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Designing renewable energy auctions for India: Managing risks to maximize deployment and cost-effectiveness☆

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ABSTRACT

We examined 20 renewable energy auctions in India and elsewhere to answer two questions: first, have auctions been effective; and second, how can they be designed to achieve India's renewable energy targets? The significant contributions lie in the larger sample size, use of secondary and primary research, and application of quantitative and qualitative analysis. We found that auctions are almost always *cost-effective*, with savings up to 58% from baseline feed-in tariffs. However, auctions may not always be *deployment-effective*, with only 17% of the auctions with greater than 75% deployment. We then examined how to best design auctions by assessing seven major risks, and found the following: first, for every 1% increase in total risk, deployment effectiveness decreased by 2% points; second, project specific risks have 60% greater impact than auction specific risks; and third, deployment effectiveness is most affected by auction design, completion, and financial risks. We also found that effectiveness of auctions in India can be improved by ensuring competition, improving transmission infrastructure, providing payment guarantees, using pay-*as*-bid auctions, including stringent penalties for delays, and introducing auctions in a controlled manner.

1. Introduction

1.1. Motivation

Auctions and feed-in tariffs are two popular procurement mechanisms for renewable energy worldwide. In India, typically governments have been using auctions for solar power and feed-in tariffs for wind power procurement.

Under feed-in tariffs, governments offer long-term contracts and guaranteed payment for electricity at a fixed rate. Although feed-in tariffs are a popular mechanism, governments may not always have the best information to set the correct, competitive tariff, which can lead to cost inefficiency if too high, or non-deployment if too low [19,28].

Governments around the world are increasing the use of auctions as a means to procure renewable energy, due to their potential as a more cost-effective mechanism [19]. Under auctions, a renewable energy buyer (governments or utilities) announces interest in buying a set amount of electricity from renewable energy sources. Renewable energy sellers (project developers) who meet predefined technical and financial criteria then submit price bids to the renewable energy buyer, who typically selects the winning sellers based on the lowest bids.

Given India's budget constraints for supporting renewable energy, a cost-effective policy path is crucial to achieving the country's renewable energy targets [15]. The budget allocated to India's Ministry of New and Renewable Energy (MNRE) was reduced from INR 15 billion (USD 246 million)[2] in FY2013-14 to INR 4.41 billion (USD 72.3 million) in FY2014-15 [30,33]. Auctions, if designed properly, could help deploy renewable energy capacity in a cost-effective and transparent manner.[3]

However, in our interactions with policymakers in India, they have raised questions about the ability of auctions to achieve the

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[2] All exchange rate conversions are at 2014 average rate (1 INR = 0.0164 USD).

[3] We discuss different types of auctions in the Online Appendix.

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expected goals and whether risks in auctions can be properly managed. To assist policymakers in India, we assessed the following two questions, as identified in Ref. [18]:

- Have auctions been effective as a mechanism to procure renewable energy?
- How can auctions be designed to manage risks to achieve India's renewable energy targets?

Also, while India is already using auctions to procure solar power, attempts to use auctions for procuring wind power were stalled in the past due to opposition from the wind power industry [34,41]. Given this, we gave special attention to assessing the feasibility of wind power auctions in India.

1.2. Prior work

A number of studies have examined the use of auctions for renewable energy procurement globally. These studies had a similar goal of examining whether auctions have resulted in achieving the stated policy objectives. We discuss a few key studies below.

Kreycik et al. [23] evaluated feed-in tariffs and auctions on four criteria. They found that feed-in tariff regimes provide price certainty, which can increase investments and encourage sustained development; however, they may not result in least-cost projects. Auctions, on the other hand, while helping discover market tariffs, have challenges in terms of requirement of a large market size for bids to be competitive.

Maurer and Barroso [28] discussed efficient practices in electricity and renewable auctions. They focused on both developed and developing countries: Brazil, Chile, Peru, Mexico, Vietnam, Philippines, Europe, and North America. They concluded that, if auctions are successfully designed and implemented, they might lead to far superior results than other procurement mechanisms, such as feed-in tariffs.

Becker and Fischer [2] compared feed-in tariffs with auctions for renewable energy procurement with the experience in three emerging countries viz., China, India, and South Africa. They highlighted the importance of policy objectives on policy choice and design. They concluded that India and South Africa could achieve their capacity targets in a cost-effective manner using auctions.

Cozzi [7] assessed the success and failure of reverse auctions for renewable energy with case studies on U.K., China, and Brazil. He identified success and failure with regards to policy goals, and concluded that reverse auctions can be used for renewable energy deployment at low cost, but design elements need to be present to prevent underbidding and breach of contract.

Conti [5] examined how reverse auctions work in practice using three case studies: California, Brazil, and Texas. He concluded that − auctions: 1) have the potential to contract large volumes of renewable energy at attractive prices, 2) would require robust prescreening criteria to avoid winner's curse, and 3) would be more successful in price reductions if paired with other supply-side incentives.

IRENA [19] analyzed the design of renewable energy auctions in selected developing countries viz., Brazil, China, Morocco, Peru, and South Africa. They discussed the role of design elements for designing successful auctions, such as the type of auction, ceiling prices, auction volumes, administrative procedures, and guarantees and penalties.

Santana [40] examined the cost-effectiveness of project allocation mechanisms, such as renewable portfolio standards, feed-in tariffs, and auctions. He also examined the effect of these mechanisms in reduction of costs in the long term. Renewable portfolio standards and auctions were found to be cost-effective in the short term; however their long run effectiveness depended on technology specific approaches.

Kylili and Fokaides [24] reviewed auctions for power generation from renewable energy. They presented case studies from five countries in depth to identify the defects of the auction mechanism and to offer recommendations. They identified underbidding to be a major problem in auctions and suggested the inclusion of minimum viability criteria as well as sealed-envelop auctions.

Rohankar et al. [38] examined the viability of solar power projects in India, allotted under various central and state government policies. Specifically, they evaluated long-term sustainability of the projects deployed, given much lower tariffs than benchmark tariffs. The authors also identified underbidding as an issue with auctions and recommended the use of feed-in tariff in addition to enforcement of RPO/REC markets.

Malagueta et al. [26] assessed the impact of large-scale integration of concentrated solar power (CSP) plants in the Brazilian electricity system through auctions. They concluded that CSP is not yet competitive in the Brazilian electricity market and noted that CSP plants would more likely have to replace hydroelectric power plants, where investments in RE is largely driven with the motivation to replace fossil fuels.

Contreras and Rodriguez [6] developed a Public Private Partnership (PPP) model for development of wind power in isolated areas in Columbia. They modeled the relationship between public sector and private investors using a bi-level programming method including an auction mechanism. They highlighted the importance of a stable regulatory framework for decentralized wind power development in the country.

Butler and Neuhoff [4] compared the feed-in tariff policy in Germany with competitive auctions in the U.K. They concluded that the long-term price guarantee provided by feed-in tariff reduced regulatory and market risk in Germany. This ensured less-than-expected higher prices in Germany compared with the price discovered in the U.K. They also suggested that support policies play a critical role in determination of prices.

Ferruzzi et al. [16] proposed a decision making model (for a prosumer dealing in low-voltage grid-connected micro grid) to formulate an optimal bidding model in the Day-Ahead energy market, considering the uncertainty of solar PV power production. The authors present an original approach based on Analog Ensemble method to estimate the uncertainty linked to solar PV power production in a micro grid setup. Results indicate different optimal bids based on the risk adversity of the prosumer with respect to the uncertainty involved in Solar PV power production.

Rio [36] examined the interactions between energy efficiency and renewable electricity support schemes to assess whether choice of specific instruments and design elements within those instruments affects the results of the interactions. The author went beyond the previous work in this area by considering instruments such as feed-in tariffs in addition to tradable certificates. The author concludes that for a support instrument to qualify in the optimal set of policy measures, it should complement existing measures and should not overlap or lead to conflicts [37]. aimed to clarify the differences between the two approaches used to measure the cost-effectiveness of renewables support policies. The authors note that the equimarginality principle and the lowest costs of support principle could partly overlap and their policy implications clearly differ, leading to different policy prescriptions. While the former favors technology neutral instruments and design elements, the latter approach favors instruments and design elements that adjust support levels to the cost of the technologies.

Though some of these studies provided insights into designing