



Auctions for renewable energy support – Suitability, design, and first lessons learned

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ABSTRACT

Auctions are a promising tool to support worldwide renewable energy expansion. Nevertheless, their introduction poses a serious challenge to both policy makers and project developers. Our aim is to develop a bridge between auction theory and the implementation of auctions in the context of renewable energy support (RES). We present suitable theoretical concepts to model the specific situations for RES. In addition, we provide structured theory-based guidance for implementation and participation.

In this regard, we theoretically analyze auction formats that are potentially suitable for renewable energy auctions. We focus on the most discussed auction formats in practice: pay-as-bid and uniform price auctions. We highlight advantages and point to potential pitfalls for bidders and auctioneers under relevant market and framework conditions in the RES context. Finally, our theory-based results are substantiated by first-hand experiences from different countries.

1. Introduction

The Paris Agreement concluded by the parties of the [United Nations Framework \(2015\)](#) represents a milestone for the expansion of renewable energies (RE) worldwide. Because electricity from renewable energies is not yet competitive with fossil fuels, governments subsidize project developers. To mitigate excessive costs, many countries have recently implemented or are planning to implement competitive mechanisms such as auctions. In addition to competitive price determination, they aim to efficiently allocate support to project developers. [REN21 \(2016\)](#) report that at least 64 countries worldwide already implemented auctions for renewable energy support (RES). Many of these countries achieved “record bids” in terms of low support levels, which is also stated by [del Río and Linares \(2014\)](#). In the work of [del Río and Linares \(2014\)](#), 17 countries worldwide were listed and analyzed with a focus on their auction design: 13 out of these implemented pay-as-bid auctions. In addition, the U.K. and France conducted uniform price auctions. Brazil used a two-stage mechanism with a pay-as-bid auction at the end. Obviously, the frequently discussed and popular uniform price auctions seem to be less frequently implemented.

We base our work on the report from [Haufe and Ehrhart \(2016\)](#), where we deduce a systematic overview of most relevant results for policy applications. Beyond, we complement those results with real-world experiences to illustrate the relevance of auction theory in RES

practice.

First, we conduct a theoretical analysis and address possible reasons why uniform price auctions are less frequently implemented. Further, we point to other auction theoretical issues regarding suitable auction formats for RES. In contrast to [del Río and Linares \(2014\)](#) and [REN21 \(2016\)](#), we start from a theoretical auction perspective and emphasize the general characteristics of auctions. We combine auction theory and practice to identify factors for (un)successful auction implementations in the RES context. Until now, a close link has been missing and speculations or half-truths exist that discourage project developers and policy makers. We compare different auction formats under RES-relevant conditions with an auction theoretical focus to show the sensitivity and diversity of auction formats. In particular, we focus on pay-as-bid and uniform price auctions regarding their success for RES applications.

[Section 2](#) highlights the general suitability of auctions for RES based on theoretical auction findings and statements from the RE sector. In [Section 3](#), we provide basic principles of auction theory and establish a standard theoretical framework for auctions, see [Fig. 1](#). General theoretic advantages and disadvantages of potentially suitable auction formats are presented in this simplified framework. However, in the real world, market and framework conditions may deviate from what is suitable, may differ among countries, and may even change over time. Consequently, in [Section 4](#), we abandon the simplifying assumptions

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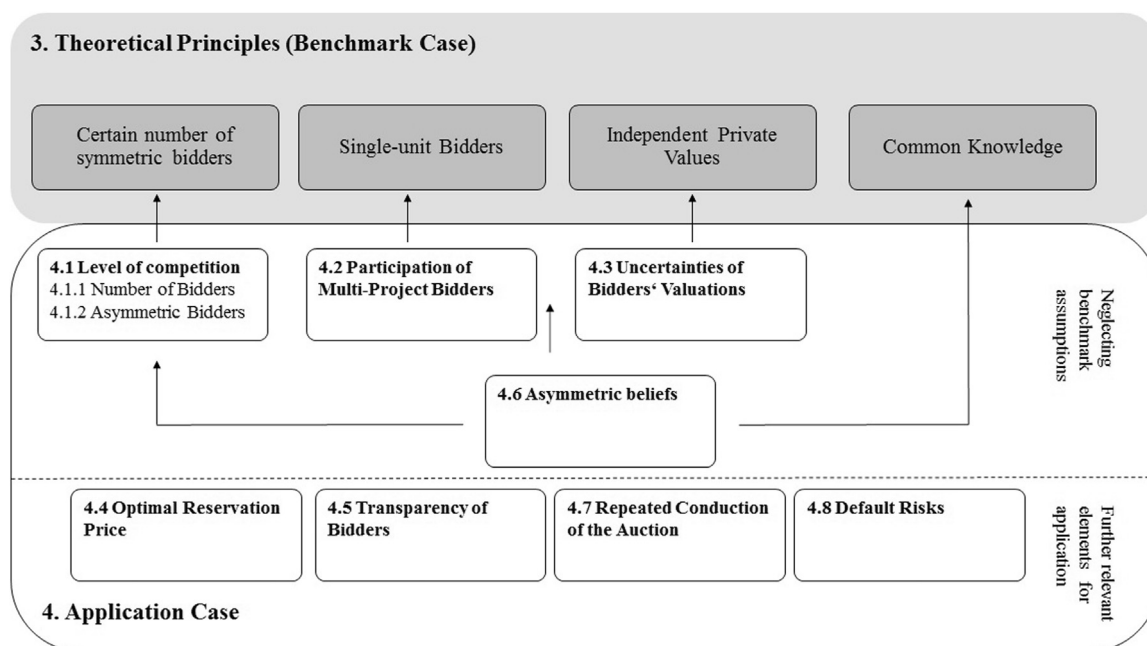


Fig. 1. The Benchmark Case and relevant deviations for the Application Case.

step-by-step and analyze the impacts, see Fig. 1. To link these theoretical findings to the real world, we provide anecdotal evidence by suitable examples from different countries.

2. Auctions and their suitability for renewable energy support

An auction is a mechanism (institution) through which one or several goods are allocated and priced on the basis of submitted bids. Arguments in favor of auctions (for procurement) are competitive price determination, minimized procurement costs, and efficient allocation (Krishna, 2009). In the renewable energy context, the reduction of support costs and the identification of the “best” suppliers with respect to predefined targets and criteria are gaining importance, and auctions are implemented as a method of choice. In general, auctions serve as pricing and allocation mechanisms in situations in which supply exceeds demand, competitive prices are missing, and information asymmetries between auctioneer and bidders persist (IRENA and CEM, 2015; McAfee and McMillan, 1986). Auctions further enable governments to control costs, expansions, and technology mix (IRENA and CEM, 2015; Latacz-Lohmann and Schilizzi, 2005). Kopp et al. (2013) point to the alternatives of conducting technology-neutral or technology-specific auctions for RES, which enable the regulation of the technology mix in an appropriate manner. In addition, valuable information can be generated through well-designed auctions in the form of signals on cost-covering support levels. In most cases, such as sealed-bid auctions, only the auctioneer has access to this information and can decide on the information to be released after the auction. Kopp et al. (2013) argue further that a well-designed auction also generates incentives for innovation.

In our subsequent analysis, we assess relevant auction types with regard to several criteria. The main criteria are incentive compatibility, expected auction revenue (support costs) and allocative efficiency. These criteria are standard in auction theory given their significant relevance for real-world implementations. In incentive-compatible auctions, bidders have incentives to reveal their true costs – to submit bids that equal their costs.¹ Expected auction revenue is one of the most

important criteria for policy makers. Further, the RES costs generated by the auction are subsequently well traceable. An auction outcome is allocative efficient if no ex-post incentives for resale exist (Ausubel and Cramton et al., 1998). That is, bidders who can supply the RE at the lowest costs are awarded.

3. Theoretical principles – designing an appropriate auction for renewable energy support

In our analysis, we focus on procurement auctions because project developers in this context act as sellers and offer the good – capacity or energy generated from RE (MW or MWh) – to the auctioneer. The government buys the good from bidders offering the best bid, such as the lowest price. Most RES auctions are multi-unit auctions² where the auctioned volume consists of multiple (homogeneous or heterogeneous) units of the good that can be supplied by several bidders. The homogeneous units are certain equivalent subsets of the total good, such as total power of 100 MW split into smaller blocks of 5 MW, 10 MW, and others. Offering predefined RE projects for bidding can be modelled by heterogeneous units because projects may differ. The bidders are awarded the amount of the units or projects as specified in their bids, such that bids win as long as the offered volume is less than or equal to the demanded amount. In addition to auctions with awards based solely on the price, multi-attributive auctions also exist. In these auctions, different criteria such as price, socio-political, geographical, and technology conditions, among others, are relevant for awards (IRENA and CEM, 2015). For reasons of clarity, we limit our analysis of homogeneous or heterogeneous multi-unit procurement auctions to the bidding price as the sole criterion.

3.1. A simplifying theoretical framework

We start our analysis of auctions for RES under the simplifying assumption of independent private values (IPV) (Milgrom and Weber,

(footnote continued)
to analyze and evaluate.

² Sometimes, single-unit auctions are conducted, for example, wind offshore auctions in Denmark. Basically, they represent a special (simplified) case of multi-unit procurement auctions with only a single good, such that all findings hold analogously.

¹ In the considered non-incentive-compatible auctions, bidders have incentives to exaggerate their costs. For real-world implementations, bid exaggerations may be difficult

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