégalaise d’Electrification Rurale (ASER) – has been founded to take over Senelec’s responsibilities regarding rural electrification, including the development of rural electrification programmes, coordination of tenders,
proposals from private operators for rural electrification, and provision of financial and technical assistance [53]. The ultimate target is to lift rural electrification rates from 9% in 2004 [3] to 60% in 2022. One of the most notable efforts for achieving this objective has been the Programme Prioritaire d’Electrification Rurale (PPER).

The PPER sub-divides Senegal into ten rural concession zones, located outside of the operating areas of Senelec (Fig. 4). PPER auctioned the rights to provide electricity services in these zones. The subsidy for the winning bidder was pre-defined and consisted of a fixed CapEx subsidy [54]. The tariffs charged to the customers are negotiated between CRSE and the concessionaire [53]. The bidder pledging to introduce the most electricity connections (given the fixed subsidy) wins the tender. This set-up was chosen to encourage concessionaires to seek extra financing (thus drawing foreign private investment into Senegal) and charge cost-reflective tariffs [53].

Concessionaires must build, maintain and renew installations, provide electricity for at least six hours per day and collect payments from customers [57]. In return, they have great freedom in their approach to providing electricity: through grid expansion, SHSs or mini-grids. The concessionaires must purchase the electricity they intend to provide through grid expansion from Senelec at the nationally regulated tariff, minus 25% as compensation for building the distribution grid [57].

The PPER was explicitly designed to attract foreign investment. For this reason, it excluded Senegalese companies from the tender [53].

5. Results of the real-world cases

In this section, the outcomes of the three off-grid energy auctions are discussed in relation to the assessment criteria presented in Section 2.1: cost-efficiency (Section 5.1), effectiveness (Section 5.2) and equality of access (Section 5.3). Table 3 summarizes the results of the three tender programmes/real-world cases.

5.1. Cost-efficiency

Peru

The Proyecto Masivo Masivo in Peru attracted two bidders in total and had only a single bidder in the northern zone. The same bidder (Ergon Peru) won all three concessions. This low number of bidders indicates weak competition and is considered to be the main shortcoming of this auction [6].

Interestingly, despite the low participation rate, the winning bids were well below the ceiling price and the losing bids (around 50% lower) [47]. Welch [48] explains this paradox by arguing that essential parts of the project costs were left out of the auction. As off-grid energy technologies are situated close to the end-users, implementing off-grid energy projects usually has a strong social component. Social challenges related to off-grid energy projects may involve gaining trust from the community [12], instructing end users on how to use the technologies [27], collecting payments and disconnecting users when bills are not paid [48].

Stakeholders from the public and private sectors involved in the Proyecto Masivo, explain in [48] that the project was initially organized to tackle technical challenges (installation and maintenance of the SHSs) and that it shielded developers from the possible social risks. Although the contract states that the developer must instruct end-users about the use of the SHSs and the payments, the developer continues to receive 80% of its annual subsidy regardless of whether end-users pay their electricity bills or not [49]. The costly tasks of issuing invoices and collecting payments were assigned to the public distribution companies, which face shortages in the human and financial resources needed to execute this task properly [48].

Uganda

The Pro Mini-Grids auction in Uganda attracted around thirty bidders. Several of these bidders were disqualified in the pre-selection stage because they did not meet the financial requirements. Formal mistakes disqualified some other bidders. Ultimately, the winners of the tenders were Winch Energy (north) and WeLight (south). At a level of around 2,500 Ugandan Shillings (0.70 US$) per kWh, the offered tariffs
were lower than in most other countries [17,58]. The high number of bidders and low bid tariffs indicate that the auctions were competitive.

After the concessions had been awarded, a new national policy capped electricity tariffs nationwide at 0.29 US$/kWh. This tariff is lower than the bid prices. Therefore, the financial support structure for the mini-grids changed from tariff-based to a structure based on a fixed subsidy to cover capital expenditure. For this reason, the final cost-efficiency of the auctions is hard to assess [17,59].

**Senegal**

In Senegal, only six out of ten concession zones were awarded to IPPs. Four of these are consortiums with a high share of foreign state-owned companies (from Morocco, France and Tunisia), and one is a private company [53]. The offered number of connections exceeds the minimum requirements for each zone by up to three times. Nevertheless, one could argue that the level of private interest was not wholly satisfactory, with four out of ten concession zones not being awarded at all due to a lack of private interest [53,56].

Initially, the auction was effective in mobilizing private investment, with private finance making up 22% to 70% of the project finance [53]. However, it seems that the project has damaged the long-term capacity to gain private funding, as several funders have expressed dissatisfaction with the progress of the programme (see Section 5.2) [53].

Some actors have stated that ASER should have developed a more comprehensive least-cost rural electrification strategy before setting up the concession zones. With the technology-neutral set-up, ASER left it very much up to the concessionaire to develop least-cost solutions [54].

**5.2. Effectiveness**

**Peru**

The Proyecto Masivo in Peru suffered from long delays. The project installed 6000 SHSs in 2017 when 150,000 were planned [48]. Several factors explain this.

First, the initial timeframe of the tender was unrealistic. Multiple sources name President Humala as responsible for this, as he exerted pressure to have the project finished before the end of his political term in 2016 [6,48]. The rush resulted in the scheduled time for different project stages being insufficient. For example, the developer Ergon only had 4.5 months to carry out a census of the villages, against an average of two years in similar projects [48]. Besides, the low quality of the data provided by MEM to Ergon regarding those villages that were not connected to the grid further delayed the census [43].

Second, the auction lacked clarity regarding the technical requirements, notably inducing a time-consuming dialogue between Ergon and MEM to establish appropriate systems protection equipment. The in-house cabling requirements could hardly be met due to unanticipated constraints in dwelling construction, leading to more delays in installations [6].

Finally, the roles and responsibilities of the different actors were not clearly defined, especially regarding bill collection, which required that the government step in to resolve the issue [6].

Since May 2021, 205,000 homes, 2,300 educational institutions and 630 medical centres have access to electricity [46]. However, the sustainability of the SHSs operation is questionable in light of the social challenges described in Section 5.1. Besides, there is today no contractual obligation to conduct equipment maintenance, although the auction contract states that Ergon must execute this task [43]. Ergon seems to consider itself an independent actor benefiting from guaranteed profits and not affected by performance targets, thereby jeopardizing the SHSs’ long-term performance [48].

**Uganda**

In Uganda, the Pro Mini-Grids tender was launched in 2017 after two years of organizing. By 2018, the pre-selection process was complete. The mini-grids were expected to be operational by the beginning of 2020. However, the current situation is that the northern mini-grids of Winch Energy are under construction and are expected to be operational in 2022 [60]. Despite the delays, the “overwhelming” support of the residents of the northern area was noted by ERA in a public hearing in 2020 [58]. In the southern case, the licence of exemption (required to build and operate the mini-grids) was revoked by WeLight energy by ERA in mid-2020 [61,62]: “it was established that WeLight Limited was unwilling and unable to implement the project in line with the terms and conditions (...)” [59]. There were no regulations in the auction regarding penalties for non-delivery.

The main explanatory factor for the long delays is a decision by the national government to set a national cap on electricity tariffs of 0.29 US$/kWh. The fact that the winning bid tariffs for the Pro Mini-Grids programme were above this cap made renegotiations necessary to ensure that the projects were feasible even under the new (lower) tariff. Ultimately, it was agreed to increase the level of CapEx subsidies to 80% of CapEx (instead of 60%–70%) to compensate for the reduced revenues from the tariff cap. The new situation also implies that future mini-grid tenders will build on a fixed tariff, and the tenders will be for minimum subsidy instead of for the lowest tariff [17].

**Senegal**

Senegal’s PPER also suffered from significant delays. The concessions were awarded in 2008, four years after the calls for bids. Only six out of ten concession zones were awarded due to a lack of interest from private investors [56]. Ultimately, the first concessionaire started operating its project in 2011 [57]. In 2015, only 3,700 households had been given access to electricity through the project, against a targeted 106,601 connections within the first 36 months after the tender [53,63]. Around half of the connections were made through grid expansion, the other half through solar-energy-based off-grid solutions [54].

---

Table 3

<table>
<thead>
<tr>
<th>Success criterion</th>
<th>Indicator</th>
<th>Peru Proyecto Masivo</th>
<th>Uganda Pro Mini-Grids</th>
<th>Senegal PPER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost-efficiency</td>
<td>No. of bidders</td>
<td>2</td>
<td>~30</td>
<td>unknown</td>
</tr>
<tr>
<td></td>
<td>Winning bid price</td>
<td>28.5 million US$/year</td>
<td>0.70 US$/kWh</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Awarded concessions</td>
<td>3/3</td>
<td>2/2</td>
<td>6/10</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>Connections (% of target)</td>
<td>205,000 homes (138%); 2,300 schools (102%); 630 medical centres (100%)</td>
<td>25 (63%)</td>
<td>3,700 households (3%)</td>
</tr>
<tr>
<td></td>
<td>Implementation time</td>
<td>2 - 5 years delayed (expected)</td>
<td>2 years delayed</td>
<td>Operations started 8 years after auction</td>
</tr>
<tr>
<td>Equality of access</td>
<td>-</td>
<td>Partial access based on least-cost considerations of the project developer</td>
<td>Discriminatory access based on bidders’ commitment</td>
<td>Increased access, but higher tariffs for customers</td>
</tr>
</tbody>
</table>

Summary of the outcomes of the three real-world case programmes with respect to the success criteria presented in Section 2.1.
The delays are attributed to organizational and bureaucratic factors. Due to the failures in previous attempts to privatize Senegal’s electricity sector, designing PPER and setting up the tender encountered significant opposition. Moreover, after the bids had been selected, it took two years for CRSE, ASER and the concessionaires to reach an agreement regarding the legal framework and the tariffs to be charged in the concession zones [54].

Tensions between Senelec and ASER have also contributed to delays. The responsibility for rural electrification was transferred from Senelec to ASER in 2001. Several interviewees in [53] state that employees at Senelec regarded PPER as a “back-door” attempt to privatize Senegal’s electricity sector (after the failed privatizations in 2000 and 2001). In line with this, interviewees state that Senelec feared PPER would harm their customer base and profits. As a result, Senelec was reluctant to give up part of its territory to concessionaires and refused to collect payments from rural customers to transfer them to ASER [53]. The lack of intervention by the Ministry of Energy – formally in charge of both Senelec and ASER – added to PPER’s significant delays (and PASER in general). Finally, the quality of the supply did not meet the standards set by CRSE, particularly regarding voltage stability [54].

5.3. Equality of access

Peru

Equality of access was well included in the product and site selection of Peru’s Proyecto Masivo, but with limited practical application. First, the most remote areas are probably still not reached by the Proyecto Masivo, because the developer was granted the freedom to prioritize the more accessible locations [43].

Besides, despite the target to enable economies of scale in the technology-specific auction, a technology-neutral auction would have supported the development of more optimal solutions for many residents. For example, Solar Pico Systems (i.e. small-scale solar solutions) better suit nomad community needs and residents located in remote areas [43]. Allowing the possibility for larger systems, such as mini-grids, could have prevented the risk to larger users of a low-energy future lock-in [64]. Moreover, the standardization of SHSs caused a disparity in electricity generated between the concession zones. As the north of the country receives less solar radiation than the south, the pre-defined 85 Wp generates locational discrepancies in electricity production [43,65].

Uganda

The Pro Mini-Grids programme in Uganda shows even more inequalities. As it included neither back-up solutions in case of non-delivery of the mini-grids nor penalties, the receiving villages depend for their energy supply on the bidders’ commitment. In the pilot project, this resulted in the northern villages receiving electricity whereas the southern villages were left without.

Senegal

In the PPER in Senegal, customers were dissatisfied with the higher tariffs they faced compared to households connected to Senelec’s grid. This social inequality has caused significant tensions, especially in areas bordering Senelec’s operating area [53,54]. CRSE is now working on the national harmonization of electricity tariffs to limit discrepancies between grid users.

6. Assessment of real-world cases based on the conceptual framework

Studying the real-world cases alongside each other yielded several interesting transversal good practices and shortcomings concerning auction design and the governance of off-grid energy access projects (Section 2). This section, and Table 4 in particular, summarizes these observations.

6.1. Auction design

Target volumes and product diversity

In line with the claims of Del Río [14], this study’s real-world cases show that larger concession zones can facilitate economies of scale and reduce the administrative burden. However, they also confirm that smaller concession zones may attract more bidders and lead to less concentrated markets (as claimed in [25,26]).

In agreement with recommendations from Anatolitis et al. [66], the rationale for granting large concession zones in Peru was to allow for economies of scale and hence generate lower bids. However, the low number of bidders in the Proyecto Masivo auctions suggests that the large concession zones may have deterred potential smaller bidders who could not provide enough connections. The fact that the off-grid energy market is a new market with few established companies reinforces the idea that the concession zones were too large. In contrast, Uganda’s small concession zones of 15 to 25 mini-grids attracted many bidders. In Senegal, the relatively large concession zones did not attract enough bidders to find a concessionaire for each zone. On the other hand, even fewer large concession zones could potentially have streamlined administrative procedures and fostered project implementation [53]. Due to the early development stage of off-grid energy markets, policymakers should support access to smaller bidders by setting product volumes corresponding to their bidding capabilities.

The real-world cases also provide insights into the consequences of restricting technologies. Restricting product diversity allows for economies of scale, saves research costs for the developers, contributes to a more coherent electrification strategy, and supports off-grid energy-market development. However, policymakers should bear in mind that this may lead to sub-optimal design and unequal access to electricity, especially if the policymakers plan to combine product restrictions with large target volumes. These observations confirm those made by Kitzing et al. [13]. However, whereas “sub-optimal design” in [13] primarily refers to higher costs than necessary, the real-world cases in this study provide examples of technological restrictions making the product entirely unusable for the beneficiaries.

The rules of the Proyecto Masivo prescribed the technological specifications of the SHSs in detail. Again, the rationale was to support economies of scale and a lower overall project cost, but this requirement resulted in a sub-optimal technology for multiple end-users. Moreover, with unequal solar resources among the SHS locations, fixed technologies lead to unequal electricity provision for end users. Due to the greater geographical and socioeconomic diversity of the end-users, the trade-off between economies of scale and matching local demands is even more visible in large concession zones.

In Uganda, developers were given more freedom in the mini-grids design. The community support for the project suggests that this is a good practice from the grid-users’ perspective. In Senegal, the winning bidders were free to develop their electrification strategy. This freedom seemed to be at the expense of the lack of a coherent national electrification process for rural areas, and it created an extra administrative burden for the concessionaires.

Support conditions, financial guarantees and price ceiling

Support conditions were different between the real-world cases. In Senegal, a fixed subsidy was awarded to the bid with the highest number of planned connections, given the fixed subsidy. This auction arrangement brought predictability regarding public expenses. However, the lack of strong penalties may have offered too little incentivization for concessionaires to deliver what they had bid.

In the Peruvian case, the performance incentive is incorporated in the “results-based” payment, as the concessionaire’s payment is based on the number of successful connections. This provides an incentive to install even more constructions than originally planned, which can result in an excess of electrification targets. Linking the payments not only to successful installation and responses to technical faults, but also
Renewable and Sustainable Energy Reviews 183 (2023) 113350

11

charging public distribution companies with the costly task of collecting the monthly payments for the actual operational performance level and stage. However, the auction arrangement took too many of the risks ceiling price and performance-based payments limited public risks. Also, the establishment of the On the other hand, strong financial requirements were placed on the shielding the developer from the social elements of implementation. Using a strong international currency for the support payments and Risk allocation

Guarantees included in the auction are beneficial in supporting effec-
tions only. It seems advisable to charge the developer with the task of
factor can promote the effectiveness of auctions. Charging developers with the tariff collection responsibility incentivizes good operation and communication with the beneficiaries, and shields incumbent distribution companies from high tariff collection costs.

Price ceiling

Financial guarantees Financial guarantees and penalties for non-delivery seem advisable, as they reduce the risk of non-delivery.

Price ceilings can contribute to limiting public expenses, but need to be established before the launch of auctions.

The developers’ risks and public risks should be balanced through financial guarantees, penalties for non-delivery, price ceilings and operation-based remuneration corrections. Careful site selection beforehand limit the demand risk.

Summing up, the real-world cases show that fixed subsidies provide predictability regarding public expenses. Price ceilings can further contribute to limiting public expenses, but they need to be established before the auction is held. Including a performance-based correction factor can promote the effectiveness of auctions. Ideally, these correction factors are based on operating performance instead of completed installations only. It seems advisable to charge the developer with the task of tariff collection because this maintains their responsibility for the operation and communication with the beneficiaries. Finally, financial guarantees included in the auction are beneficial in supporting effective project implementation. Hence, the real-world cases in this study confirm and provide new examples of the claims made in Kitzing et al. [11].

Risk allocation

In Peru, the auction organizers limited the developers’ risks by using a strong international currency for the support payments and shielding the developer from the social elements of implementation. On the other hand, strong financial requirements were placed on the developers to limit the public risks. Also, the establishment of the ceiling price and performance-based payments limited public risks. Overall, it seems that the risks were balanced evenly for the installation stage. However, the auction arrangement took too many of the risks away from the developer in the operational stage by not correcting the monthly payments for the actual operational performance level and charging public distribution companies with the costly task of collecting user payments. This latter task placed too heavy a burden on public actors and failed to offer sufficient incentives to the developer to ensure reliable electricity services in the long term.

In Uganda, demand risk was reduced by bundling the mini-grid subsidies with subsidies for productive use to ensure a predictable demand. Moreover, the rural electrification agency carefully selected the mini-grid sites and estimated the demand profiles beforehand. Guarantees that the developers could pass on the mini-grids to the rural electrification agency in case of grid arrival limited the grid expansion risk for the developers. Acknowledging the risks related to the novelty of the mini-grid market, the government provided a financial commitment to investors and did not include penalties in cases of non-delivery. This raised high interest in the programme (around 30 bidders), but it also made it easier for one of the winning bidders to withdraw from the programme.

In Senegal, the fixed-subsidy set-up limited public risks in PPFR as it provided predictability concerning the total level of public expenses. The extensive product diversity of the auction limited private risk. Demand risk was mitigated by allowing the concessionaires to choose the technologies freely and pick profitable demand centres first. Moreover, the concessionaires’ freedom to supply electricity through grid expansion eliminated the risk of grid expansion threatening the off-grid energy installations’ profitability. It also reduced the risk of not being allowed to charge cost-reflective tariffs because low regulated tariffs reduced their income and the cost of buying electricity from national system operator, Senelec, equally.

The risks that were identified in [10,11,27,28] are also recognized in the real-world cases in this study. In addition, the latter confirm that balancing the developers’ risks with public risks (including non-delivery of the energy infrastructure) is a key parameter in designing off-grid energy tenders, regardless of the approach chosen. Careful site selection beforehand is essential to limit demand risk. Additionally, it is vital to establish the procedure to follow if the main grid reaches the off-grid energy site.

6.2. Governance of energy access projects

The real-world cases show that clear procedures, responsibilities and agreements are strong enablers of the rapid implementation of tenders. This aligns with best practices found in literature, e.g. in Lucas et al. [67].

<table>
<thead>
<tr>
<th>Design elements</th>
<th>Findings from the case studies</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target volume</td>
<td>Due to the newness of off-grid energy markets, policymakers should set auction volumes large enough to allow for economies of scale and streamlining administrative procedures, and small enough to support access to smaller bidders.</td>
<td>[14,25,26,53]</td>
</tr>
<tr>
<td>Product diversity</td>
<td>While restrictive technology prescriptions may support off-grid energy market development and fall well into a coherent electrification strategy, policymakers should be watchful that the prescribed technologies match the needs of all beneficiaries.</td>
<td>[6,43,53]</td>
</tr>
<tr>
<td>Support conditions</td>
<td>Fixed subsidies provide predictability regarding public expenses, whereas including an operational-performance-based correction factor can promote the effectiveness of auctions. Charging developers with the tariff collection responsibility incentivizes good operation and communication with the beneficiaries, and shields incumbent distribution companies from high tariff collection costs.</td>
<td>[17,48,53,54,59]</td>
</tr>
<tr>
<td>Financial guarantees</td>
<td>Financial guarantees and penalties for non-delivery seem advisable, as they reduce the risk of non-delivery.</td>
<td>[17,48]</td>
</tr>
<tr>
<td>Price ceiling</td>
<td>Price ceilings can contribute to limiting public expenses, but need to be established before the launch of auctions.</td>
<td>[17,59]</td>
</tr>
<tr>
<td>Risk allocation</td>
<td>The developers’ risks and public risks should be balanced through financial guarantees, penalties for non-delivery, price ceilings and operation-based remuneration corrections. Careful site selection beforehand limit the demand risk.</td>
<td>[6,43,48,49,54]</td>
</tr>
</tbody>
</table>

Table 4 Summary of the main observations in this study regarding the auction design elements.
The case of PPER in Senegal illustrates that all programme stakeholders need to agree on the terms and conditions before the project launch. Senegale's negative attitude towards PPER caused significant difficulties and delays in setting up the programme, which to some extent could have been avoided if this uncooperative behaviour had been more stringently penalized (Rule of law) and with clearer division of responsibilities (Transparency and Accountability). PPER also scores negatively on Inclusiveness, due to the explicit exclusion of Senegalese participants. In terms of Responsiveness, the programme did adapt to concessionaires’ wishes, and efforts were made to harmonize electricity tariffs throughout the country in response to social discontent.

Also, the Proyecto Masivo in Peru shows that responsibilities have to be understood and agreed by all stakeholders before the launch of tenders (Transparency). Leaving the responsibility for tariff collection and community instruction to the distribution companies was not accompanied by adequate human and financial resources. Moreover, the winning bidder, Ergon Peru, was not fully aware of its responsibility regarding shutting off power and reconnecting in case of faulty payments.

Although the technical requirements for the SHSs did not suit some households, the uniformity of the product is thought to have allowed economies of scale and thereby more widespread dissemination of the SHSs at least cost (Efficacy). The choice of technology also captured Peru’s lowest income groups and most remote populations. Thus, the product design indicates that decision-makers have made efforts to balance interests between beneficiaries and companies (Inclusiveness).

The Pro Mini-Grids case of Uganda shows the importance of ensuring stable and harmonized policies when a tender is launched (Rule of law). The sudden capping of mini-grid tariffs by the national government contradicted the tender’s terms and conditions. The subsequent re-negotiations led to considerable delays in the northern zone and complete cancellation of the installations in the southern zone. On the other hand, the auction developers did display efforts to balance interests between developers and rural communities, with a focus on rural industrialization (Inclusiveness). Moreover, the developers managed to create a competitive auction environment (Efficacy).

Table 5 summarizes how the three programmes could be measured on the six good governance success factors described in Section 2.2.2. The scores are purely indicative and based on the author’s evaluation of the real-world cases. The lessons from this study regarding good governance of energy projects strengthen the claims made in [29,34,35].

7. Discussion and conclusions

7.1. Limitations and suggestions for further research

The authors suggest the following directions for the extension and improvement of this research.

First, more detailed research on the case programmes may provide more depth to the observations described above and possibly reveal other interesting mechanisms that do not appear in this paper. The fact that the real-world programmes did not run completely synchronously has been ignored in this paper, because their project periods were assumed to overlap sufficiently to rule out any substantial differences regarding, e.g., technological maturity. Further research could look more deeply into this factor. More importantly, future research should include more data sources. In particular, the authors recommend that a large and representative set of interviews be performed. Direct communication with stakeholders can provide insights that are not described in the literature and correct existing misconceptions using local knowledge. Interviews could be combined with field research.

Further research should also be conducted to fill the gaps that this research has left regarding the programme arrangements and their results. Some data are difficult to find in literature, such as the exact regulations regarding the PPER in Senegal and the reason for the lack of bids for four out of ten concession zones. Moreover, too little information was available to the authors to say anything meaningful about the programmes with respect to some of the governance success factors (Table 5).

In addition, this research could be extended to more countries. Off-grid energy tenders have been set up in many countries worldwide in the last few years. As soon as the results of these tenders become public, a more quantitative and statistical cross-unit analysis could provide more robust observations than those described here. In this respect, care should obviously be taken to correct for different country backgrounds, for example, by researching how similar auction designs perform under different country backgrounds, or determining which mechanisms different auction designs evoke when they are implemented in countries with similar backgrounds.

7.2. Conclusion and policy implications

The objective of this study has been to gain more insights into the successful implementation of off-grid energy auctions to enhance rural energy access in low- and middle-income countries, with a special focus on auction design and governance. A selection of real-world case studies from Peru, Uganda and Senegal were analysed for this purpose. These insights and the policy implications they give rise to are summarized in this section.

- Firstly, auctioneers face a challenge in striking the right balance between (1) facilitating economies of scale and streamlining administrative procedures (e.g. through large concessions and providing technological restrictions); (2) allowing adequate product designs for a diverse group of beneficiaries (e.g. through technology-neutral auctions); and (3) attracting enough bidders in the relatively young off-grid energy sector (e.g. through small concession zones).
- Secondly, this paper provides further confirmation that balancing public and private risks is essential in designing off-grid energy tenders. Shielding developers from risks may increase participation and hence competitiveness in the tender. However, this could exert too heavy a burden on public actors in the later stages and fail to offer sufficient incentives to the developer to ensure reliable electricity services in the long term.
- Thirdly, the advantages and limitations of different payment types have been illustrated: whereas a fixed subsidy gives certainty regarding public expenses (Senegal), results-based financing provides more incentives regarding further expansion of the project (Peru). The Ugandan case illustrated the potential fragility of minimum-tariff auctions in countries where electricity tariffs are decided centrally.
- Finally, the real-world cases in this research underscore the importance of clear procedures at all stages of off-grid energy programmes. More specifically, this involves the description of technology requirements and allocation of responsibilities (such as installation, payment collection and maintenance). The real-world cases in this paper show that unclarity in responsibilities and inconsistent procedures can lead to significant delays. The Ugandan
Renewable and Sustainable Energy Reviews 183 (2023) 113350

and Senegalese cases also show the need to take up sufficient possibilities in the programme design for taking action against parties that do not fulfil their responsibilities. Good governance procedures also mean inclusiveness: the affected stakeholders should be included in the design and planning of the programme in order to build a programme that reflects the interests of the different stakeholders. Altogether, the contribution of this research has been to provide new examples about design elements and governance issues in off-grid energy auctions in low- and middle-income countries, a topic that has so far received relatively limited attention in the academic literature. The authors suggest that further research include interviews and field research for data collection and recommend that efforts be made to involve more real-world cases once more data is available regarding their outcomes.

CRediT authorship contribution statement

Martijn Backer: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Visualization. Dogan Keles: Conceptualization, Methodology, Writing – review & editing, Supervision. Claire Bergaentzlé: Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

Appendix. Data sources

See Table 6.

Table 6

Classification of the sources consulted for this study.

<table>
<thead>
<tr>
<th>Peer-reviewed academic</th>
<th>Institutional / government documents</th>
<th>Mainstream media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources</td>
<td>[2,15,21,27,28,68]</td>
<td>[5,11,20,25,70,71]</td>
</tr>
<tr>
<td></td>
<td>[10,14,19,22,64]</td>
<td>[6,42,44–46,49]</td>
</tr>
<tr>
<td></td>
<td>[8,9,24,29,34,37]</td>
<td>[7,13,35,47,72,73]</td>
</tr>
<tr>
<td></td>
<td>[6,12,36,43,48,57,69]</td>
<td>[17,51,52,58,59,62]</td>
</tr>
<tr>
<td></td>
<td>[4,56,53,54,56,63]</td>
<td>[60,61,65,74]</td>
</tr>
</tbody>
</table>

References


