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GREEN POWER FOR AFRICA: OVERCOMING THE MAIN CONSTRAINTS

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Design and Assessment of Renewable Electricity Auctions in Sub-Saharan Africa

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Abstract Auctions have recently been regarded as a useful alternative to other support schemes for setting the remuneration of renewable electricity (RES-E) worldwide. They have also been increasingly adopted in the sub-Saharan Africa (SSA) region, mostly due to their promise to support the deployment of RES-E projects cost-effectively. The aim of this article is to identify the design elements of RES-E auctions in SSA and assess their pros and cons with respect to different criteria. The results show that the design elements adopted in the SSA auctions are similar to other countries, but some design elements are deemed very relevant in order to address specific constraints to RES-E investments in SSA countries, including pre-selection of sites, technology-specific (solar PV), and price-only auctions. However, the main distinctive feature of auctions in SSA is that they are part of a broader policy mix of support mechanisms aimed at de-risking and providing technical support.

Keywords: sub-Saharan Africa, renewable energy, auctions, PV, design elements, policy mix.

1 Introduction

Many countries in sub-Saharan Africa (SSA) have experienced or are currently experiencing an energy crisis. Six-hundred million people in SSA lack access to electricity (Castellanos *et al.* 2015). With an electrification rate of only 26 per cent (World Bank 2017), the region has 13 per cent of the world's population, but 48 per cent of the share of the global population without access to electricity. SSA is the only region in the world where the absolute number of people living without electricity is increasing (IEA 2014: 30).

Some authors provide in-depth analyses of the SSA electricity sector (see Castellanos *et al.* 2015; KPMG 2016; Quitzow *et al.* 2016; Eberhard *et al.* 2016; Climatescope 2016; IEA 2014). Several factors are behind the energy crisis, including high-demand growth, low installed capacity, non-cost recovering tariffs, low utilisation rate of existing capacity,

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ageing, insufficient, and poorly maintained power infrastructures leading to transmission and distribution losses, dominance of one energy source (hydro), and negligible power trading across countries. Large investments are thus required to address this energy crisis.[4]

Electricity from renewable energy sources (RES-E) has the potential to mitigate the energy crisis since it is domestically available, it can be cost-competitive, and deployed much faster than fossil fuel-based power plants. It can trigger additional economic benefits and it is a core component for any low-carbon strategy, offering important environmental co-benefits, including improved local air quality (Quitzow *et al*. 2016).

However, non-hydro RES-E represents a tiny fraction of SSA's electricity mix. Renewables accounted for around 30 per cent of SSA-installed capacity in power generation (about 31GW) in 2016. However, most of this capacity is hydro-based (25 per cent, 25GW), with other RES accounting for only 5 per cent (6GW). Fossil fuels account for the largest share (68 per cent, 67GW), followed by nuclear (2 per cent, 1.9GW) (estimations based on IRENA 2017a and UNSD 2017).

Strong barriers to RES-E in SSA persist. A useful theoretical framework on the barriers to investments in RES-E in less developed regions, such as SSA, is provided by Pueyo *et al*. (2015). According to these authors, RES-E investments face three types of constraints: economic/financial, regulatory/political and technical, which are more severe in developing countries (*ibid*.: 32). In particular, the economics of renewable energy projects in developing countries are more challenging due to: (i) the capital-intensive nature of RES-E projects, which amplifies funding cost differentials; (ii) the higher level of perceived risk, which raises costs through the higher cost of finance and the larger share of equity in a project's finance structure; (iii) the lack of domestic debt-finance of suitable maturity, and scarcity of equity finance, particularly private equity; and (iv) low prices of electricity that prevent cost-recovery (*ibid*.: 30). Several studies have identified the specific barriers to RES-E in SSA (*The Economist* 2016; Quitzow *et al*. 2016; Castellanos *et al*. 2015; Climatescope 2016). The required capital spending in the power sector is an unbearable financial burden for government budgets (Castellanos *et al*. 2015). But other (interrelated) barriers include higher capital costs than elsewhere due to higher risks (*The Economist* 2016), different types of risks (construction and operation, foreign exchange and country risks), poor financial health of utilities (Quitzow *et al*. 2016), off-taker risk (Eberhard *et al.* 2016), the structure of the electricity sector (dominated by single, and often state-owned utilities responsible for a large share of generation, transmission, and distribution) (Climatescope 2016), technical limitations of weak grids (*The Economist* 2016; Quitzow *et al*. 2016; Eberhard *et al.* 2016), artificially low tariffs, and the large amounts of investments being required.

Different barriers could justify the adoption of different policies (policy mix). Pueyo *et al* (2015) identify several policies to address the different constraints to RES-E investments (economic/financial, regulatory/political, and technical). Focusing on the economic and financial barriers, administratively-set feed-in tariffs (FITs) and feed-in premiums (FIPs) are main alternatives to address those barriers. Under FITs, a total payment per MWh of RES-E generated, paid in the form of guaranteed prices and combined with a purchase obligation by the utilities is provided. Under FIPs, a payment per KWh on top of the electricity wholesale-market price is granted. FITs were adopted in a number of SSA countries in the past, including Ghana, Kenya, South Africa, and Uganda. However, they only delivered very small investments in SSA (Kruger and Eberhard 2016; Eberhard *et al.* 2016). Some of these countries (Ghana, South Africa, and Uganda), but also others in the SSA region have recently implemented auctions as a more appealing instrument than FITs, following the successful experience in South Africa and elsewhere. Auctions have also been implemented in Burkina Faso, Zambia, Namibia, Ethiopia, and Mauritius.

An auction is a process in which a good or several goods are offered up for bidding. In so-called procurement auctions, an auctioneer will buy the good (RES-E), from the bidder(s) offering the best bid, for example lowest support level (AURES 2017). The main differences with respect to FITs are: (i) auctions are more transparent in the setting of support levels; (ii) support is restricted to those being awarded in the auction; and (iii) FITs are an open window for a long period of time. Project developers can apply for the FIT anytime whereas, in tenders, project developers can only apply when a call is open. Auctions are now implemented in 67 countries worldwide (up from six countries in 2005) (IRENA 2017b). The attractiveness of auctions lies in several advantages compared to administratively-set support. They mitigate the information asymmetry problem when setting remuneration levels; they are particularly suitable to control costs, expansion, and the technology mix; and they are more likely to lead to allocative efficiency (Haufe and Ehrhart 2015).

Auctions have increasingly been adopted due to their alleged advantages in terms of efficiency in RES-E promotion. This is something particularly convenient in developing countries, where economic resources are more limited, given budget constraints (Spratt *et al.* 2016). A critical problem in these countries is the unavailability of finance. Financial markets tend to be immature and perceived risks are higher (Spratt *et al.* 2016: 7), which raises the cost of finance.

Whether auctions will fulfil the expectations depends on the choice of design elements but also on their combination with other instruments (i.e. a policy mix). Therefore, the aim of this article is to analyse recent experiences with RES-E auctions in SSA. The pros and cons of their design elements are assessed, and an analysis of the functioning of those schemes with respect to different criteria is provided. Whereas previous contributions have analysed specific schemes, mostly the South African one (see e.g. Eberhard, Kolker and Leigland 2014; del Río 2016), but

Table 1 **Main design elements in RES-E auctions**

Design element	Description
Volume	There are three main ways to set the volume auctioned: capacity (MW), generation (MWh) or budget (million €).
Timing	The existence of regular rounds with a schedule is a critical design element. The alternative is stand-alone auctions, i.e. set at irregular intervals.
Diversity	Diversity with respect to technologies, locations, actors, and sizes of the installations could be promoted in an auction by organising different auctions per alternative (e.g. technology-neutral vs technology-specific), by including minimum quota per alternative, by providing different remuneration levels for different alternatives, or by lowering pre-qualification requirements or penalties for specific categories (i.e. small actors).
Participating conditions: facilitation and requirements	Several elements may facilitate the participation in an auction, while others are rather requirements for this participation: • Streamlining of administrative procedures • Supporting dialogue with stakeholders and information provision (e.g. measurement of resource potentials) • Pre-qualification requirements are required in order to participate in the bidding procedure and are adopted to prove the seriousness of bids. They can refer to specifications of the offered project (such as technical requirements, documentation requirements, and preliminary licences) or to the bidding party (providing evidence of the technical or financial capability of the bidding party). They also include economic guarantees (bid bonds). • Local content rules refer to the requirement to use renewable energy equipment which is manufactured by local firms.
Support conditions: types and forms of remuneration	Remuneration in an auction can be provided for generation (MWh) or capacity (MW). Generation-based remuneration can be provided as full payment (FIT) or through a premium top-up on the market price (FIP).
Selection criteria	Price-only auctions are organised using only one criterion (the bid price). In multi-criteria auctions, the price is the main criterion among other criteria (e.g. local content rules, deliverability, impact on local R&D, industry and jobs, and environmental impacts).
Auction format	In a single-item auction there is a single product which is allocated to a single owner and the product cannot be split (e.g. 50MW of PV are allocated to a single bidder, to be deployed at a specific site). In a multi-item auction the auctioned product is split among different owners and bids are submitted for only part or the total auctioned amount (e.g. 50MW of PV are allocated to several bidders, to be deployed at a specific site or in different places).
Auction type	Under sealed-bid auctions, project developers simultaneously submit their bids with an undisclosed offer of the price at which the electricity would be sold. An auctioneer ranks and awards projects until the sum of the quantities offered covers the volume of energy being auctioned. Under the multi-round descending-clock auction, the auctioneer offers a price in an initial round, and developers bid with offers of the quantity they would be willing to provide at that price. The auctioneer then progressively lowers the offered price in successive rounds until the quantity in a bid matches the quantity to be procured. Hybrid models may use the descending-clock auction in a first phase and the sealed-bid auction in a second phase.
Pricing rules	Under uniform pricing, all winners receive the strike price set by the last bid needed to meet the quota (highest accepted bid) or the first bid that does not meet the quota (lowest rejected bid). Under the pay-as-bid (PAB) alternative, the strike price sets the amount of generation eligible for support and each winner receives his/her bid.
Price ceilings	In order to limit the costs of support, the auctioneer can set a maximum bid price.
Realisation period	Deadlines are set for building the projects which have been awarded contracts.
Penalties	Penalties can take different forms: they can forbid participation in successive auctions, reduce the level of support, reduce the length of the support period by the time of the delay, lead to the confiscation of bid bonds or result in penalty payments.

Source Authors' own elaboration based on del Río *et al.* (2015a).

also Uganda (e.g. Castalia LLC 2016) and Zambia (Lucas 2016), there is not a joint comparison of different schemes in SSA, which are very recent. The pros and cons of their design elements have not been studied. Those design elements have not been compared with auctions for RES-E worldwide. Finally, their functioning has not been assessed in a systematic manner, using different criteria.

Accordingly, this article is structured as follows. The next section provides the analytical framework for the analysis of the choice of design elements in RES-E auctions. Section 3 explains the methodology followed in the analysis of those design elements in SSA countries. The analysis is carried out in Section 4. Section 5 discusses the results and concludes.

2 Analytical framework: components for the assessment of design elements in auctions for RES-E[5]

Before an auction is implemented to promote RES-E investments, governments must consider whether this is an appropriate mechanism, taking into account their energy policy priorities. An analysis of the market should be carried out, including potential bidders, potential barriers to RES-E deployment, the situation of the supply chain, grid infrastructures, and so forth. Then specific design elements can be chosen. These are highly context-specific and what works in one market is not necessarily applicable to another.

2.1 Design elements in auctions for RES

The most relevant design elements in RES-E auctions are described in Table 1 (see del Río *et al*. 2015a and del Río 2017a for further details).

Table 2 **Description of the criteria and indicators**

Criteria	Description
Effectiveness	'*A priori* effectiveness': degree to which the volume offered is contracted. 'Realisation rate effectiveness': degree to which the volume contracted is actually built.
Static efficiency (direct and indirect costs)	Reaching the target at the lowest possible system generation costs (€, €/MWh). An auction outcome is efficient if the bidders with the lowest generation costs are awarded. The relevant costs here include generation costs and transaction costs. Indirect costs (balancing, profile, and grid costs (€, €/MWh)) should be included.
Impact on the local supply chain	This refers to impacts on the local supply chain.
Actor diversity	The participation of small actors is actively encouraged.

Source Adapted from del Río *et al*. (2015a).

2.2 Assessment criteria

Defining 'success' in the choice of design elements is certainly not a trivial issue. Assessment criteria are used for this purpose. Although effectiveness and (static) efficiency are the most common criteria used in the assessments, several contributions expand the set of relevant criteria to include other aspects, such as dynamic efficiency, impact on the local supply chain, and actor diversity (see del Río *et al*. 2015a). However, an unambiguously preferred ranking of criteria does not exist in the literature. Table 2 describes the criteria considered in this article.[6]

Static efficiency refers to the minimisation of the (system) costs of RES-E generation, which can be disaggregated into direct and indirect costs. The former include installation, operation, and maintenance of renewable energy technologies. Direct generation costs refer in this article to allocative efficiency, to which the equi-marginality principle applies.[7] Indirect costs refer to balancing, profile, and grid costs.[8]

2.3 Market, bidders and system effects

The links between specific design elements and criteria to assess those design elements are mediated by the effects on bidders and the market. Design elements affect the participation of bidders in the auction by influencing the costs, risks, and expected benefits of participation (bid levels with respect to generation costs). In general, the higher the costs, the higher the risks or the lower the expected benefits, the lower the number of participants (del Río 2015). The lower the level of competition, the higher the bid prices and the lower the efficiency of the auction (Haufe and Ehrhart 2015). Effectiveness is affected by those design options with an impact on investors' risks (negative influence), competition (negative influence, since a higher level of competition induces more aggressive bidding and, eventually, underbidding and underbuilding), and bid levels (the higher these levels, the higher the realisation rate). The impact at bidders' level translates into market effects, which include the number of bidders in the auction, the diversity of those bidders, and their market concentration. In turn, these aspects have consequences on the functioning of the auction (assessed with the aforementioned criteria).

3 Method

The analysis of the design elements in SSA auctions is based on country case studies. We have selected those countries which have implemented auctions for RES-E and where winning projects have been awarded contracts as of 1 February 2017. These include Zambia, Uganda, and Ghana. Zambia should be lauded for being one of the first SSA countries to run a solar tender efficiently and effectively. The Uganda tender for solar is one of the main pillars of a comprehensive support framework for small-scale renewable energy deployment, the GET FiT programme, that converts the awarded FIP into a grant fully reimbursed after the first five years of operation of the project. Ghana was one of the first countries in SSA to introduce a Renewable Energy Act along with a FIT scheme that attracted the interest of many developers looking

Table 3 **Main socioeconomic and power sector data for the selected countries (2015)**

	Ghana	Uganda	Zambia
Nominal GDP (US$ billion)	36.2	21.9	16.2
GDP per capita (US$)	1,343	619	1,044
Real GDP annual growth (%)	3.4	5.4	3.1
Population (million)	27.4	39	16.2
Unemployment (% of labour force)	4.3	4.1	13.3
Ease of doing business within SSA (1: most friendly, 47: least friendly)	11	12	6
Electricity generation mix (%)	Hydro: 73 Oil: 20 Gas: 7	Hydro: 80 Oil: 14 Other renewables (biomass): 6	Hydro: 97 Oil: 3
Net installed capacity (GW)	3.1	0.9	1.9
Total electricity generation (TWh)	14.1	3.8	11.3
Transmission and distribution losses (%)	27.6	7	16.3
Electrification rate (%)	76	15	26
Per capita electricity consumption (KWh)	362.1	83.8	583.2

Source Based on data from KPMG (2016), IEA (2017).

to develop up to 1.5GW of RES-E-based power plants. However, given the low credit worthiness of the off-taker and the inability of the government to provide a credit enhancement mechanism, only a 20MWp solar PV plant was built under the FIT. In order to unlock the pipeline of projects and select good projects at low prices, the government launched a first auction in 2015.[9] The RES-E auctions analysed in SSA are based on PV. They aim to diversify the electricity generation mix, reducing the dependence on hydro and conventional electricity sources, in a context of fast-growing populations, economies and, thus, electricity demand and considerable solar potentials in those countries. PV projects are deemed particularly suitable for auctions, given their maturity, standardised nature, and the likely high degree of international competition in PV compared to other RES-E technologies (e.g. biomass). The three countries have implemented their first and only auction for RES-E during 2014 and 2016. This is in contrast to South Africa, the country in the SSA region with the largest (seven-year) experience in the organisation of RES-E auctions.

Table 4 **Design elements in auctions for RES-E in selected SSA countries**

Design element (category and subcategory)		Uganda	Zambia	Ghana	Rest of the world*
Period and technological scope		11 months (January–December 2014) Small PV (< 5MW)	2016 PV	12 months (November 2015–November 2016) PV	
1 **Volume**	Generation (GEN), budget (BUD) or capacity-based (CAP)	CAP (20MW)	CAP (2x50MW)	CAP (20MW)	CAP: 21 BUD: 4 GEN: 4
2 **Periodicity**	Schedule (Y/N)	N	N	N	Y: 10 N: 16
3 **Diversity**	Technology-neutral (TN), multi-technology (MT) and technology-specific (TS)	TS (solar PV)	TS (solar PV)	TS (Solar PV)	TS: 20 MT: 2 TN: 5
	Geographically neutral (Y/N)	N; preferred zones for the location identified	N (site-specific)	Y; the developer chooses the site in coordination with the off-taker (ECG)	Y: 17 N: 9
	Actor neutral (Y/N)	Y	Y	Y	Y: 25 N: 1
	Size neutral (Y/N)	N Maximum project capacity 5MW	N	N Maximum project capacity 20MW	Y: 10 N: 16
4 **Participation conditions**	Pre-qualification requirements	Previous experience, financial capability Bids and performance bonds	Experience, expertise, and financial resources Bid bonds Technical requirements	Technical criterion: successful track record of developing PV projects Financial criterion: submission of financial statement for at least 3 years; show positive value of equity and profits for each of the last 3 years	Variable
	Local content rules (Y/N)	N	N	Y (minimum of 20%)	Y: 11 N: 15
	Information provision (Y/N)	Y	N	Y	Y: 6 N: 20

Table 4 **Design elements in auctions for RES-E in selected SSA countries (cont.)**

Design element (category and subcategory)		Uganda	Zambia	Ghana	Rest of the world*
5 **Support cost condition**	Type of remuneration (capacity vs generation)	Generation	Generation	Generation	GEN: 24 CAP: 3
	Form of remuneration (FIT, sliding FIP, fixed FIP)	Sliding FIP (difference between winning bid prices and a FIT 11 US cents/KWh)	FIT	FIT	FIT: 17 sFIP: 8 fFIP: 1
6 **Selection criteria**	Price-only vs multi-criteria	Multi-criteria 70% price 30% (technical, financial, environmental, and social parameters)	Price	Price	Price: 18 Multi-criteria: 8
7 **Auction format**	Multi vs single-item	Multi	Single (project-specific)	Single-item	Single: 6 Multi: 20
8 **Auction type**	Static, dynamic, and hybrid	Static	Static	Static	Static: 25 Dynamic: 0 Hybrid: 1
9 **Pricing rules**	PAB vs uniform	PAB	PAB	PAB	PAB: 21 Uniform: 3 First-price: 3
10 **Ceiling prices**	Ceiling prices (Y/N)	Y	N	Y (ceiling price is the FIT)	Y: 19 N: 7
11 **Realisation period**	Deadlines for construction (years)	2	1	2	Variable
12 **Penalties**		Contract termination, confiscation of bids, and performance bonds	Contract termination, bid bond withheld	Contract termination, confiscation of bids, and performance bonds	Variable

Source Authors' own elaboration.
*Number of countries applying each design element.

The research consisted of country fieldwork and desktop research. Secondary literature, official data, and documents were consulted. This was complemented with interviews with relevant stakeholders in the three countries. Table 3 compares the chosen countries on the basis of selected socioeconomic and energy indicators. The three countries are similar in some respects (medium-size, low gross domestic product (GDP) per capita levels, moderate GDP growth rates, and power mixes strongly based on hydro). However, they show some differences regarding some indicators. Unemployment is comparatively higher in Zambia. Transmission and distribution losses are relatively high in Zambia, and especially in Ghana, and much more modest in Uganda. Ghana has a high electrification rate, which is very low in both Zambia and Uganda. Finally, per capita electricity consumption is orders of magnitude lower in Uganda than in the other two countries.

4 Results

4.1 Design elements

Table 4 summarises and compares the design elements in the three countries. It also shows which design elements are more common in the rest of the world (last column).[10]

A main feature of the schemes in SSA is the strong involvement of international institutions and donors, which have provided funding and technical assistance. In Zambia, a main role has been played by the World Bank through the Scaling Solar programme. Scaling Solar provides advice to assess the right size and location for solar PV power plants in the country's grid; simple and rapid tendering to ensure strong participation and competition from committed industry players; fully developed templates of bankable project documents that can reduce negotiation time; concessional financing and insurance attached to the tender; delivering competitive bidding and ensuring rapid financial close; risk management; and credit enhancement products to lower financing costs and deliver power at lower tariffs.

In Uganda, external support was also provided to implement a tendering process, in this case through the GET FiT programme. GET FiT is supported by the governments of Norway, the UK and Germany, the EU (through the EU Africa Infrastructure Fund) and the World Bank (GET FiT Uganda 2015). The main support instruments implemented within the GET FiT programme include: the GET FiT Premium Payment Mechanism (GFPPM),[11] a standardised set of legal documents (including bankable power purchasing agreements (PPAs), implementation agreements, and developer financing agreements for small independent power producers (IPPs)), World Bank International Development Association (IDA) Partial Risk Guarantee (PRG) Facility, the Technical Assistance (TA) Facility,[12] an interconnection component and additional funds to build new interconnection infrastructure and refurbish existing infrastructure (Castalia LLC 2016). A unique feature of the GFPPM in Uganda is that donor-funded premium payments are received up-front. The developer will receive the first 50 per cent, of the total 20 years' premium payment amount, upon commercial operation. The remaining 50 per cent is paid in annual 10 per cent tranches over the first five years of operation. For biomass and hydro projects, the GFPPM is administratively set. However, due to the rapid fall in the price of PV, it was decided that, for PV projects, the premium should be the result of an auction process.

In Ghana, the government received technical assistance from GIZ (German Society for International Cooperation), which implemented the programme 'Capacity for a Successful Implementation of the Renewable Energy Act in Ghana' (C-SIREA) to design an auction scheme that would allocate at least cost the scarce resources that the country could spend on credit enhancement mechanisms. C-SIREA supported the government in defining the auction process and features, preparing standardised documents (including minimum technical requirements) and supporting the established tender committee along the different phases of the process through the provision of technical and transaction advisers.

Regarding specific design elements adopted in SSA countries, most of them are standard in other countries (Table 4), such as volume defined in capacity terms (instead of generation or budget), and remuneration based on generation (rather than on capacity). The absence of a schedule for auctions is common to other countries, which is somehow surprising, given the detrimental consequences of auctions at irregular intervals or infrequent ones in terms of underbidding, higher investor risks, and constraints to the development of a robust supply chain (see del Río 2017a).

We would like to stress the relevance of some design elements applied in order to address the constraints to investments faced by many SSA countries.

A main difference from other countries is the lack of geographical neutrality, with the exception of South Africa, where auctions are geographically neutral. Auctions in SSA are either site-specific (Uganda and Zambia) or the off-taker has an important role in the choice of the site (the developer chooses the site in coordination with the off-taker in Ghana). Site-specific auctions optimise the integration of variable RES-E into the grid and reduce the administrative burden for project developers. In Uganda, preferred zones for project location were identified.[13] In Zambia, the two projects (50MW each) will be located in the Lusaka South Multi-Facility Economic Zone. The pre-selection of sites is related to the lack of assessments of the stability of the grid and the weak grids in these countries, which encourages the location of projects close to the grid. Simplicity and transparency of design is key to attract investors in a high-risk perceived environment, as in SSA countries. This is why several design element choices have been made: technology-specific (only PV, rather than technology-neutral), sealed-bid with PAB (rather than dynamic auctions or static auctions with uniform pricing), and price-only auctions (instead of multi-criteria-based tenders).

Technological specificity usually brings benefits in terms of dynamic efficiency (if the least mature technologies are promoted). In general, a problem with lower neutrality is market segmentation, which could lead to few bidders and low competition in a given contingent, higher bids (higher support costs), and higher generation costs (lower static efficiency). However, in the case of SSA, technology neutrality is unlikely to lead to more participation and greater competition. The reason is that auctions in this region are particularly suitable for PV, and therefore PV is likely to concentrate most projects in a technology-neutral auction anyway. Auctions in the SSA countries analysed are for PV only. This is in contrast to the auctions in South Africa where, in addition to PV, wind, small hydro, and biomass are included, although they are also technology-specific. There are many PV project developers in these countries. According to one interviewee, this is probably due to the simplicity of these projects compared to other renewable technologies, such as biomass or hydro, where there are barely any projects being developed. Solar PV projects can be implemented more quickly and lead times are thus reduced, which make them particularly suitable for an auction, and for SSA countries which need to have additional generation sources rapidly implemented in order to cover increasing electricity demand needs in a context of power capacity deficits. For those other technology alternatives, an administratively-set FIT may make more sense. Donors have pushed strongly for auctions being based on PV in SSA.

Regarding auction type, static auctions have been the choice. Sealed bids are simpler than dynamic ones, leading to lower participation costs (Maurer and Barroso 2011). Not revealing information during the auction process becomes an advantage of sealed-bid auctions when competition is weak because bidders could use that information to coordinate their bidding, increasing the final price of the auction. Static auctions are less vulnerable to implicit collusion than dynamic ones (Haufe and Ehrhart 2015). However, the winner's curse, which occurs when bidders do not know their actual valuation for the good, is more likely under static auctions.

The pricing rule has been based on pay-as-bid in the three countries, and also in South Africa. It is also the most common choice worldwide. The uniform pricing rule (lowest rejected bid) has a main theoretical advantage: it is incentive compatible, for example there is no incentive for cost exaggeration and bidders bid their true cost. The reason is that with uniform pricing and lowest rejected bid, the bidders' own prices do not influence the price they will be paid in case of winning (Haufe and Ehrhart 2015; Kahn *et al.* 2001; Federico and Rahman 2003). However, uniform pricing leads to uncertainties regarding award prices for bidders in case of winning. Furthermore, in practice, the uniform pricing rule creates a risk of irrational behaviour (underbidding), underbuilding and, thus, ineffectiveness (see del Río 2017a). The support is not inflation-indexed in the three countries.

Two of the auctions in SSA are price-only auctions (Zambia and Ghana) whereas, in Uganda, a multi-criteria auction has been implemented, in which the price represents only 30 per cent of the criteria and technical, financial, environmental, and social parameters account for the rest. Price-only auctions would result in the lowest bidders being awarded contracts, whereas selection of the preferred bidder on criteria other than price allows for the achievement of multiple policy objectives (e.g. local employment, local environment, industrial development, etc.) (del Río, Wigan and Steinhilber 2015b). However, the least-cost bidders might not be selected in multi-criteria auctions, leading to a lower allocative efficiency and higher support costs. According to one interviewee, this was the case in Uganda, where donors decided to implement a multi-criteria analysis among other reasons to line up the selection with their own policy goals. In South Africa, the multi-criteria auctions led to some local benefits (see del Río 2016 for an overview) and a greater acceptance of the scheme, but at the cost of higher complexity (Kruger and Eberhard 2016) and lower transparency.

Pre-qualification requirements and penalties are standard measures to ensure the seriousness of bids and that winning projects are built. But, if set too stringently, they may discourage the participation of actors by increasing the costs of participation, leading to lower levels of competition and higher bid prices and policy costs. This is not the case in the three countries being analysed. According to one interviewee, the technical requirements in Ghana should have been more precise. They were set in very general terms, subject to the interpretation of participants on the required information which had to be submitted. In contrast to the lax requirements in Ghana, technical specifications may have been too strict in Uganda, setting narrow requirements for individual components, rather than for the quality of the power produced.

Finally, one country has implemented local content requirements (Ghana), whereas the other two have not. Local content requirements are a common practice in many countries around the world, with nearly half having adopted them. Their main advantage is the positive local socioeconomic impacts, as in Uganda, where local development opportunities in the rural regions have been encouraged (also due to the project size limit and the selected site). But they may restrict participation in the auction, leading to lower competition and higher bids. This design element is particularly unsuitable when there is not a local supply chain in the specific technologies being eligible to participate in the auction, because it would result in higher energy costs with very modest local benefits. According to one interviewee, the part of the supply chain which could be local was identified in Ghana and the 20 per cent local content requirement was set accordingly. Local content requirements may be in conflict with access to reliable and cheap energy, which is a main priority in SSA countries.

4.2 Assessing the success of auctions in SSA

4.2.1 Actor diversity

The auctions in SSA have attracted a considerable number of actors. In Zambia, 48 solar power developers were attracted, of which 11 were qualified and seven submitted final proposals (IFC 2016). Two companies were awarded contracts, despite the fact that a bidder submitted the lowest bids for the two sites. This is so because the Scaling Solar tender does not allow awarding both sites to the same bidder, which increases actor diversity (at the expense of higher support costs). In Uganda, 24 expressions of interest were received and nine qualified developers were invited to submit technical and price bids. Seven developers submitted their bid packages in August 2014. There were two winning bidders (Meyer, Tenenbaum and Hosier 2015). In Ghana, the auction launched in November 2015 attracted 33 developers, 18 of which were pre-qualified to submit a bid. Five applicants submitted technical and financial proposals and one bidder was recommended for negotiation (Behrle 2017).

Regarding the types of actors, mostly large, international investors have been attracted, although some local developers have participated (in Uganda). In Zambia, they were mainly large, well-established companies, with company domicile mostly in Europe. In Uganda, five of the pre-qualified companies were international solar developers and four were local companies. The high presence of local developers can be explained by the small maximum size of the projects (5MW) that reduces attractiveness for the larger international developers (Castalia LLC 2016) and the pre-existence of a FIT since 2007 that spurred local project developers. The winners of the auctions in the three countries show a combination of African and international well-established firms. In the case of Zambia, there were two winners, both international actors, a large utility from Italy (ENEL) and a PV project developer (First Solar). In the case of Uganda, there were two winners (Access Power MEA and Building Energy). Access Power is a Middle East and Africa (MEA) project developer, founded in 2012. Founded in 2010, Building Energy is one of most prominent Italian's independent renewable energy power producers. In Ghana, BioTherm Energy is Africa's leading IPP. This African-born utility has been successful in securing over 250MW of PPAs on the African continent in seven different countries.

4.2.2 Policy effectiveness

Regarding *a priori* effectiveness, the results can be deemed quite satisfactory. In Uganda and Ghana, 20MW were auctioned and they were all awarded, whereas in Zambia, 100MW were auctioned for the two projects (50MW each), and 73MW were awarded (45MW and 28MW).

It is difficult to judge effectiveness in terms of realisation rate at this stage, since the deadline for building the projects has not ended. However, there are signs that they will be built. In Zambia, the projects are scheduled to be completed in Q3 2017. The fact that the two winners are well-established international companies and the de-risking under the Scaling Solar programme are cause for optimism. One of the 10MW grid-connected solar PV plants awarded in Uganda entered into operation on November 2016. The other (also 10MW) has started construction and is expected to enter into operation in Q3 2017 (GET FiT Uganda 2017). The premium payment (a top-up to the FIT) offered by GET FiT was likely necessary for all power plants supported by the programme. Integration into the electricity system is guaranteed since the sites are preselected based on their capability to evacuate the power from the projects. In addition, investments in transmission infrastructure represent another pillar of GET FiT. In Ghana, it is too early to tell whether the 20MWp PV project awarded in November 2016 will be built. Policy effectiveness has been high in South Africa, both regarding the capacity being procured as well as the capacity expected to enter into operation (South African Government 2015).

The relatively low volumes auctioned in the three cases mean that they will contribute marginally to the countries' power mixes. However, a second round is expected in both Zambia and Ghana. In Uganda, the Electricity Regulatory Authority (ERA) will promote an additional 30MW of solar PV (GET FiT Uganda 2015). According to one interviewee, one main advantage of auctions with respect to FITs regarding effectiveness is that the sovereign guarantee to mitigate the off-taker risk (due to lack of credibility of the utility) provided by the government cannot be given to all projects applying for a FIT (due to scarce resources), and the auction allows the selection of one or two projects, the best ones, to which the guarantee can be provided. Thus, bidders winning the auction know that they will receive such a guarantee, and investors' risks are reduced accordingly. The fact that unsuccessful bidders have not complained is a sign that the processes were well developed and operated.

4.2.3 Static efficiency

Regarding the cost-effectiveness of the schemes, the results are mixed. The Zambian auction has led to remarkable low prices (winning bids of 6.02 US cents/KWh and 7.84 US cents/KWh), which can be partly related to the low risks facilitated by the Scaling Solar programme. According to USAID (2016: 6), the concessional lending provided by the World Bank made these projects commercially viable. The fact that land is provided for free by the Zambian government and the denomination of PPAs in dollars (which reduces currency risks for investors) has helped to further reduce costs. However, the pre-selection of the site has been an issue in Zambia, with Eckhouse and Hirtenstein reporting criticisms by one of the winners in the auction arguing that 'the location of the project isn't ideal… it's not flat and has rocks that will need to be removed' (2016). In addition, the sites are not in places with the highest level of solar radiation in Zambia (del Río 2017b), but they are close to a new substation (Eckhouse and Hirtenstein 2016), which facilitates grid integration in a country with an underdeveloped grid. The first geographically-neutral wind auction in South Africa led to considerable challenges for grid connection and permit approvals for the winning projects (Haffejee 2013), which suggests that the site was not optimal in terms of transmission and land use and that site-specific auctions would have mitigated these problems.

In Uganda, the wining average price was 16.37 US cents/KWh, which was higher than in Zambia and South Africa. The smaller sizes of the project (preventing economies of scale), the creditworthiness of the off-taker, being the first auction, and being a landlocked country are factors negatively affecting cost-effectiveness (Meyer *et al*. 2015). The deadline for obtaining title to land was particularly tight and turnover (revenue) requirements for the solar tender may have been too high (Castalia LLC 2016). Tender documents for the solar procurement identified preferred zones for the location of the proposed plants. Finally, GET FiT's technical specifications may have been too strict, setting narrow requirements for individual components, rather than for the quality of power produced, preventing developers from choosing the least-cost option to meet requirements (Castalia LLC 2016).

In Ghana, the preferred bidder's offer of 11.7 US cents/KWh is lower than the FIT of about 18 US cents/KWh and between the prices in Uganda and Zambia. However, in Ghana, the bidders had a 20 per cent local content requirement and concessional lending was not provided, as in Zambia and Uganda.

One of the reasons for the site-specificity of auctions in SSA is the weaknesses of grids. The limited grid infrastructure in SSA countries constrains the choice of sites. Those with the best solar resources are not chosen and, thus, direct generation costs (and bid prices) are not minimised. The sites in Ghana and Zambia were selected according to grid integration studies, which were performed to identify the amount of variable RES-E which could be fed at various substations, considering technical constraints and resource availability. Although the first auction was not site-specific in Uganda, the next round may be site-specific as the government was supported in developing a grid integration model for variable RES-E, which takes into consideration their technical constraints and economic benefit to the system. Site-specificity can be recommended in SSA given that, as stressed by two interviewees, it is quite complicated to obtain different types of permits in these countries (access to land and infrastructure, connection permit, and environmental impact assessment). Identification of these sites by the government makes it easier for project developers to obtain those permits and they usually favour this design element.

4.2.4 Impact on the local supply chain

The technological diversity provided by the projects is high regarding the electricity generation sources in three countries (since there was no solar PV connected to the grid), but low in the sense that the only RES-E supported by the auction is solar PV. The impact on the local supply chains will likely be low, since they are non-existing in the three countries and most investors are not local ones. This might be a little bit different in Ghana, where there was a 20MWp PV plant prior to the auction, and where the 20 per cent local content requirement and the fact that there will be several other rounds can be expected to positively impact the local supply chain.[14]

5 Discussion and conclusions

This article has analysed the design choices in the auctions in three SSA countries and has provided an initial assessment of their outcomes. Several lessons can be extracted from the experience with auctions in the three countries analysed. Note, however, that the experiences are nonetheless very limited and difficult to translate into general principles.

The three cases suggest that auctions can be an effective and cost-efficient way to introduce non-hydro renewable energy sources in countries with little existing experience in these sources such as those in SSA, changing the perception that cheap renewable energy projects cannot be deployed in poor countries with weak institutions and high costs for conducting business. The simplicity of PV projects makes the setting of support through auctions (rather than administratively) an appropriate choice since competition is likely to be greater than in projects with longer lead times (e.g. biomass).

Auctions for RES-E support might be useful to address some of the constraints to RES-E investments in SSA, including limited economic resources and weak grids. Their simplicity and transparency in setting remuneration levels may make it attractive for potential investors and policymakers alike. Their alleged advantage in terms of allocating efficiently the limited financial support available to RES-E is something particularly convenient in SSA countries, where economic resources are more limited, given budget constraints. They allow for the selection of good projects by experienced developers and discourage lower quality projects to go ahead. They also allow to control for the quantity of RES-E capacity connected to the grid, which is useful for purposes of grid management, particularly in SSA countries, which have weak grids.

However, auctions are not a panacea. This article has shown that, at least for SSA countries, the success of auctions depends on the choice of design elements, but it also depends on the existence of an 'enabling environment', which implies minimum institutional, regulatory, human, financial, and infrastructure capabilities. In particular, auctions need to be complemented by other instruments which directly reduce risks. Thus, auctions must be part of a more comprehensive combination of measures (policy mix) which extends over time and which addresses the barriers to RES-E deployment mentioned in Section 1. Auctions should be part of a broader package of measures aimed at de-risking and capacity building (need for technical assistance for the design and implementation of the auction processes). The experiences in SSA suggest that, in the context of those countries, the auction procedure should be combined with market-based de-risking mechanisms which directly reduce the financing costs and participation risks in order to attract potential bidders, and have appropriate competition levels and lower bid prices. This has been the case in the Scaling Solar programme in Zambia and the GET FiT programme in Uganda, which are programmes with auctions being one among other instruments. External financial support in the form of a package of de-risking/credit enhancement mechanisms has proven useful in this regard.

International institutions, such as the World Bank, and foreign governments have played and can play a very relevant role in this context. In particular, the World Bank Scaling Solar programme has contributed to mitigate international banks' concerns about political risk, reducing the costs of capital and making these emerging markets more appealing to developers. GET FiT includes a donor-financed premium to supplement the Ugandan FIT in the first five years of the project lifetime and the World Bank's PRG to mitigate the risk of default by the utility (Quitzow *et al*. 2016). The standardised PPAs and IAs (implementation agreements) offered by GET FiT reduced the time needed to finance closure and signature of the PPA and were important for lenders, because they reduced the cost of legal due diligence.

In addition to a PPA plus de-risking, the programmes have reinforced the institutional capabilities in those countries by providing technical support. Technical assistance was included in the three countries in order to develop human, regulatory, and institutional capacities, investments in technical capacities for the development of the grid, and financial mechanisms to reduce the financial risks and increase the financing capacity. According to one interviewee, technical assistance is necessary in auctions for RES-E in SSA countries, given the lack of experience in renewable energy technologies and in international tenders. It is particularly recommendable, given the capital intensity of these technologies, in order to give investors more confidence, improving selection of projects and, thus, reducing bid prices.

The governance structure is different across the experiences in the three countries. The GET FiT programme in Uganda has a broader scope in the sense that it has a multi-stakeholder governance structure, involving the ERA, governmental stakeholders, donors, and a number of energy sector and infrastructure investment experts, which monitors progress and proposes measures to address relevant challenges (GET FiT Uganda 2014; Quitzow *et al*. 2016). In this sense, the Zambian case is more 'supply-driven' (the World Bank steered the process rather than empowering local institutions to do it), whereas the cases in Uganda and Ghana are more demand-driven, with a committee with many actors, including local ones, where the respective governments played a dominant role.

Even if auctions are supplemental to other policy measures and tools, they can play an important role in supporting RES-E effectively and cost-effectively. Whether they can meet the expectations depends on the choice of design elements. Most of the design choices made in the SSA auctions are deemed standard and appropriate in order to address the constraints to RES-E investment in these countries. These include alternatives that enhance the simplicity and transparency of design, which are key aspects to attract investors in a high-risk perceived environment such as the one existing in SSA countries: technology-specific (PV), sealed-bid with PAB, and price-only auctions. Site-specific auctions address problems related to a weak grid and obtaining administrative permits, which can be particularly burdensome in SSA countries. The strong pre-qualification requirements help to avoid underbidding and improve the effectiveness of the scheme.

Finally, the transparency of the auction schemes in the three countries should be stressed. This attracts the participation of bidders, which has a positive impact on competition and, thus, on bid prices. However, an underlying problem in the SSA auctions is the lack of proper energy planning, for example documents which indicate how much capacity will be needed in the medium and long terms and which technologies would cover such capacity. This complicates the efficiency and effectiveness of tenders, given the lack of long-term signals on future volumes. Therefore, a national energy planning exercise would increase confidence of the project developers and help government to plan a schedule for the tenders. Currently, each country has only organised a stand-alone auction.

Notes

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4 According to *The Economist* (2016), Africa requires between US$60 and US$90 billion annually to address its energy shortfall, roughly quadruple 2014 investment levels. The World Bank estimates that investments of between US$120 billion and US$160 billion are required per annum in order to provide electricity access to the entire SSA region by 2030.
5 This section draws heavily on and summarises the findings of the EU-funded Auctions for Renewable Energy Support (AURES) project. See del Río *et al*. (2015a, 2015b) and del Río (2015) for further details.
6 Full details on the description of these criteria and how they were derived are provided in del Río *et al*. (2015a).
7 According to Tietenberg (2008:18), the least cost means of achieving a target occurs when the marginal costs of all possible means of achievement are equal.
8 Balancing costs occur due to deviations from schedule of variable RES-E power plants, and the need for operating reserve and intraday adjustments in order to ensure system stability. Profile costs are mainly back-up costs, i.e. additional capacity of dispatchable

technologies required due to the lower capacity credit of non-dispatchable RES-E. Grid costs are related to the reinforcement or extension of transmission or distribution grids as well as congestion management, including re-dispatch required to manage situations of high grid load (Breitschopf and Held 2014).

9 South Africa was not included in the analysis for several reasons: (i) It is a very different country with respect to the others in fundamental aspects: economic structure and economic conditions, size, institutional capacities, etc. (ii) South Africa first implemented its auction scheme in 2011, i.e. it has a long-standing experience in RES auctions. This has likely resulted in policy learning over the years and improvements in the scheme. This is not the case in the other three SSA countries analysed. (iii) South Africa has been a well-researched country regarding RES auctions.

10 This last column is based on the analysis performed by the authors for 26 RES-E auction schemes from around the world.

11 The GET FiT premium gives small power producers FIP payments in addition to the national FIT. The costs for the already existing FIT are passed down to the consumers. However, the costs for the FIP payments are taken up by the donors. Small-scale biomass, hydro, bagasse, and solar PV plants can apply for the FIP payments.

12 This includes: enhancement of skills for FIT tariff modelling, least cost development planning, solar PV tender, project due-diligence expertise, strategic communication, and negotiation.

13 These zones were defined after a review of grid capacities, local loads, and solar radiation rates (Meyer *et al*. 2015). The tender documents also stated that projects had to be located no further than 3km from the grid and that all interconnection costs were to be borne by the bidder and included in tariff bids (Castalia LLC 2016).

14 In fact, two solar PV assembly lines have been inaugurated in Ghana (one of which was part of the winning consortium).

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